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 Deliverable 2.1 Technologies analysis, regulatory framework and use cases' descriptions

ID: 5G4LIVES_D2.1_Final

5G4LIVES project has received funding from European Union's CEF Digital programme 5G for Smart Communities under grant agreement no. 101133716

5G4LIVES

D2.1. TECHNOLOGIES ANALYSIS, REGULATORY FRAMEWORK AND USE CASES' DESCRIPTIONS

Project Title:	5G for a Better Tomorrow: Protecting Lives and the Environment in Riga and Turin
Project Acronym:	5G4LIVES
Contract Number:	101133716
Project Coordinator:	RIGAS PILSETAS PASVALDIBA
WP Leader:	WP2 | MoT

Document ID N°:	5G4LIVES DELIVARABLE 2.1 TECHNOLOGIES ANALYSIS, REGULATORY FRAMEWORK AND USE CASES' DESCRIPTIONS	Version:	FINAL
Deliverable:	D2.1	Date:	30/05/2024
		Status:	Approved

Document classification	PU

Approval Status	
Prepared by:	RIGAS PILSETAS PASVALDIBA
Approved by: (WP Leader)	Comune Di Torino
Approved by: (Coordinator)	RIGAS PILSETAS PASVALDIBA

CONTRIBUTING PARTNERS

Name	Company / Organization	Role / Title
Ilona Platonova	RCC	5G4LIVES Project manager
Klāvs Balamovskis-Kalniņš	RCC	5G4LIVES Smart city expert
Emīls Zinkēvičs	RCC	5G4LIVES Project manager assistant
Staņislavs Šeiko	RCC	Strategic expert
Juliana Dzeidzjule	RCC	SORA expert
Aleksandrs Timoškevičs	RMP	River Police Department, Deputy Chief
Jānis Skrims	RMP	River Police Department, Chief of Reaction Unit
Vladimirs Petrovs	LMT	5G4LIVES Technical Lead
Evija Plone	LMT	5G4LIVES Project Manager
Lorenzo Pessotto	MoT	5G4LIVES Project Manager
Lauris Labanovskis	VASES	5G4LIVES VASES Project's leading expert

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Klāvs Saliņš	VASES	5G4LIVES VASES Project expert
Aleksandrs Vērdiņš	VASES	5G4LIVES VASES Project expert
Guntars Saidāns	VASES	5G4LIVES VASES Project expert
Raimonds Kurpnieks	VASES	5G4LIVES VASES Project expert
Dainis Zariņš	VASES	5G4LIVES VASES Project expert
Māris Klaučs	VASES	5G4LIVES VASES Project expert
Monta Baltā	VASES	5G4LIVES VASES Project Manager
Federico Dellanoce	MoT	Civil Protection - Drone Unit
Davide Giuseppe Ture	MoT	Civil Protection - Drone Unit
Stefano Primatesta	PoT	5G4LIVES PoT Project expert
Ascanio Pattara	Wind3	5G4LIVES Wind3 Project expert

REVISION TABLE

Version	Date	Comments
1.0	13.03.2024	Draft table of contents, sent for discussion to LMT, VASES, MoT, PoT, Wind3
1.1	27.03.2024	Finalized table of contents after discussion with all involved partners
2.0	01.04.2024	Collection and processing of initial information from all involved Partners
2.1	12.04.2024	Obtaining information from RCC structural units about Riga use-case
2.2	26.04.2024	Obtaining information from Italian Partners about Torino use-case
2.3	13.05.2024	Obtaining information from LMT and VASES about technological analysis
3.0	27.05.2024	Reviewing and formatting information, version of evaluation matrix added by LMT.
3.1.	30.09.2024	Revision of Figures and Tables, as well as harmonization of used terms.

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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) 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 UAVs 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 counter-Unmanned Aircraft System (C-UAS) hacking technology, integrating satellite data, and improving pilot-UAVs command for better emergency response. The project also includes research in Riga on safety protocols and procedures for urban UAV 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 UAVs, 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 UAVs 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 C-UAS hacking technologies, leading to more efficient emergency responses. Additionally, developing safety protocols, and procedures for urban UAV flights, and validating BVLOS flight methodologies will set new standards for public safety and security. the project emphasizes 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

4G	Fourth generation of mobile telecommunications technology
5G	Fifth Generation of mobile telecommunications technology
ARNS	Aeronautical Radio Navigation Service
BS	Base Station
BVLOS	Beyond Visual Line of Sight
CE	European Conformity (From French "Conformité Européenne")
CEPT	European Conference of Postal and Telecommunications Administrations
CRPC	Consumer Rights Protection Centre
e.i.r.p.	Equivalent Isotopically Radiated Power
e.r.p.	Equivalent Radiated Power
EMC	Electromagnetic compatibility
EU	European Union
GHz	Gigahertz
GNSS	Global Navigation Satellite Systems
GPS	Global Positioning System
IMT	International Mobile Telecommunications
ITU	International Telecommunication Union
LTE	Long Term Evolution (commonly known as 4G)
MFCN	Mobile Fixed Communication Networks
MHz	Megahertz
mW	Milliwatt
NRP	National Radiofrequency Plan
RED	Radio Equipment Directive
RF	Radiofrequency
RLAN	Radio Local Area Network
RNSS	Radio Navigation Satellite Service
SRD	Short range devices
UA	Unmanned Aircraft
UAV	Unmanned Aerial Vehicle
UAS	Unmanned aircraft system
C-UAS	Counter-Unmanned Aircraft System
UTM	Unmanned traffic management
eUARV	Electronic Unmanned Aircraft Restrictions Viewer
UE	User Equipment
VASES	Valsts Akciju Sabiedrība “Elektroniskie Sakari” (State Joint Stock Company “Electronic Communications Office” of Latvia)
VLOS	Visual Line of Sight
WiFi	Wireless Fidelity (wireless networking)
WP	Work Package
RMP	Riga Municipal Police

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EXECUTIVE SUMMARY

The present document is the deliverable D2.1, which describes the outputs from Tasks 2.1, 2.2. and 2.3 in Work package 2. Those tasks are carried out within first five months of the project and required engagement of most of the partners of the consortium. The classification of the use-cases is also aligned with deliverable D4.1. already submitted by the project consortium. The focus of this deliverable is to describe the use-cases in more detail as further assessment has been carried out on technical and legal framework.

To define the new use-cases, the current procedures and UAV use was assessed, and literature review was carried out by partners to obtain current and future perspectives of the UAV use in public safety.

The document also discusses the geomorphological aspects, highlighting the risks due to geographical factors of the areas. Locations are in Torino and two of them in Riga. Document proposes piloted solutions to mitigate these risks, emphasizing the use of automated UAVs with 5G connectivity for efficient surveillance and rescue operations.

The report further outlines the technical specifications of UAVs suitable for these operations, the importance of software for mission management, and the regulatory aspects of using radio frequency bands for UAV communication. It also provides an in-depth analysis of the regulatory framework and operational requirements for Beyond Visual Line of Sight (BVLOS) UAV operations in Europe.

Lastly, the document discusses the European Drone Strategy 2.0, which aims to advance the European UAV market by building on the EU’s safety framework for UAVs and promoting large-scale commercial UAV operations. The strategy focuses on developing competencies and skills for UAV operations, integrating U-space services, and ensuring operational safety. The new regulation will be crucial to ensure successful adaptation of the project outputs in the long term.

This deliverable is crucial as it provides a comprehensive analysis of the **technologies** to be employed, alongside an examination of the **regulatory framework**. It also outlines detailed descriptions of the **use cases**. It's connected to Milestone 2 (Use cases and requirements definition), and its public dissemination underlines its role in setting the foundational understanding for the project.

In conclusion, the 5G4LIVES project is a significant initiative that leverages advanced technology to enhance public safety and environmental health. It presents a comprehensive approach to managing risks and emergencies, highlighting the potential of UAV and 5G technology in these critical areas. The document underscores the importance of regulatory compliance, technological advancements, and strategic planning in achieving the project’s objectives. It provides valuable insights into the future of UAV operations and the role of 5G technology in enhancing these operations.

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1. INTRODUCTION

This chapter contains information on the possibilities of using the mentioned RF bands for the needs of UAVs in Latvia, references to the relevant technical conditions, and the related administrative procedures, explained in a simplified manner.

In Riga, there are nine swimming areas where lifeguards operate. One of the competencies of the Riga Municipal Police is to perform rescue operations at the swimming sites of Riga city. In addition, residents of Riga also swim in other areas where there are no rescue stations and which are not monitored by the police, prompting an increase in the management area of the police officers, at least covering the territory of all nine swimming sites.

Torino, stands at the forefront of innovation, particularly in the realms of UAV technology and 5G connectivity. With its forward-thinking approach, Torino has emerged as a hub for technological advancement, spearheading initiatives that harness the power of UAVs and 5G to enhance various aspects of urban life.

Torino boasts a progressive approach towards the integration of UAVs into its urban landscape. Leveraging the agility and versatility of UAVs, the city has implemented numerous initiatives across diverse sectors, including but not limited to:

1. Urban Planning and Infrastructure Management: UAVs are employed for aerial surveys, monitoring, and inspection of infrastructure, aiding in efficient urban planning and maintenance.
2. Emergency Response and Public Safety: Torino is testing the use of UAVs for emergency response and disaster management scenarios. UAVs equipped with thermal imaging cameras and other specialized sensors are deployed to provide real-time situational awareness to emergency responders during crises such as natural disasters or accidents.
3. Environmental Monitoring: Torino utilizes UAVs for environmental monitoring, including air quality assessment, biodiversity surveys, and wildfire detection, contributing to sustainability efforts and environmental conservation.
4. Delivery Services: The city explores the potential of UAV delivery services for rapid and efficient transportation of goods, reducing traffic congestion and carbon emissions.

In tandem with its UAV initiatives, Torino is at the forefront of 5G deployment, establishing a robust and high-speed communication infrastructure that underpins various technological innovations. The integration of 5G technology in Torino offers:

1. Enhanced Connectivity: 5G networks provide ultra-fast and reliable connectivity, facilitating seamless communication and data exchange among UAVs, IoT devices, and urban infrastructure.
2. Low Latency: The low latency of 5G networks enables real-time data transmission, crucial for applications such as UAV navigation, remote monitoring, and telemedicine, where immediate response is imperative.
3. Support for Emerging Technologies: Torino's 5G infrastructure fosters the development and adoption of emerging technologies such as augmented reality (AR), virtual reality (VR), and autonomous systems, unlocking new possibilities for innovation and economic growth.

Torino's progressive approach towards UAV integration and 5G connectivity epitomizes its commitment to leveraging technology for the betterment of urban life. Through strategic investments, partnerships, and collaborative efforts, the city continues to lead the way in harnessing the transformative potential of UAVs and 5G, shaping a more connected, resilient, and sustainable future for its residents and beyond.

2. DESCRIPTION OF SURVEILLANCE AND RESCUE FUNCTIONS

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All locations will be equipped with 5G technology, as indicated in the figure displaying the course and structure of the implementation of scenarios. Green hydrogen produced from renewable resources will be utilized as back-up systems (where possible). This measure will enhance energy independence and security. At least four UAVs will be purchased. By expanding the use of hydrogen technologies, the climate indicators in the area will be improved while preserving the environment's quality. The hydrogen will also be green, meaning it is produced from renewables. Since the weather conditions in winter and summer vary significantly - from frozen water to a full-fledged bathing season - use cases (Turin, Vecaki, and Kisezers) will be tested and demonstrated over three seasons, namely summer, winter, and a season for validation and result verification. At each site, there will be embankment observation (search and rescue in landscaped areas and observation of the beach) and search and rescue activities during two different seasons (life-saving on official bathing beaches and life-saving on ice). It is important to consider several scenarios, such as developing safety protocols for Beyond Visual Line of Sight (B-VLOS) flights, Notice to Air Mission (NOTAM) procedures, balancing between police purposes and airport Riga Control Zone (CTR) restrictions, and inspecting landscaped and abandoned areas to prevent arson or other incidents. Surveillance and rescue operations will be carried out using modern and intelligent technologies, which will help reduce the load on necessary personnel, speed up rescue time, and benefit all members of society, including visitors to Kisezers, Turin, and Vecaki, families with children, deaf or blind people, persons with reduced mobility, athletes, and lovers of various recreational activities, guests of the city, and even pets. As a result of these activities, the environmental and social spheres will improve, including saving human health and life and improving the environment by reducing CO_2 and cleaning up recreational areas.

2.1 RIGA TERRITORY

In Riga, there are nine swimming areas where lifeguards operate. One of the competencies of the Riga Municipal Police is to perform rescue operations at the swimming sites of Riga city. In addition, residents of Riga also swim in other areas where there are no rescue stations and which are not monitored by the police, prompting an increase in the management area of the police officers, at least covering the territory of all nine swimming sites. Currently, 2-3 lifeguards per station monitor the public beach area, which will be a very demanding and tiring task.

The project will be implemented at two locations: Kisezers and Vecaki public beach. In each location, there is existing static infrastructure - the lifeguard station. To acknowledge the needed technological specifics both area landscapes must be defined.

2.2 VECĀĶI BEACH

Vecāķi Beach, located in the northern part of Riga, Latvia, is a popular sandy beach on the shores of the Gulf of Riga, known for its clean water and natural surroundings. Stretching for several kilometers, the beach is complemented by pine trees, dunes, and a small forest, and is a favored destination for swimming, sunbathing, and other outdoor activities such as beach volleyball, kitesurfing, and windsurfing. Alongside the beautiful natural environment, Vecāķi Beach also features several cafes and restaurants offering both traditional Latvian cuisine and international dishes. Vecāķi is one of the 3 official seaside swimming spots in Riga, and it is conveniently accessible by train, bus, bicycle, or private car, using the recently constructed bike path. Thanks to the nearby nature park "Piejūra," the Vecāķi district is not only a popular vacation spot for local residents but also for all inhabitants of Riga, both in the winter and summer seasons. It is a long sandy beach, approximately 8 km in length, surrounded by pine forests, quiet on weekdays but very popular on sunny weekends in the summer. It is not only a place to sunbathe in the summer but also an inspiring location for winter walks and a stress-relief spot for mental clarity. In recent years, Vecāķi has experienced rapid development, renovating historic houses, creating forest walkway boardwalks towards the sea, constructing several cafes and restaurants, and organizing tours and concerts.

In the Vecāķi coastal area lies the nature park "Piejūra," which is a specially protected area due to valuable biotopes in the territory and on the beach. The "Nature Conservation Plan" states that "Piejūra" was "established to protect many rare coastal biotopes, mesotrophic lakes with oligotrophic to mesotrophic plant communities in mineral-poor water bodies and their embankments. Particularly important are biotopes such as embryonic dunes, foredunes, wooded seashore dunes, and old-growth boreal forests." Vecāķi's "Piejūra" nature park is visited by large streams of

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people, driving out the dune area and beach area every day. During the summer season, passenger traffic to the swimming spots in Riga's city territory, including Vecāķi, significantly increases, and the number of planned traffic on routes to the swimming spots in the city of Riga is increased to serve the growing passenger flow. To expand the accessibility of swimming spots from other neighborhoods of Riga city, the 29th and 58th bus routes are extended to Vecāķi. Throughout the year, public transport to Vecāķi is used by 350,000 to 450,000 passengers each month, with approximately 5 million people arriving at Vecāķi annually. Vecāķi is also one of the greenest districts of Riga, and care must be taken to improve this district to fulfill the European Green Course. Payment for paid parking lots is only during the summer season (from May to September), with the number of transactions varying from 5,000 in May and September to 13,000 in June, July, or August, proving the popularity of Vecāķi Beach among city residents and guests.

The standard surveillance area of Vecāķi Beach is near the Vecāķi rescue station. It covers the beach area and approximately 700 meters in width, including the coastal and sea swimming area where buoys are placed. The placement of buoys depends on factors such as wind, changing currents, tide, and wave height. The lifeguards' UAV patrol must also be performed beyond the buoys, as attention must be paid specifically to swimmers who are beyond the safe depth zone or who risk being blown out to the open sea due to strong winds.

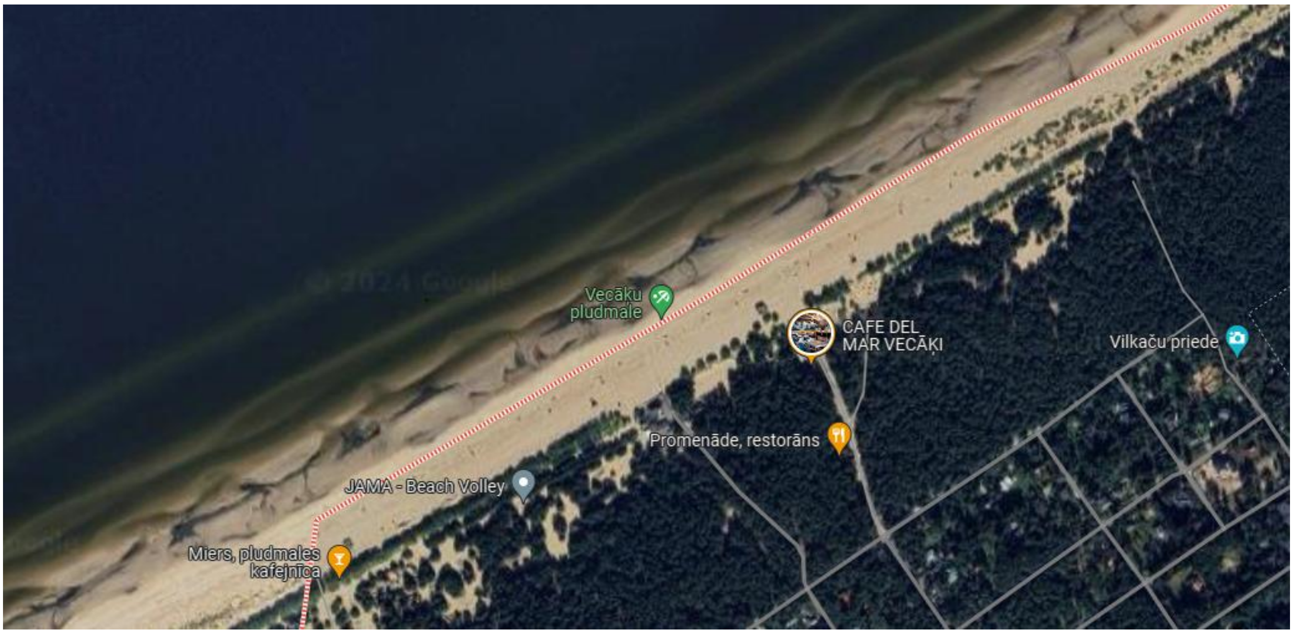

Figure 1. Vecāķi beach teritory

2.2.1 Winter

Outside the swimming season, the Vecāķi rescue station is staffed by a single professional responsible for maintaining security and overseeing order. During the winter months, the focus of the municipal police rescuers shifts to specific activities. These include maintaining public order, conducting rescue operations for individuals who have fallen through the ice, and performing under-ice dives. The latter is primarily aimed at locating deceased individuals, which may include, for instance, ice fishermen. This comprehensive approach ensures the safety and well-being of all visitors throughout the year.

During specific intervals, access to ice-covered areas is restricted, particularly when sea ice forms. The RVPP diligently monitors these areas to ensure compliance with the prohibition. The primary focus is on preventive measures and issuing timely warnings.

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Public order supervision is a year-round operation. Law enforcement officers routinely patrol the beach to prevent unauthorized vehicular entry, as such activity is strictly prohibited in this area. They also monitor visitor behaviour, ready to intervene should any aggressive behaviour or altercations arise.

There are instances when, despite receiving a call for water rescue operations, certain circumstances prevent the execution of these operations. In such scenarios, the RVPP promptly relays all pertinent information regarding the incident to the State Fire and Rescue Service's Operational Command Centre. This communication highlights the prevailing conditions that render the execution of rescue operations impossible with the technical resources at the disposal of the RVPP. This procedure ensures a coordinated response to emergencies, leveraging the collective resources of multiple agencies.

2.2.2 Summer

During the summer season, the primary focus is on patrolling the Vecāķi beach swimming area. Buoys are used to demarcate the designated swimming area, signalling to swimmers the boundaries of the permitted territory.

The police's main responsibilities include:

1. Identifying whether beach visitors have swum beyond the boundaries of the designated swimming area.
2. Determining if assistance needs to be provided to any swimmer who is experiencing difficulties in the water.
3. Searching for children who have gone missing on the beach.
4. Providing first aid to visitors who have sustained injuries, for instance, while engaging in active sports or due to cuts from glass fragments present in the sand.
5. Monitoring public order on the beach itself - identifying conflicts that require the dispatch of additional patrol units for public order enforcement.
6. The presence of wildlife or pets in the terrestrial and aquatic parts of the swimming area.
7. The presence of fishing nets in the swimming area.

These measures ensure a safe and enjoyable experience for all beach visitors.

PATROLLING THE SWIMMING AREA

At present, the RMP monitor swimmer safety by patrolling with boats near the buoy area. Spending all day in the sun, especially on hot summer days, exposes police officers to the risk of sunburn and heatstroke. A significant risk is also posed by melanoma, which can be promoted by prolonged exposure to the sun, especially on the water, which has a particularly high radiation dose.

The RMP also have separate UAVs under direct operator control, which allow for the observation of swimmers. These UAVs allow for surveillance with both a regular video camera and a thermal camera. However, considering that the flight duration of these UAVs is not long and a pilot is required to operate them, these UAVs are used periodically. Due to staff shortages, lifeguards at the rescue station often do not have the opportunity to continue piloting the UAV if a person with an injury arrives at the station who needs first aid, or a parent who has lost a child. Thus, at this moment, the primary observation of the swimming area is performed by a person with a boat. However, when the person with the boat is on a break, a UAV is used, which can also give audio commands to a person who has swum beyond the buoys. It should also be mentioned that in cases where rescue operations are required, such as pulling a drowning person out of the water or performing resuscitation measures on the shore, all police lifeguards will be involved. Currently, it is not possible to use regular UAVs for the coordination of rescue workers, as the UAV pilot also has to be in the boat and go to sea. In addition, if the UAV is already up, the pilot has to bring it back, which takes a certain amount of time, which can be critical in the case of performing rescue work.

Cases where it is useful to send a UAV with or without employee involvement:

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1. Information has been received that a person needs help in the water and the accident site is not in the lifeguard's field of vision.
2. Information has been received about a missing person with specific characteristics (clothing, swimsuit) and the accident occurred outside the lifeguard's field of vision.
3. When a person is noticed swimming beyond the swimming area boundary - buoys.
4. In case a large crowd of people is observed in a specific place, which could indicate a possible accident.
5. When information has been received about a dead wild animal.
6. When information has been received about an animal in the swimming area that is outside the lifeguard's field of vision.
7. First aid (cut hands, legs).
8. Monitoring of navigation devices so that they do not swim in prohibited areas.
9. When information has been received about a victim who has swum far from the shore, but the accident is outside the swimming area, is not in the lifeguard's field of vision.
10. Received news about an exhibitionist or some other suspicious person or group.

The vessel is sent:

1. It is noticed that the victim in the water needs immediate help (shouting, attracting attention, or drowning).
2. To perform daily patrols.
3. When information has been received or noticed that a person is drowning or has gone underwater in the water part of the swimming area.
4. When a person refuses or ignores the request not to swim beyond the swimming area boundary - buoys.
5. The presence of fishing nets in the swimming area.

Upon receiving information about incidents where immediate action may be necessary, either a boat or an all-terrain vehicle (ATV) will be dispatched in any case. An UAV is necessary for situation verification, clarification, incident location determination, and rescuer coordination.

In situations where the initial information does not indicate the need for an employee to urgently, physically get involved, then a UAV can be sent to clarify the circumstances.

There are situations where, upon receiving information about the need to conduct water rescue operations, circumstances arise that prevent the execution of these operations. In such cases, all available information about the incident is forwarded by the RMP to the Operational Command Centre of the State Fire and Rescue Service, indicating that conditions have arisen in which it is not possible to ensure the execution of rescue operations with the technical resources available to the RMP.

2.3 MEŽAPARKA AND ĶĪŠEZERA TERRITORY

Mežaparks is a beautiful and tranquil neighborhood located in the northern part of Riga, the capital of Latvia. Situated on the shores of Lake Ķīšezers, it was one of the neighborhoods established in the early 20th century and designed as a recreational area for city residents. During the summer, a series of events and festivals take place in the park, including the Latvian Song and Dance Festival, which occurs every five years.

Lake Ķīšezers is the largest lake in Riga and is popular for swimming and surfing throughout the summer and ice fishing in the winter. The lake spans 1730 hectares, with an average depth of 2.4 meters, reaching 4.2 meters at its deepest point. The area around Lake Ķīšezers offers several recreational opportunities, including the Riga Zoo, one of the oldest zoos in Europe, and the Mežaparks Great Bandstand, a popular outdoor concert venue. The amphitheatre hosts the Song Festival, recognized by UNESCO in 2003 as a masterpiece of cultural heritage. These grand events attract

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up to 40,000 singers and dancers, with the number of spectators often exceeding this figure. Access to the Mežaparks Bandstand is possible from three different sides.

Mežaparks offers a wide range of activities, including Newlyweds Hill, a BMX track, Kisezera beach, an adventure park, Mini Golf, an outdoor gym and training ground, a playground for parents and younger children, frisbee golf, sports and leisure equipment rental, and water sports activities. The area around Lake Ķīšezers is known for its extensive infrastructure and range of social activities, making it the healthiest and most diverse recreational area in Riga. Residents and tourists can reach the park by public transport, car, walking, or cycling, with a well-maintained bike path leading to the park for easier access. As a result of COVID-19 restrictions and reduced travel abroad, the number of local vacationers in Latvia has significantly increased, especially in recreational areas near Riga.

The Mežaparks/Ķīšezers area also includes the nature reserve "Jaunciems" - from March 15 to July 1, visitors are prohibited, and throughout the year there are restrictions on vehicle entry. The monitoring of this territory falls under the functions of the municipal police.

Figure 2. Lake Ķīšezers and Mežaparks teritory

2.3.1 Winter

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During winter, certain periods and areas are designated as off-limits for ice activities. During these times, the local government conducts patrols to identify violators of these rules and encourages them to leave the water bodies. The areas are confirmed by an executive order and are currently displayed on Google Maps as a separate layer. However, it is planned to move this to the GeoRiga portal, and accordingly, this layer would be digitally available as soon as it is confirmed. In winter, there are relatively many situations where individuals fail to acknowledge the restrictions (the ice layer tends to shrink rapidly), therefore, prompt control and warning would prevent residents from falling in and consequently, fatal accidents.

In certain cases, underwater anglers need to be urgently rescued as they have fallen into the ice, or their piece of ice is no longer connected to the mainland. In such situations, a rescue team needs to be called. The use of new technologies would allow for surveillance of the incident site and image transmission to rescuers, which would allow the victim to be found faster. In cold weather, even a few minutes delay in finding the exact location can mean a lost life.

Continuous public order monitoring also takes place throughout the year. At the beach and in the water body, public order violations are observed and prevented, as well as previously coordinated public events with the municipality, for example, ice fishing competitions.

There are situations when, upon receiving information about the need to perform rescue operations on the water, conditions have arisen that do not allow the performance of rescue operations. In such cases, all available information about the incident is passed on to the Operational Command Centre of the State Fire and Rescue Service, indicating that such conditions have arisen in which it is not possible to ensure the performance of rescue operations with the technical resources available to the RMP.

2.3.2 Summer

During the summer period, the number of beach users increases, including at unregistered beaches, while in the off-seasons of spring and autumn, shore fishing intensifies.

Shore fishermen

To identify shore fishermen, we currently have to rely on reports or patrol the area with a boat and thermal camera. This is particularly relevant during the night in autumn, summer, and spring. It is desirable to equip UAVs with a thermal camera. If the optics and thermal imaging are powerful, there is no need to fly along the shores while circling the lake’s perimeter, as a powerful thermal camera will “see” the water part of the lake along the shore and the shore section from the middle of the lake.

Control of Prohibited Zones

The nature reserve “Jaunciems” - it is forbidden for people and vessels to be present during the bird nesting period from March 15 to July 1, and there are restrictions on vehicle entry all year round.

March 1 to April 30 - this is the period when fishing from boats is prohibited. In this period any boat is suspicious during night time.

Water Rescue Operations

Individuals or vessels can disappear over water. For instance, a child may be blown deeper into a lake on a mattress, an athlete may be unable to reach the shore of Ķīšezers Lake on their own, or a motorboat’s engine may fail in the middle of Ķīšezers Lake, necessitating the boat and its passengers to be brought ashore. In such cases, an aerial UAV is used to determine the location of the person or vessel.

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Currently, the use of UAVs in Mežaparks during an event only occurs when a decision is made to perform a specific task. These tasks may include:

- Obtaining video footage that characterizes the flow of incoming or outgoing visitors and how congested the access roads to the concert hall in Mežaparks are.
- The need to forecast information about the number of visitors. Partially, forecasts can be based on the event organizer's information about sold tickets, but there are also events in Mežaparks for which tickets are not sold, making it difficult to determine both the demand for public transport and the direction of evacuation routes.
- Observing event safety from a distance, without interfering with the competition with a police vessel, in case public events take place on the water, for example, sailing competitions.
- Identifying potential illegal UAVs and their operators before safety regulations are violated, responding to radar surveillance system reports about airspace violations.
- Identifying/checking information about suspicious movement of a person or vehicle.

Above the event venue itself (Mežaparks stage), RVPP avoids flying, in accordance with current regulations.

From the official swimming area's drowning rescue point of view, a UAV is not the only solution as monitoring cameras with a stream are currently used for monitoring needs. Potentially, the video stream from monitoring cameras could also be automated. However, it should be noted that in the unofficial swimming areas in the territory of Ķīšezers Lake, where people regularly relax, such video surveillance cameras are not installed.

There are situations when, upon receiving information about the need to perform rescue operations on the water, conditions have arisen that do not allow the performance of rescue operations. In such cases, all available information about the incident is passed on to the Operational Command Centre of the State Fire and Rescue Service , indicating that such conditions have arisen in which it is not possible to ensure the performance of rescue operations with the technical resources available to the RMP.

Continuous public order monitoring also takes place throughout the year. At the beach and in the water body, public order violations are observed and prevented, as well as previously coordinated public events with the municipality, for example, ice fishing competitions.

There are situations when, upon receiving information about the need to perform rescue operations on the water, conditions have arisen that do not allow the performance of rescue operations. In such cases, all available information about the incident is passed on to the Operational Command Centre of the State Fire and Rescue Service, indicating that such conditions have arisen in which it is not possible to ensure the performance of rescue operations with the technical resources available to the RMP.

2.4 TORINO TERRITORY

2.4.1 Geomorphological introduction

From a morphological point of view, the territory of the City, which covers a surface area of just over 130 square kilometers, is located in the central-eastern part of the territory of the homonymous Metropolitan City, where the Alpine margin, at the easternmost foothills of the Susa Valley, approaches the edges of the Torino Hills, determining a "constriction" of the Piedmont plain. This constriction separates the higher areas of the Po Valley, which extend towards the Cuneo area, from the increasingly extensive flat area that opens towards Lombardy and Emilia from the capital of Savoy. The physical-environmental configuration of the Torino territory thus appears sharply distinct in two areas, separated by the River Po: a large predominantly flat area and a narrower, elongated hilly area. Therefore, most of the City's territory consists of a slightly sloping plain, gradually sloping from west to east, with a drop of about 60 meters

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from the border with the Municipality of Collegno to the River Po. The city centre is thus located at an average altitude of 239 meters above sea level of the Municipal Palace and has developed over the centuries in the area between the confluence of the Dora Riparia with the River Po, east of which extends the hilly strip formed by the Torino Hills, which delimit its eastern boundaries; the hilly front then extends northeast for about thirty kilometers, along the southern edge of the western Po Valley between Moncalieri and Chivasso, then seamlessly connecting with the hills of Asti and Monferrato. The plain area, covering approximately 10,000 hectares, has altitudes ranging from 200 to 240 meters above sea level and mainly presents a sub-flat morphology with a slight slope towards the east and northeast, while the hilly front east of the plain, has a narrower width, equal to over 2,900 hectares, but it is the part of the municipal territory that reaches the highest altitudes, with elevations ranging from 716 meters above sea level at Bric della Maddalena, 710 meters above sea level at the nearby Bric della Croce, 672 meters above sea level at the Basilica of Superga, 583 meters above sea level at Bric del Vaj, and 624 meters above sea level at Bric di San Vito. A characteristic of Torino is therefore the presence of four main watercourses, which have marked its history and development over the centuries: the River Po, the longest river in Italy, which marks the eastern border of the original city and today of the historic centre, the River Dora Riparia, which descends from the Susa Valley and crosses the city territory from west to east, and which had the greatest influence on the industrial development of Torino from the mid-1800s to the post-war period. The other two tributary rivers of the Po, the Stura di Lanzo and the Sangone, approximately delimit the northern and southern boundaries of the City, in historically agricultural areas, where the river waters have been mainly exploited for irrigation purposes and less as an energy source for industrial uses. Currently, the municipal territory is heavily urbanized, so most of the surface area (about 80 square kilometers) is destined for anthropic uses (residential areas, roads, infrastructure, and services related to human use), while the rest is public and private green space, agricultural land, and woodland (about 50 square kilometers). The wooded area, concentrated almost entirely in the hilly territory, covers approximately 1,064 hectares, while the agricultural area is just under 700 hectares, mostly located on the southwest and north outskirts of the municipal territory.

From a geological-structural point of view, the ensemble of reliefs forming the Torino hills can be considered a singular dynamic sedimentary complex: in a word, a mass of sedimentary layers hundreds of meters thick, of the most varied nature (from clayey particles to multi-meter boulders) folded, mutually displaced, and still imperceptibly moving. To a specialist eye, there are hundreds of indications of structural discontinuities, expressions of fracture planes or faults. In extreme synthesis, the hilly territory corresponding to the Torino district is formed by a superposition of sedimentary deposits, of marine or terrigenous origin, extremely heterogeneous in nature, lithology, compactness, powerful in total several hundred meters; they were deposited over a period of time ranging from Oligo-Miocene to Pleistocene, or over a span of 45 million years. The deposits, especially the clastic ones (sandstones and conglomerates: often in altered form or colluvial, therefore sands, gravels, and boulders) come from the valleys of the western Alpine chain, during its formation and migration westward, through a long and tormented history of overthrusts and folds imposed by the migration of deep slabs. Such paroxysmal manifestations occurred over a period corresponding to the last 3-5 million years and evidently continue to this day. The arrangement of these rocks would be tabular or concave in a static evolutionary model. In reality, even the floors of the ancient Oligo-Miocene and Pliocene Padan Sea have been and are still involved in the crustal movements that characterize the Italian peninsula as well as other areas of the Mediterranean. Like the Alpine system, so too the reliefs of the Hill and the buried structures in the subsoil of the Po plain reflect an evolutionary style of overthrusts, subductions, and reciprocal roto-translational movements (strike-slip faults, direct and reverse). What is seen today is the most evident and elevated portion of the ensemble of deposits, which in extreme simplification can be represented as a large anticlinal fold with decidedly asymmetric flanks: the one towards the Po (where, among other things, the majority of settlements are located) with a strong or very strong inclination (40-70° slope) and the southern one with gradually gentler inclination. In practical terms, this heterogeneity, if not chaotic nature of lithologies and structural arrangements, can translate into an almost generalized situation of endemic 'fragility' of the hilly territory.

To all these natural components, elements conditioning stability, primarily and exclusively, represented by modern buildings and related infrastructure, must be added. Starting from the 1900s, the first hill paths began to develop, and a funicular was built connecting the city to the Basilica of Superga. During World War II, numerous woods

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were cut down, and in the 1950s and 1970s, new urbanizations affected the most beautiful areas. This phenomenon has led to further hydrogeological instability, profound alteration of the landscape and natural heritage, a reduction in both natural vegetation and public use of numerous hilly areas. Furthermore, the progressive decrease in timber uses has led to the abandonment of many wooded areas (Robinia coppices) that are deteriorating due to the numerous falls to which this species is subject, worsened by the invasion of Blackberry and Old Man's Beard that tangle around the plants and shrubs and cause thinning. In addition, in some areas once cultivated, the expansion of shrub and tree vegetation, especially near old abandoned farmhouses, has progressively colonized areas once used as meadows or orchards, forming the so-called "invasion forests." In practical terms, it appears necessary to intervene rapidly to restore the woods to acceptable conditions, providing for a planned "cleaning" of the undergrowth to prevent fires and gradually converting the old coppices into high forests, contributing to preventing hydrogeological instability and halting degradation.

The high complexity of the problem of assessing risk conditions induced by natural events in urbanized areas in hilly terrain is strongly conditioned not only by local geo-morphology but also by the high level of urbanization that, especially in the past, has been poorly guided by strict urban planning criteria compatible with the geomorphological context of the area. Thus, the current technical problem is articulated in two aspects: on one hand, the assessment of phenomena concerning the ongoing evolution (morphological, climatic, land use), and on the other hand, the protection of existing structures, even when construction is clearly in unsuitable or geologically "critical" areas. Regarding the geographical distribution of phenomena, a high percentage of them are present near the hydrographic network and in the steepest areas. The hills of Torino represent a particularly critical case concerning the concentration of phenomena compared to the hilly areas of neighbouring municipalities; in the latter, due to the smaller extent of urbanization and in some cases a less unfavourable geomorphological situation, areas historically prone to instability are decidedly less extensive and frequent than in the Torino area.

2.4.2 Updated cartography of the hillside

Figure 3. Raster image of the hillside 2010

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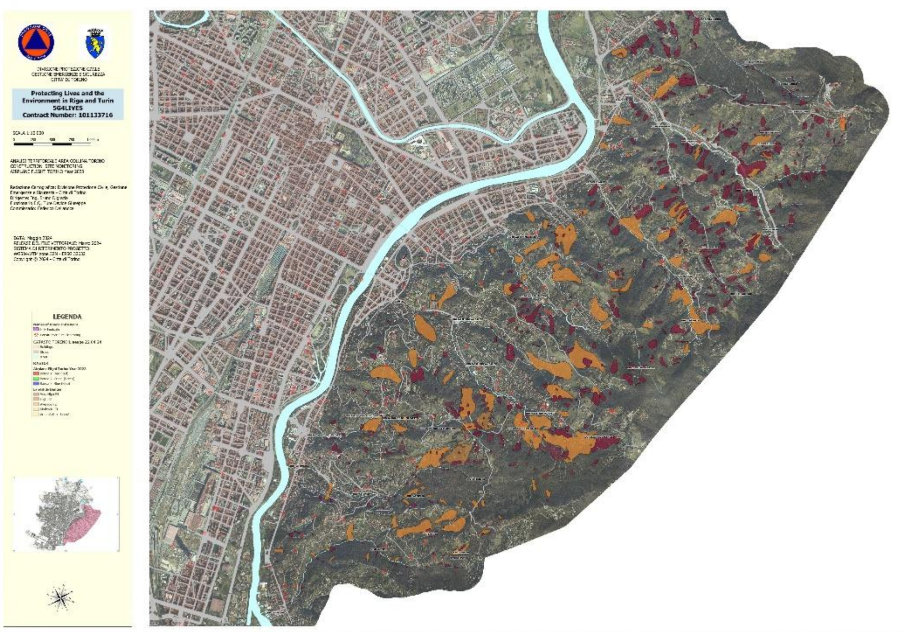

Figure 4. Raster image of the hillside 2023

Figure 5. Construction sites on the hillside 2023

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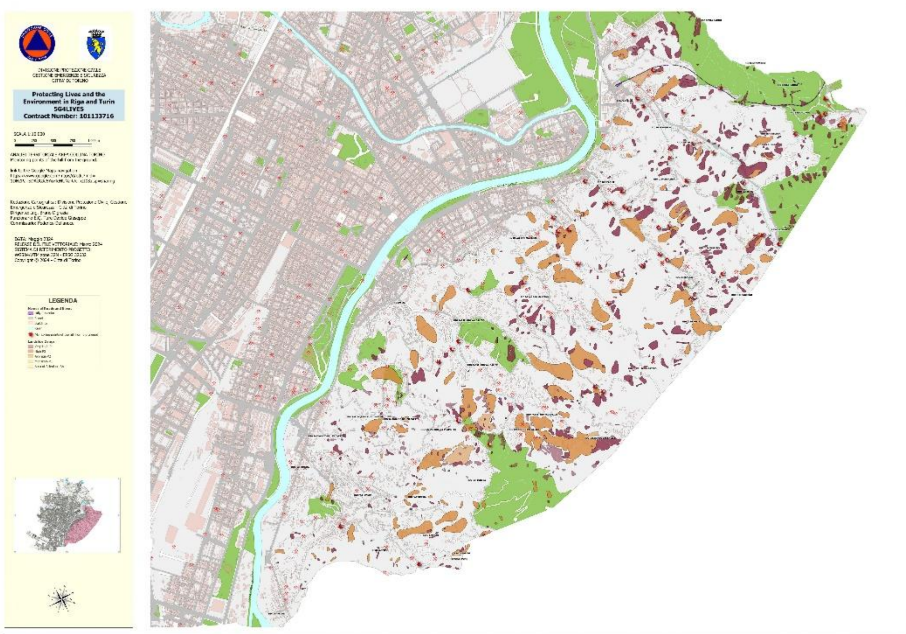

Figure 6. Ground monitoring points and consturction sites on the hillside 2023

2.4.3 Google Maps: interactive navigation of the area

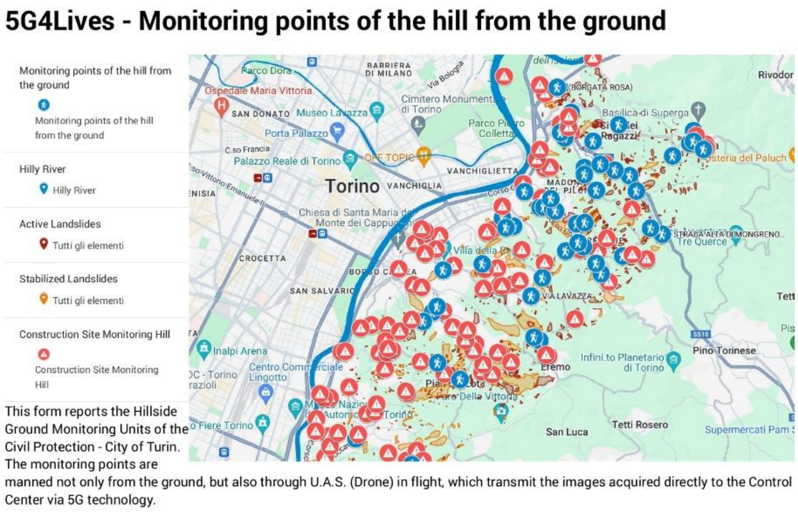

Figure 7. Example of Google Maps representation of the area[1]

2.4.4 Risk analysis of the area

To introduce the part concerning risk analysis, it is necessary to start from the physical-environmental configuration of the Torino territory depicted above, which appears clearly distinguished into two areas, separated by the Po River, namely a wide predominantly flat area, with a slight sloping gradient from west to east, and a hilly strip, narrower and elongated, which extends in the eastern area of the Municipality for about thirty kilometres, then connecting seamlessly with the central Piedmont hills. Another important characteristic of Torino is the presence of the

[1]Google maps 2024, *5G4LIVES - Monitoring points of the hill from the ground*, Google, accessed 5 April 2024, <https://www.google.com/maps/d/u/0/viewer?mid=1zvhYIHCEnpABe0IP8CukH0A8oymQOlE&hl=it&ll=45.053762929433105%2C7.727517331589149&z=13>

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already mentioned four main watercourses (the Po River, the Dora Riparia River, the Stura di Lanzo Stream, and the Sangone Stream), as well as a considerable number of smaller streams, right tributaries of the Po, which mainly flow in the hilly area. The strong anthropization and urbanization of the territory for most of its surface (about 80 square kilometres) represent an important feature for risk analysis, as well as the wooded area of over 1000 hectares concentrated almost entirely in the hilly territory. Starting from these territorial characteristics, we can summarize that the multiplicity of potential risks present embraces both those of natural origin, connected to the territorial morphology, and those of anthropic nature, directly related to human presence and its activities.

In hilly areas, the main causes of risk are often due to the difficult morphological conditions of the territory, such as the gradient of the slopes, the shape of the valleys, and the predominantly torrential hydrography, which certainly constitute some of the most significant natural elements that generate the onset of a possible risk situation. The plain, on the other hand, is subject to all the risks related to the fluvial dynamics of the large watercourses. It should also be noted the significant exploitation of such territories from a settlement point of view, which historically characterized the City, significantly affecting aspects related to risks linked to human presence, which is widely distributed throughout the territory. In densely populated areas, moreover, the impact of transport infrastructures is always very significant, with consequent risk phenomena connected to them, but also the presence of industrial and craft settlements is a potential source of dangers for the territory and the environment.

SPECIFIC NATURAL RISKS

The municipal territory of the City of Torino is therefore burdened by all the typical problems of hilly areas and alluvial plain areas, and for this reason, it fully represents the situation just described. From the point of view of risks of natural origin, hydrogeological and hydraulic risk is certainly the most relevant and widespread in the area under study. The flood events of 1994 and 2000, but also the more recent ones in 2008 and 2016 that affected Piedmont, were among the most damaging of all those recorded over the centuries, with very significant repercussions on the territorial, economic, and social system: even in this area, flood events have left significant signs of their passage. In this context, moreover, the presence of the Po River and also of the other various watercourses of greater and lesser importance that cross the municipal territory represent the main source of danger, especially for the inconvenience that the rise in the level of the main watercourses or the sudden modification of the regime of the smaller streams can cause in different municipal hilly areas.

The main areas of flood risk mainly affect the areas along the Po River and the Dora Riparia, which morphologically extend from west to east: the danger can come mainly from the west and south, due to possible floods, which upstream of the City collect water from the wide basins of the Cuneo area, the Pellice and Chisone Valleys, and the Susa Valley: for these reasons, it is important to note how flood events have a significant impact on the territory of Torino, since the expansion area of the river waters also affects inhabited and urbanized areas as well as the city's road network. In general, therefore, it is estimated that the foreseeable impact of hydraulic risk on the territory of the City of Torino can be high.

Being characterized by the presence of an extensive hilly area, other potential risks due to natural events can be represented by the risk of landslides and geomorphological instability. The analyses related to the events of recent decades confirm that even the dynamics of the smaller streams are still a cause for concern for the hilly areas and can cause problems and localized damage to the inhabited areas and the road network, although certainly far from the potential and destructive ones of the major watercourses. For the hydrogeological risk, this impact is therefore also judged to be high: in fact, there are numerous areas subject to possible landslides and landslides on the municipal territory, which can affect inhabited settlements and the road network connecting them to the plain area of the City. In this context, the General Regulatory Plan of the City of Torino has mapped 648 active landslides, 101 stabilized landslides and 206 linear landslides - the latter contributing to increased threat level of floods.

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In the panorama of risks of natural origin, it is important to mention, as increasingly recorded in recent years, the risk linked to exceptional meteorological events in different seasons (particularly violent and sudden thunderstorms, strong winds, intense low-altitude snowfalls, drought phenomena, and heatwaves in the summer months): these characteristics are certainly intrinsic to the geographical position of a location like Torino, which is located on the edge of the great plain but strongly affected by the proximity of the Alpine arc on one side and the Piedmont hills on the other. Given the continuous succession of this type of events in various areas of Piedmont and Torino with increasingly high intensity, the impact of exceptional meteorological events has been attributed a medium/high level. In fact, phenomena of particularly intense and localized nature are increasingly occurring even in these areas (where historically meteorological events have always been directly linked and influenced by the seasons), even in periods of the year not directly connected to seasonality.

SPECIFIC ANTHROPIC RISKS

In the study area, we can still mention the risk of forest fires. The presence of vast wooded areas in the municipal hilly area certainly represents an important potential triggering element for this risk. From the available information, in fact, in recent decades the problem appears to be very circumscribed and attributable to a few events of slight entity in areas adjacent to the city territory in other Municipalities. Often such potential events can be linked to specific episodes of ignition of small fires for the destruction of brushwood and residues of agricultural production, or to superficial behaviours and distractions by citizens, which can cause small outbreaks in periods of drought and drying of vegetative masses. In any case, it is necessary to consider the considerable potential danger of the phenomenon linked to the presence of woods very close to the inhabited settlements in the hilly area of the Municipality, as well as the possible involvement of local roads in case of widespread fires: for these reasons, a potential medium impact for this type of risk appears reasonable.

Therefore, based on the considerations outlined above, the emergency situations that will be taken Into account in the two scenarios can be connected to the following types of risks:

Natural-origin events:

1. Hydraulic risk (river overflow, flood events).
2. Hydrogeological risk (landslide phenomena, landslides and collapses linked to slope, river, and torrential dynamics).
3. Risk linked to exceptional meteorological events (heavy rainfall and snowfall, thunderstorms, strong winds and tornadoes, hot and cold thermal anomalies).

Events of anthropic origin:

1. Fire risk (forest or urban fires of large proportions with collapses of buildings and structures).

In conclusion, forecasting and managing extreme weather events and anthropic risks on the hillside are vital for the safety of the urban area of Torino. The implementation of nowcasting tools and improving civil protection planning can help mitigate the negative effects of extreme phenomena.

The pictures below show the areas of the hillside that are subjected to landslides and fires.

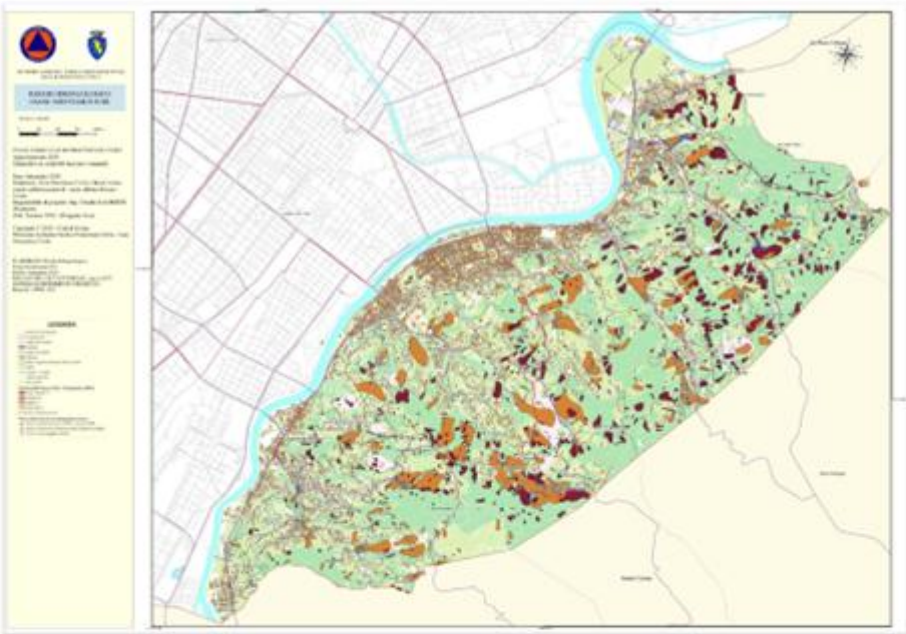

Figure 8. Areas of the hillside subject to landslides

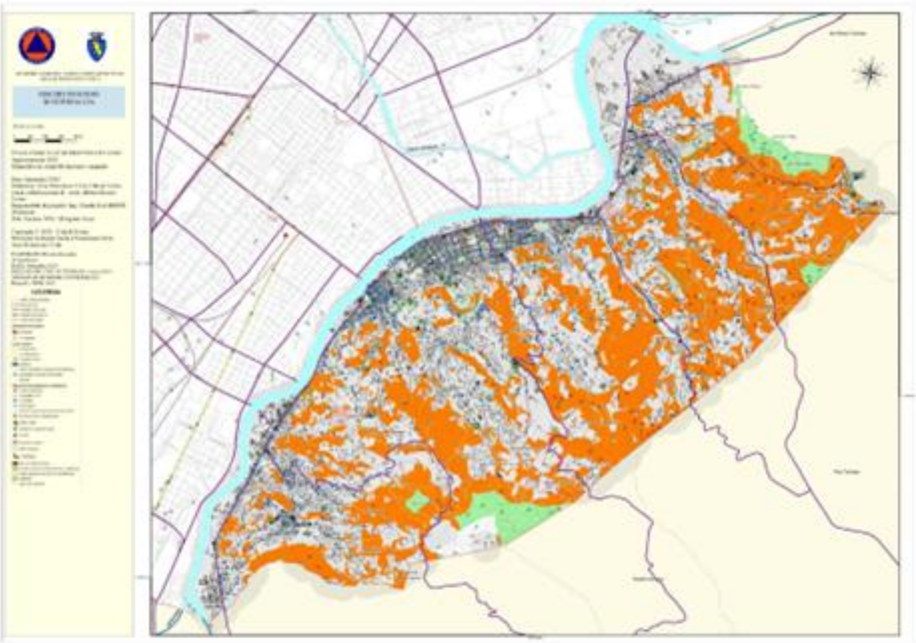

Figure 9. Areas of the hillside subject to fires

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3. DESCRIPTION OF PILOTED SOLUTIONS AND TECHNOLOGIES

To reduce the potential for human error and help with situation awareness, the lifeguards are using UAVs that are manually piloted by one of the lifeguards. However, this approach still involves significant human involvement, which will be critical in emergency situations where every lifeguard needs to be available for rescue operations. To address this issue, the 5G4LIVES project will implement a UAV solution that can reduce human involvement in public beach area surveillance.

The project aims to operate a fleet of UAVs as Beyond Visual Line of Sight (BVLOS) flights in a dynamic, complex, populated environment, using native communication infrastructure with safety and cybersecurity considerations. The system will provide a fleet of UAVs with a high availability level, ready to execute a mission on demand. The described three territory stations will be equipped with two UAV solutions, each consisting of a UAV, network remote ID, payload (camera), and docking station (UAV-box). The docking stations will be installed on existing infrastructures, such as roofs, and will be used to store, protect, and recharge the UAVs. The UAVs and docking stations will cooperate to open/close the roof and start/stop recharging. The UAVs will operate in a special UAV zone, which will be defined for each area to increase air, ground, and operation safety. Each area will be under continuous surveillance, with peak periods during the summer when warm weather attracts people to public beaches for sunbathing and swimming and during the winter when freezing lakes and the sea attract people to do winter sports like skating and ice fishing.

Cellular connectivity, particularly 5G, will be used as the primary communication channel to control the UAVs and send/receive live video feed. Network availability forecast solution will be used to increase flight safety by network availability prediction and almost real-time information. UAVs pilots will be able to create and launch automatic UAV missions to perform regular area surveillance with POI (point of interest). Each use case has different goals to achieve and different restrictions or limitations due to geographical and regulatory aspects, hence, each use case will be looked upon separately.

3.1 RIGA USE CASE

The goal of the piloted solutions is to make life-saving operations more efficient and relieve rescuers from procedures that can currently be digitized. From the description of the use-case from interviews with stakeholders and actors, it is possible to identify areas and improvement processes that are associated with the use of UAVs and specific technological improvements that are viable with better cellular connectivity and user-specific programming. This is shown in table 1 below.

Table 1. Improvement processes based on identified difficulties

Problem/ Difficulties	Solution	Enabling technologies
Limited personnel for UAV management	Automation and semi-automation of UAV operation	- 5G Network - Unmanned Traffic Management (UTM) tools and systems - Mission planning and control software - UAV with 5G and BVLOS capabilities - Software and applications based procedures and processes - Monitoring hardware with 5G capability - AI-based components for automation of data processing
Need for quick and accurate interpretation of information received from UAV	Data processing and postprocessing with appropriate visualization	- 5G Network - Image processing - Tools for information receiving and processing with 5G capabilities - High resolution cameras and sensors with 5G network transmission capabilities

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		- Gimbal with capability to send online axis position data - AI-based components for automation of data processing - User-centric interface
Need for information retrieval during nighttime	Data processing and postprocessing with appropriate visualization	- 5G Network - Image processing - Night vision capabilities camera
Contactless Ice condition measurement	Special payload equipment installed into UAV for automated measurement	- 5G Network - Radar-based technologies - Sonar-based technologies
Need to provide audio information close to objects	Special payload equipment installed into UAV for voice command repeated (online / recorded)	- 5G network - Loudspeaker installed into payload / UAV
Need for geolocation parameters of objects	Special hardware / software integrated into UAV sensors and systems	- Gimbal with capability to send online axis position data - 5G Network
Need for quick deployment of UAVs	Automatization and digitalization of components and processes	- Doc-station with platform support automation - Digitalization of procedures and operations - Near real-time data flow and processing
Large surveillance area	UAV performance, UAV operation / management	

3.1.1 Goal

The primary objective of the described scenarios is to facilitate Beyond Visual Line of Sight (BVLOS) applications, which involve extended-range missions where the UAV operator lacks direct visual contact with the UAV. BVLOS operations unlock one of the important case UAV applications with significant identified improvements, such as autonomous operation. To address this challenge and unlock commercial potential, several key elements must be ensured:

1. Comprehensive awareness of air traffic near the UAV, both during the planning and flight phases.
2. Ensuring BVLOS flight sustainable capability in all operations phases.
3. Remote, near real-time command and control of the UAV, managed by automated systems, human operators, or a combination of both.
4. Seamless communication with relevant Air Navigation Service Providers (ANSPs) to provide real-time mission status updates and enable emergency interventions when applicable.
5. Establishment of predefined protocols or contingency measures to guide the UAV's actions in case of anticipated or unforeseen emergencies.

To meet these requirements throughout the entire flight duration, the UAV 's telemetry must be transmitted in almost near real-time with high accuracy and precision. Leveraging 5G technology, which offers features such as network slicing and mobile Edge Computing (MEC), holds promise in meeting these connectivity needs. Additional requirements to be considered:

1. Adapting existing UAS operations to seamlessly integrate with 5G networks across various stages of a mission is essential.
2. Planning and route definition considering mobile network coverage and performance requirements from the 5G network.
3. Validation by assessment of the feasibility of meeting UAV operator needs concerning coverage, infrastructure, functionality, and capacity of the 5G4LIVES platform.

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4. Execution activities with proactive monitoring of ongoing missions to ensure adherence to plans and effective management of emergencies, including temporary or permanent loss of radio connection with the serving 5G base station.
5. Post-flight analysis, with continuous refinement of procedures and systems based on insights gathered from mission outcomes.

Scenario directly addresses to ensure the following KPIs of the 5G4LIVES platform:

1. Reduction in response time;
2. UAV deployment rate;
3. Operation success rate;
4. Decision-making time.

3.1.2 Operational Environment

The direct operational environment is based in the Kisezers and Vecaki locations, and RCC UFCC locations are based outside of the operational environment. The number of UAVs – 2 for each operational location.

UAVs are stored at special dock stations in specially organized areas in Locations. Docking stations support the ability to monitor the condition of UAVs, and batteries, and provide battery replacement. Information about the UAV's condition and readiness for operation is remotely available for operator checking at FCC. Docking stations are located directly at the locations, on the territory of rescue stations, have protection against weather conditions and damage, as well as lighting (signaling), and are fenced to restrict access to unauthorized persons. Docking stations support the use of green energy sources for recharging UAV batteries, such as solar panels and hydrogen power elements.

To perform monitoring using UAVs, there is a reserved airspace zone secured by the NOTAM, to exclude the possibility of operating manned aircraft and UAVs that are not part of the 5G4LIVES platform in the location.

Monitoring with UAVs is automatically carried out according to a predetermined schedule during daylight and night hours. In Figures 8, 9 and 10 the detailed flight plans are shown.

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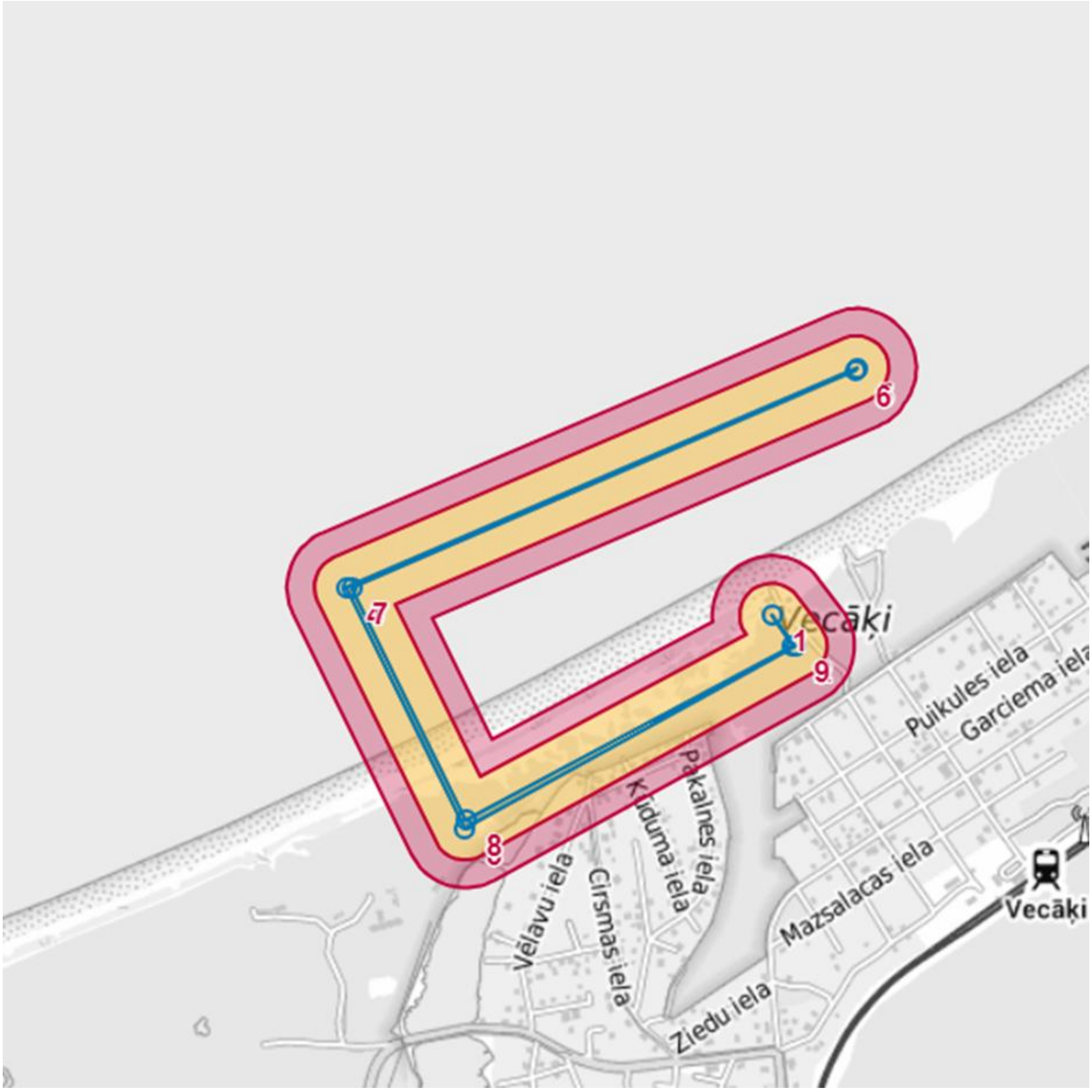

Figure 10. Vecāķu flight plan

Vecāķu flight plan is the only Latvian flight plan that does not create a visible square area, but the drown is flown in more of a specific straightened route that is repeated on the way back to the starting point of the operation.

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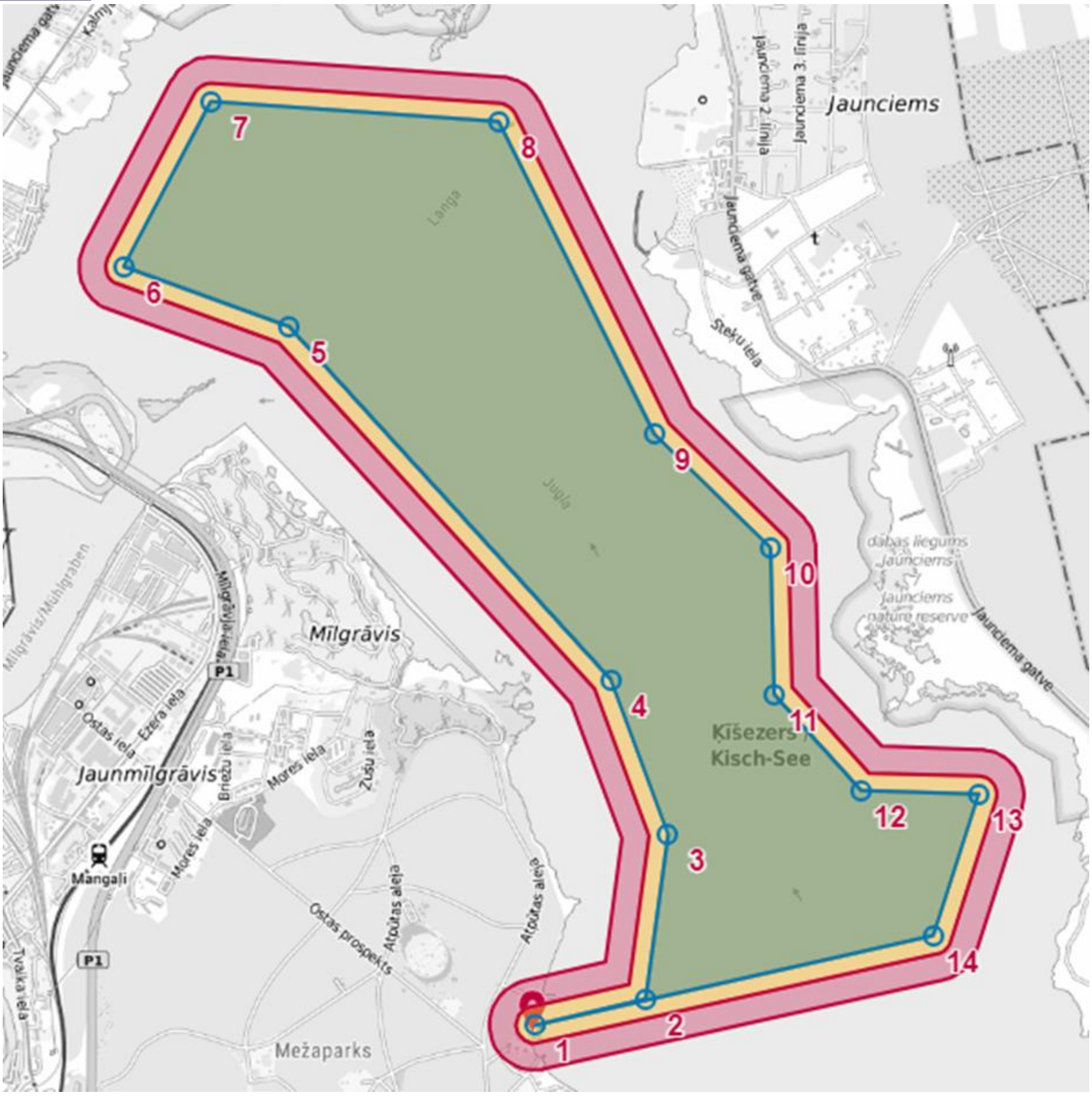

Figure 11. Ķīšezers flight plan towards Jaunciems

Ķīšezers flight plans are divided in two versions, since it is such a large body of water. The first flight plan is concentrated with the direction towards the neighbourhood of Jaunciems. Which from the two flight plans is covering most of the area space in Kīšezers. The other flight plans is directed toward Jugla which is depicted below.

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Figure 12. Ķīšezers flight plan towards Jugla

Even though the area to cover by the UAV is smaller, this particular flight zone might be even harder to patrol without a UAV than the other area of Ķīšezers. This is the result of the recreational opportunities provided in Mežaparks which has a large amount of citizen visitors each day.

3.1.3 From the unmanned aviation point of view

In the locations, specially reserved zones are designated for operations, prohibiting manned aviation flights. In each location, 2 UAS operate, centralized, and managed by the FCC. FCC operators maintain communication with municipal police and rescue officers, both mobile and radio, which provides their supporting tools with the proper situational awareness to fulfill their tasks. All operations phases are performed in BVLOS conditions.

3.1.4 5G4LIVES platform

The 5G4LIVES operations environment and platform are fully integrated at the Locations. The operating zones of 5G4LIVES are limited by the special reserved operating zone and limited vertically, in accordance with the maximum specified operating altitude in the specific geozone. 5G network coverage is provided in the operating area of the 5G4LIVES platform, with stable necessary parameters, performance, and appropriate coverage.

3.1.5 Coordination of operation

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FCC controls and manages operations at the Locations. FCC has 2 operators of the 5G4LIVES platform - 1 Main Remote Pilot, managing UAV's and related systems, and 1 Remote Pilot, monitoring and coordinating information received from UAV's. An Operation Supervisor may also be involved – a person coordinating management at the FCC, making decisions on engaging related bodies in case of the need for response in the locations and coordinating all involved parties who are users of the 5G4LIVES platform information. Depending on the situation and the ability to meet the requirements, this role can be performed by Remote Pilots, provided they have the appropriate clearances. All operations in FCC are conducted in accordance with the Operations Manual (OM), which outlines all the necessary procedures for operation.

Basic operating scenarios are stored in the 5G4LIVES platform, and according to the schedule or specific operation call, the Remote Pilot selects a scenario, ensures the possibility of operation according to the checklists and OM, and activates the scenario. When activating the scenario, special tools supporting BVLOS capability components check operational-specific parameters. Tactical corrections to the saved operating route and other flight parameters can be made based on the responses received from the 5G4LIVES platform tools. Thanks to the platform's automation and special tools, checking, tuning, and activating the scenario takes minutes.

3.1.6 Assumptions

All UAS operations are entirely within specially reserved airspace. Therefore, no intervention from other Stakeholders or Actors, except the FCC is required.

1. All UAS operating within the 5G4LIVES platform meet specified operating requirements and are fully connected to all required services and network components.
2. ANSP / CAA Units can give some restrictions to operations in case of high-priority other operations in a designated zone.
3. All UAS operations, that are entirely within special reserved airspace are in charge of the FCC. Therefore, no intervention from a human Location actor is directly required.
4. The 5G4LIVES environment (routes and operation specification) assures that all UAS operations are de-conflicted.
5. All operations at all phases are conducted by the OM.

SCENARIO HIGH-LEVEL DESCRIPTION

Monitoring is carried out during daylight and night hours, with a specified number of operations per period. The activates the scenario according to the schedule or on demand, and the following components of the 5G4LIVES platform are activated:

1. UAS GCS .
2. BVLOS Capability support tools.
3. UAS Dock-station systems.
4. UAS Platform.
5. Network UAS ID broadcasting.
6. Operations management software platform.
7. Tools and components with AI and automatization capabilities.

The Remote Pilot acts according to OM procedures. The scenario's saved settings include a flight plan, including takeoff, exit after takeoff to the operating area, flight along the specified route covering the specific mission area, orientation of UAV monitoring systems for effective coverage of the observation area, specified speed and altitude of flight, return to the docking station, landing.

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Critical procedures and activities at all operational phases are digitized, including the ability to use a digital checklist, information provision services in a centralized user- interface, UAV fleet and Remote Pilots management, post-flight information services, etc.

In the FCC, all data from all devices and systems (air, ground, marine level) connected and acting in the 5G4LIVES platform are transmitted via the 5G network. Platform automation components, according to the activated specified scenario, process the received data in real time (determining the number of people and other parameters included in the specific scenario) and output the processed information to the corresponding 5G4LIVES user interface.

By the centralized information flow in the FCC, obtained from UAV sensors and other sources (ground and marine, mobile, and stationary), the 5G4LIVES platform operator can assess the situation at the location from various parameters at any given moment. This, along with automated data processing (for relevant use cases), allows for quick decision-making. The 5G4LIVES platform ensures connectivity such that Users acting directly on the Location (municipal police and rescuers) also receive visual and other necessary information on mobile devices in real time. This synchronizes situational awareness across all platform Users, ensuring coordinated and consistent actions during relevant operations and services.

From all the listed difficulties the introduction of the new solution will bring rescue operation based improvements. The solutions involve the use of automated UAVs, a real-time video stream equipped with both thermal and video cameras, so it can be used during both the light and dark hours of the day, which will be sent to the RMP video management system and shared with an AI-based support service that computes and gives results, sends notifications based on pre-programmed tasks from which RMP officers can react in real time very fast with the added speakers to give remote commands to swimmers throughout the UAV. The pre-programmed tasks are as follows:

1. 5G and UAVs are important for locating people in the water after accidents because they allow for real-time data transmission and remote monitoring of the search area. UAVs will be used to survey large areas of water quickly and accurately, while 5G connectivity enables the transmission of high-quality video and other data from the UAVs to search and rescue teams.
2. 5G and UAVs are important for locating people on ice during periods of ice restriction because they provide a safe and efficient means of surveying the search area. UAVs will be equipped with thermal imaging cameras to detect body heat, and 5G connectivity enables real-time transmission of data and images to search and rescue teams.
3. 5G and UAVs are important for locating people in a specific area because they can provide a bird'seye view of the search area and help search teams identify potential hiding places or hazards. UAVs will be equipped with high-resolution cameras and other sensors to gather data, and 5G connectivity enables real-time transmission of data and images to search and rescue teams.
4. 5G and UAVs are important for locating people and vessels in a specific area because they can cover large search areas quickly and accurately. UAVs will be equipped with specialized sensors such as sonar to detect underwater objects, and 5G connectivity enables real-time transmission of data and images to search and rescue teams.
5. 5G and UAVs will be important for searching for people based on specific appearance/characteristics because they can provide an aerial view of the search area and help search teams identify potential matches. UAVs will be equipped with high-resolution cameras and other sensors to gather data, and 5G connectivity enables real-time transmission of data and images to search and rescue teams for analysis.

The existing rescue stations in Ķīšezerā and Vecāķi will be used as UAV base stations, where UAV dock stations will be installed, hence, RMP will act as owners of the UAV operation zone and will have the authority to coordinate UAV flights. The use case flight demonstrations are planned during cold and warm seasons, with subsequent verification and evaluation. From all the scenarios and described opportunities the Project team followed the stakeholder's opinion to select the possible best solutions that might bring the most benefits of improving emergency response and increasing public safety.

3.1.7 Warm weather

UAV flights will be tested in the Vecaku Beach aquatory during the active bathing period, which spans from the 15th of May to the 15th of September. These flights will occur between 07:00 and 23:00. Outside of this time frame, the UAV will only be used for specific observations when necessary. The rescue officers are present at the location from 10:00 to 22:00. Outside of these hours, the Flight Control Center (FCC) will relay information to nearby patrols. The tests will provide insight into: 1) the utilization of various operations within a single flight; 2) the flight's distance and signal strength; 3) the integration of artificial intelligence. Modifications to the flight plan will be made after the testing procedure.

Two flight plans will undergo testing at Kisezers lake. During the time of mild weather (April to October), the initial flight will be directed towards the Jugla destination, followed by a second trip to the Jaunciems destination. Every flight will occur parallel to the coastline to identify individuals and vessels engaged in swimming activities. The testing will determine the ideal distance of flight to the shoreline for optimal identification of a boat and a swimming individual. In Section 2.1, where the scenarios of the rescue operation are described, it can be emphasized that during the testing process, information will be collected and several scenarios will be tested simultaneously - for example, evaluating various information from the video to ensure observation process for RMP.

Observation in warm weather

One of these processes is patrolling the swimming area in Vecāķi to maintain public order and compliance with safety measures on beaches and water. The technical implementation would be as follows - the UAV reaches the patrolling territory (above the water surface) by moving over areas where there is no active gathering (above the trees and crossing the sandy beach area at a safe distance from the rescue station). Then it moves over the water behind the buoys and uses video mode. During daylight hours, the UAV can patrol the swimming area above the water. Continuous video data transmission to the control centre or operator. There, continuous video material analysis takes place to identify objects that are in an area where they should not be. The solution allows for the independent identification of floating objects in an area that is outside the permitted swimming area, further signalling to the rescuers. Rescuers react according to the protocol that has been in place so far, identifying reckless swimmers.

The same can be done during public events in Vecāķi. During the event, supporting operations would be for searching for missing persons or identifying special objects in video objects. As well as patrolling the prohibition in Kīšezers. This would be done during daylight hours, the UAV can patrol by flying over long prohibition zones, visually identifying or using a thermal camera to identify objects that are in the territory. The received video data is continuously analysed, identifying moving objects that would be prohibited from being there. Further on, the additional use-case scenario in Ķīšezers would be monitoring and patrolling fishermen.

The result of this task is the timely identification of irregularities and violations, their preventive prevention, while reducing the involvement of the required number of personnel. Since there may be an increased number of visitors near the waters in the summer, which is also shown by the above data, then observation and monitoring with the help of safe and stable 5G coverage and UAV can significantly reduce the number of various deaths in this type of public and visited places.

Rescue operations in warm weather

During the monitoring process, it is necessary to identify people and boating tools. If individuals or boating tools are in a crisis situation (blown deep into the water on a mattress, lost strength and called for additional help, a drowned

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boat), then the UAV is involved as the first object search option. Automated flights can be used to pinpoint the exact location of people, objects, fishermen, and their boats in the territories and support the further action of the rescuers.

In certain situations (if technical solutions will be available), specialized sensors, for example, light sensors can be used to fix objects under water and pass this information to rescue teams, thus allowing faster identification of the objects being searched for. Such a need would be to search for objects underwater ((drowned person, drowned boating tool, car submerged in water (for example, broke under the ice in winter or drove into the river from the promenade), searching for evidence underwater (for example, contraband) etc. – currently, this is physically done by divers. In this case, as a support tool for work optimization (not for complete replacement), a water drone could be used, which is equipped with an underwater camera, thermal camera, powerful sonars, etc. to speed up the determination of the precise search location.

In situations when personnel go on a rescue operation in a crisis situation, then the team has radios with them, which would allow communication with the video surveillance centre, which could also provide additional instructions, based on the information available from the video image. As indicated by police officers involved in rescue work, often determining the exact location of the incident is a big challenge, therefore the functionality, when the accident location continues to keep in the visibility zone, is also important when developing system architecture solutions.

At the Ķīšezers rescue station swimming area, it is also possible to pilot the monitoring of swimmers, as there are practically no waves there and the number of swimmers is relatively small. Therefore, it is possible to develop computer vision solutions (iespējams pārvietot observations sadaļā).

The rescue operations will benefit that the search for missing persons and rescue operations will be launched at least 10 minutes earlier, as the reporting time of the event will decrease. Also, knowing the last human data, it will be possible to use at least 30% less human resources and equipment at the disposal of the police (boats, quad bikes, machines, etc.) to carry out the rescue operation, since rescue and search work will be started from the place where the person was last identified. It should also be considered that the temperature of the Baltic Sea and lakes in Latvia in summer reaches about 20C, which is low enough to reduce the rescue time of persons and save lives or reduce the lasting consequences of health.

3.1.8 Cold weather

During the winter period, the UAV would allow for the detection of individuals who are on the ice, if there is currently a prohibition in place to be on the ice. Such surveillance is necessary both during the dark and light hours of the day. Thermal camera equipment is necessary for this kind of identification. The aim of the police operation is to warn individuals that they are in a dangerous zone, therefore it may be useful for the UAV to automatically play a warning when approaching individuals who have entered the dangerous zone. UAV batteries need also to be tested during this period to check if they work, how long a flight is possible at all; camera visibility capabilities also need to be tested - the ability to identify people in light clothing on ice, the ability to distinguish animals in the dark from people, etc.

Observation in cold weather

The flight is planned along a specific route (insert image?) if the water area is frozen, then the maximum that the UAV allows is above the frozen sea ice over the frozen sea territory, using video image and thermal camera. In winter, the boundaries of the swimming area are not decisive, restrictions are set for a large area. A thermal camera is necessary for the dark hours of the day, as darkness sets in at 5:00 PM in winter. Thus, during winter periods, people on the ice are dangerous, for example, at the beginning or end of winter, during thaws, the intensity of observation will be increased to prevent dangerous situations as much as possible. At the same time, it is also possible to identify public order violations from the video image, the inappropriate presence of vehicles on the beach, or to provide support for searching for missing persons.

Search and rescue operations in cold weather

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Despite increased observation, the need for rescue and search work still arises. Considering the observation data, timely and operational action is especially important, especially in the winter period. Hence, it would be useful for the UAV's functionality to be able to identify if a person has nevertheless fallen into the ice and needs the help of rescuers for this or another reason. Currently, no automated algorithms have been identified that would allow this surveillance to be fully digitized, so the received image also requires staff attention. During the winter period, timely and accurate receipt of UAV data due to low temperatures, snow and ice is especially important during the winter period and as well the accountability of the UAV operator, since the UAV operator also needs to make sure that the warned people really return to the shore, following the received instructions.

3.1.9 Technological aspects of the use cases

Scenarios and use-cases will be as set of saved plans with settings for all 5G4LIVES Platforms components, to be activated and launched according to the needs and situation. Plans will be saved as activation components in 5G4LIVES Platform management and control software. First upgrade in technology with the 5G4LIVES platform is the connection which changes are visible with figures 11. and 12.

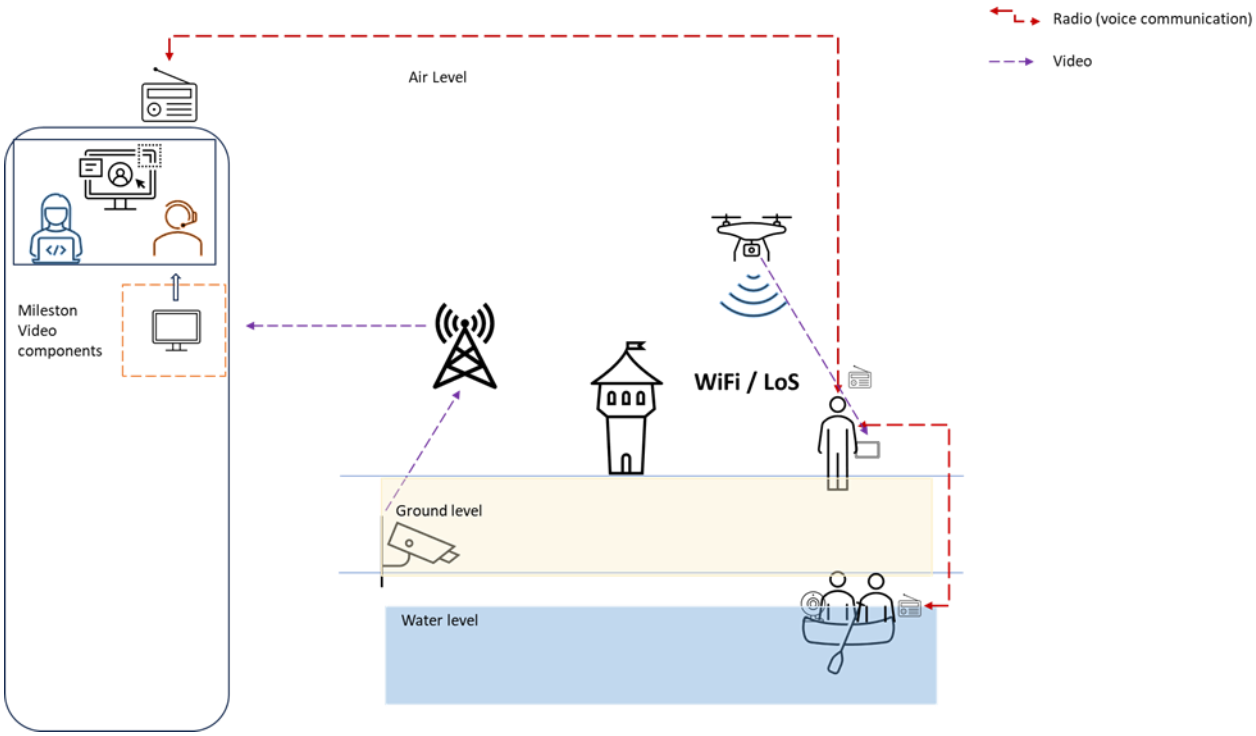

Figure 13. Current state of connectivity layout

The current state of operations can be defined as more of a manual practice. There is a simple enumeration of defined operations which are fulfilled by the UAV operator himself. There are none UAV scenarios described, meaning this does not only refer to automated solutions, but to RMP officer task list that does not enforce the use of UAVs for specific tasks. Once the UAV is used, it is used in direct control of the operator.

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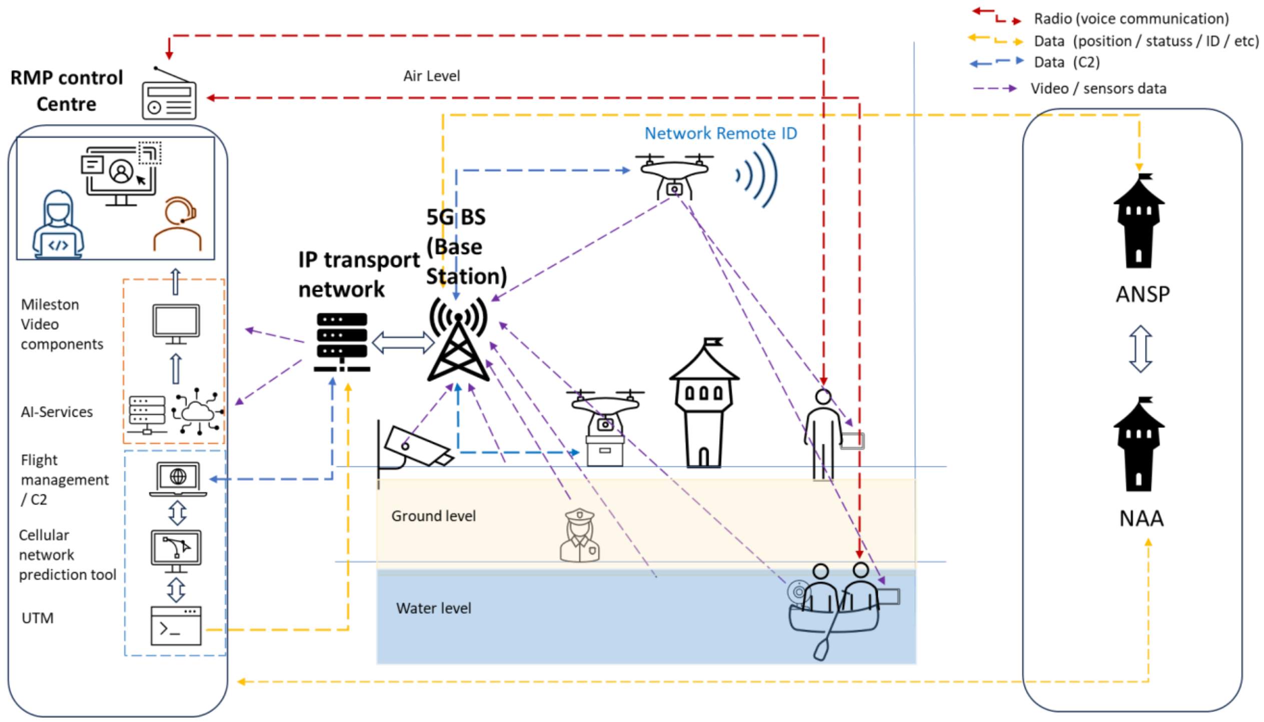

Figure 14. 5G4LIVES Platform environment's connectivity layout

The 5G4LIVES environment introduces multiple upgrades. Automatization of operations that the UAV flight system will ensure at any given time. Digitalization of the operations procedures helps to avoid the human errors. BVLOS / UTM component capabilities which will be elaborated on further. Close to online data flow and control in 5G environment, meaning everything can be reflected in real time. To enable operations in 5G ecosystem, UAV should be equipped with modem, supporting of n40 band (2300 MHz), or commonly referred to as the 2.3 GHz 5G band. In Riga Use-Cases, will be used spectrum of 2300-2330MHz

BVLOS CAPABILITIES

One of the primary objective of the 5G4LIVES scenarios is to facilitate Beyond Visual Line of Sight (BVLOS) applications, which involve extended range missions where the UAV operator lacks direct visual contact with the UAV. BVLOS operations unlock one of the important case UAV applications with significant identified improvements, such as autonomous operation.

These innovative applications face a critical challenge due to the challenge of ensuring collision avoidance with other aircraft, including general aviation planes, and other UAVs. To address this challenge and unlock commercial potential, several key elements must be ensured:

1. Comprehensive awareness of air traffic near the UAV, both during planning and flight phases.
2. Remote, near real-time command and control of the UAV, managed by automated systems, human operators, or a combination of both.
3. Seamless communication with relevant Air Navigation Service Providers (ANSPs) to provide real-time mission status updates and enable emergency interventions when necessary.
4. Establishment of predefined protocols or contingency measures to guide the UAV 's actions in case of anticipated or unforeseen emergencies.

To meet these requirements throughout the entire flight duration, the UAV 's telemetry must be transmitted in almost near real-time with high accuracy and precision. Accurate positioning information relative to other air traffic is crucial for collision avoidance, emphasizing the necessity of continuous connectivity to the network with low latency

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and high reliability. Leveraging 5G technology, which offers features such as network slicing, Mobile Edge Computing (MEC), and antenna beamforming, holds promise in meeting these connectivity needs:

1. Adapting existing UTM functionalities to seamlessly integrate with 5G networks across various stages of a mission is essential.
2. Planning, considering route definition considering mobile network coverage and resource requirements from the 5G network.
3. Validation by assessment of the feasibility of meeting UAV operator needs concerning coverage, infrastructure, functionality, and capacity.
4. Execution activities with proactive monitoring of ongoing missions to ensure adherence to plans and effective management of emergencies, including temporary or permanent loss of radio connection with the serving 5G base station.
5. Post-flight analysis, with continuous refinement of procedures and systems based on insights gathered from mission outcomes.

UA SPECIFICATIONS

Type: rotorcraft without parachute.
Altimetry: barometric altimetry.
Maximum speed: Up to 20 m/s (in case of Vecaku beach it should be limited to 10 m/s by software).
Maximum wind speed: 8.0 m/s
Dimensions: 0.5 m (diagonal, including propellers)
Maximum pitch angle: 25.0 degrees

FLIGHT SPECIFICATIONS

Height of flight geography: 50 m (take-off/landing zones it must be reduced approx. up to 20 m)
Ground risk buffer manoeuvre: Ballistic.
Assumptions:
GPS inaccuracy: 3 m
Position holding error: 3 m
Reaction time: 3 s (minimal allowed)
Altitude error (barometric): 1 m
Altitude error (GPS): 4 m
Additional errors: 0 (could become known after UAS (including software) launch)
Considering the previously mentioned parameters these results were received:
Horizontal contingency volume: 80 m
Vertical contingency volume: 94 m
Ground risk buffer: 66 m
Height of flight geography: 50 m

3.2 TORINO USE CASE

The execution, at the municipal level, of civil protection planning activities and rescue direction with reference to the relevant structures, according to the Civil Protection Code (Legislative Decree 1/2018), is a fundamental function of the Municipalities. The Mayor, as the Municipal Civil Protection Authority, as well as Public Safety and Health Authority, is responsible for organizing municipal resources according to predetermined plans to address the specific risks of their territory. In the event of disasters, the Mayor must assume the direction of emergency services, as well as coordinate rescue and assistance activities for affected populations and provide necessary interventions.

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To efficiently perform Civil Protection services, it is necessary to have careful and precise emergency planning. Only through the drafting of a Municipal Civil Protection Plan and its continuous updating to keep it consistently relevant and current, can the Administration, in close coordination and synergy with its internal structure and support functions, identify risk scenarios present in its territory, identify activable resources, organize procedures to be adopted promptly according to alert operational phases, define monitoring and surveillance activities in the territory, as well as inform and assist the population.

Following the entry into force of new sector regulations and the evolution of the reference context, there arose the need to proceed with a radical updating of the aforementioned Plan, in order to make it more effective in terms of representing territorial analysis, recognition of vulnerable elements, definition of risk scenarios, and related intervention models. The new Municipal Civil Protection Plan, conceived as a dynamic tool to facilitate future updates, coordinated also with the Green Plan and the City's Climate Resilience Plan, details the modalities and procedures for the activation and intervention, in peacetime and in emergency, of all components of the Municipal Civil Protection System, in relation to the various risk scenarios to which our territory is subject. The plans and programs for management, protection, and restoration of the territory and other areas of territorial strategic planning, as provided for by the Civil Protection Code, must be coordinated with the new Municipal Civil Protection Plan to ensure its coherence with the risk scenarios and operative strategies contained therein.

3.2.1 1st scenario: intervention model for sudden events

The specific events considered "sudden" from the aforementioned emergency situations that will be taken Into account in the two scenarios are as follows:

1. Forest fire risk.
2. Large-scale urban fire risk.

The intervention model for sudden events provides for the immediate activation of the local civil protection system following a report of a critical situation on the territory, which occurs without precursor phenomena and without the possibility of initiating monitoring and alerting actions. The operational levels are defined according to the following articulation:

1. Operational Phase of Normality, which indicates the state of normal activity and surveillance.
2. Operational Phase of Alarm, which indicates the degree of full activation in an emergency resulting from the occurrence of calamitous events, as well as the reporting and location on the territory of precise and serious critical phenomena.

All operational procedures for sudden events have been structured according to a single operational level (operational phase) identified in the respective intervention model, namely the Alarm Operational Phase. The management of emergency relief operations is structured through the following successive stages:

1. Verification of the report of a calamitous event.
2. In case of positive verification, activation of the C.O.C. (Centro Operativo Comunale).
3. Acquisition of the first data relating to the calamitous event.
4. Summary evaluation of the calamitous event.
5. Adoption of rescue measures and emergency management.

3.2.2 2nd scenario: intervention model for events with advance notice

The specific events considered "with advance notice" from the aforementioned emergency situations that will be taken Into account in the two scenarios are as follows:

1. Hydraulic risk (river overflow, flood phenomena).

2. Hydrogeological risk (landslide phenomena, landslides, and collapses linked to slope dynamics, river, and stream dynamics).
3. Meteorological risk, connected to the following exceptional events:

    - Intense and prolonged rains;
    - Intense rainfall of a stormy nature;
    - Exceptional snowfalls at low altitudes.

The advance notice event allows for the preparation of preventive processes for forecasting, analysis, and monitoring of the territory, which allow the risk to be reported to all subjects belonging to the local civil protection system, in order to contain the possible evolution of critical situations. The intervention model for events with advance notice, therefore, establishes the methods of activation and coordination of all subjects and entities, according to their respective competencies, based on codified procedures.

The Warning System performs three essential functions for the civil protection system connected to each other:

1. Forecasting.
2. Activation of Operational Phases of civil protection plans aimed at managing civil protection events/emergencies, linked to the color codes of alerts, defined in the forecasting phase. The activation of the following Operational Phases (other than the Normality Operational Phase in green) corresponds to the alert color code, according to the provisions of the current Regional Discipline:
    - Attention Operational Phase (yellow);
    - Pre-Alert Operational Phase (orange);
    - Alarm Operational Phase (red).
3. Communication among institutional subjects, non-institutional subjects, and citizens, in order to implement the actions provided for in civil protection plans and the correct behavioral norms aimed at self-protection is one of the fundamental functions of the Warning System.

The specific step of forecasting the expected meteorological, hydrogeological, hydraulic, and avalanche situation and evaluating the criticality on the territory are expressed univocally in terms of alert, connected to event scenarios and to the effects and damages that meteorological, hydrological, hydraulic, and avalanche phenomena can determine on the territory. This forecast provides qualitative and quantitative elements for the evaluation of criticality on the territory, also connected to the forecasted meteorological phenomena. The forecasting phase consists of the evaluation, supported by adequate numerical modelling, of the expected situation, as well as of the effects that such a situation can determine on the integrity of life, property, settlements, and the environment; to this phase, which occurs in advance of the event, corresponds the activation of prevention actions aimed at reducing/mitigating possible damage and preparing for the management of any emergency situations, with reference to civil protection planning. The monitoring and surveillance phase is articulated in:

1. Qualitative and quantitative observation, instrumental and direct on the territory, before the event or of the ongoing event.
2. Short-term prediction of the relative effects through meteorological "nowcasting" and/or flow models initialized by measurements collected in real-time.

3.2.3 1st scenario: 5G quadricopter UAV for real time video streaming of an emergency in BVLOS and/or EVLOS

Given that to date, no UAVs have been identified on the national and international market that natively utilize 5G technology to redundantly transmit and manage flight commands between the remote control and the UAS (Unmanned Aircraft System), as well as to transmit video streams from the UAV to the remote control, it is necessary to make a distinction between the UAS to be used in the first scenario and the one to be used in the second scenario.

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In the case of the first scenario, namely during the use of a UAV to transmit real-time video streaming to the control centre, from discussions with the company importing the DJI Enterprise series of UAS products to Italy, it has emerged that UAS with a 4G module may be available on the European market as of August 2024. This module will provide an additional communication channel between the radio and the UAV. It has also emerged from email exchanges that the aforementioned additional communication module will operate both in 4G and 5G and will provide redundancy in the transmission of images acquired between the UAS and the remote control and between the remote control and the remote station. The aforementioned redundancy will therefore provide additional security both in the management of UAV piloting commands and in the transmission of images to the control centre. In the event that the 4G/5G transmission module mentioned above is not yet available by the end of the summer of 2024, 5G connectivity will be used exclusively to send video streams from the remote control to the control centre through a dedicated external modem.

The first scenario involves the use of a UAV during an emergency to monitor the affected area in real time. The UAV will be operated in BVLOS exploiting one of the PDRA scenario defined by EASA. However, based on the authorization process and based on the discussion with ENAC (the Italian aviation authority) the use-case demonstration may be operated in EVLOS, i.e. a BVLOS supported by airspace observers.

UAV SPECIFICATIONS

The UAV identified and deemed suitable for use in this scenario is the Matrix M30T produced by the Chinese company DJI, the flagship model of the Enterprise range. The Matrix M30T integrates multiple high-performance sensors into a single camera payload and can also be used with DJI's fleet management and flight planning software called FlightHub 2. The Matrix M30T model features a zoom camera with a 48-megapixel CMOS sensor and 1/2" optical zoom from 5x to 16x and digital zoom up to 200x, a 12-megapixel wide-angle camera, 8K video resolution, and a laser rangefinder that can provide precise coordinates of objects up to 1,200 meters away, as well as an additional radiometric thermal camera with a resolution of 640 x 512 px.

The choice of the UAV was conditioned by some specific features, namely an IP55 protection rating for exceptional performance in challenging environments, including wet weather, allowing it to fly even in particularly unfavourable weather conditions (rain), and with external temperatures from -20°C to 50°C. Among the flight safety devices, there is a six-way obstacle avoidance system and, above all, the new emergency landing system with only three propellers. The OcuSync 3 Enterprise transmission with four antennas ensures strong redundancy and supports LTE backup connectivity, even in complex terrain and working conditions.

Therefore, the DJI proprietary data transmission system (commands and images) between the UAV and the remote control, called OcuSync 3 Enterprise, allows the on-site pilot to initiate an automatic flight and then potentially resume control of the UAV as needed. Through the slots, which can accommodate a SIM card, it is possible to pair an LTE SIM card both with the remote control and with the UAV to redundantly link the radio connection.

SOFTWARE FEATURES TO MANAGE MISSIONS

The dedicated DJI FlightHub 2 software installed on a computer in the control centre, or potentially on a server reachable from the control centre, allows remote management of UAV missions associated with the platform. It will thus be possible, with the UAV powered on and ready to take off, to activate the mission remotely or more simply via the pilot's remote control on-site. Through the aforementioned software, it will also be possible to assist in real-time with live photo and video acquisition.

5G Coverage - 5G SIM on UAV - 5G SIM on Remote Control. The video produced by the UAV is sent to the remote control via a radio connection or alternatively, in the event of interference and/or malfunctions, via a 5G module. From

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the remote control, through the 5G network, the acquired images and videos are transmitted to the remote control station.

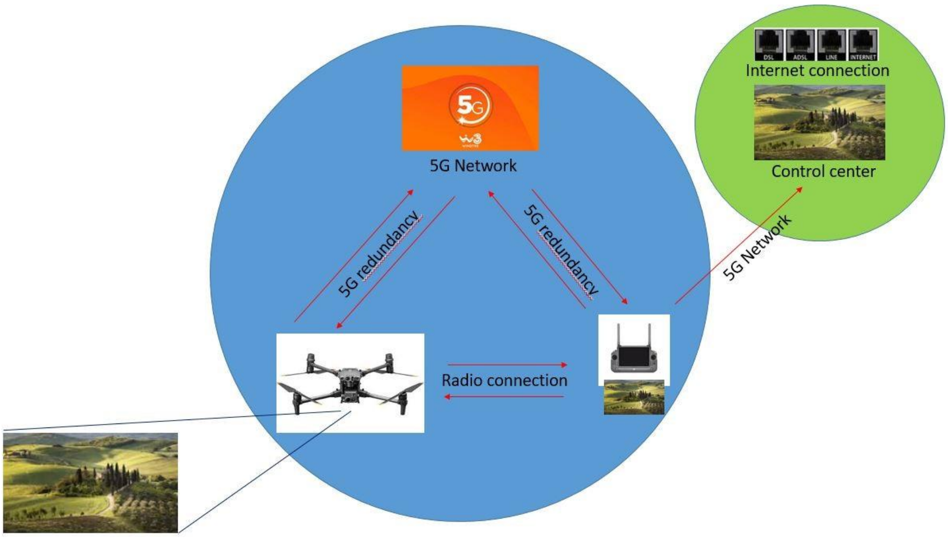

Figure 15. Real time UAV patrolling in 5G diagram

3.2.4 2nd scenario: BVLOS flight of a fixed wing UAV for monitoring and risk assessment

In the case of the second scenario, which involves the use of a UAV in BVLOS during the pre-emergency phase to map the area of interest using photogrammetric techniques to provide images containing the state of a portion of the hilly territory of Torino, at the moment no EASA C6 certified UAV has been identified. This certification is necessary for the UAV to be used for BVLOS flight in the Specific STS-02 category. In this second scenario, 5G technology will be used exclusively through a dedicated modem to provide network connectivity to the ground station, which will be responsible for managing the UAV's flight.

The second scenario involves the use of a UAV during the pre-emergency phase to map the area of interest using photogrammetric techniques to provide images containing the state of a portion of the hilly territory of Torino, where, during cases of significantly heavy rainfall, landslide phenomena deleterious to the city can occur. Once the UAV reaches the operational area, it will be launched by the pilot and operated in BVLOS mode.

UAV SPECIFICATIONS

The UAV identified and deemed suitable for use in this scenario is the fixed-wing UAV Ebee X, or a superior model, produced by the Swiss company Sensefly - AGEagle. The Ebee X has a wingspan of 116 cm and its structure is built of expanded polypropylene (EPP). It has the capability to carry various sensors on board, including RGB, thermal, or multispectral sensors for targeted acquisitions to achieve specific objectives. By correctly setting various parameters, it is possible to achieve a detail of 1.5 cm Ground Sample Distance (GSD).

SOFTWARE FEATURES TO MANAGE MISSIONS

The eMotion software dedicated to planning photogrammetry missions is provided as part of the UAS. Simply select the area you want to map, and the software will generate the flight plan for the AGEagle Ebee X.

Regarding the sensor installed on the Ebee X, it will also be possible to set the required Ground Sampling Distance (GSD). It will also be possible to automate individual flights of multiple Ebee X UAVs to be executed simultaneously in different locations, always having the option to control the trajectories and telemetry of the UAVs, as well as decide on a new landing point during the flight.

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Unlike the UAV used in the first scenario, the AGEagle Ebee X does not transmit images acquired directly to the Ground Station, but records them locally on a Micro SD Card on board the UAS, and they will be available to the pilot as soon as the Ebee X has landed. The acquired images, enriched with metadata of interest, will be ready to be processed with any third-party post-processing systems dedicated to photogrammetry.

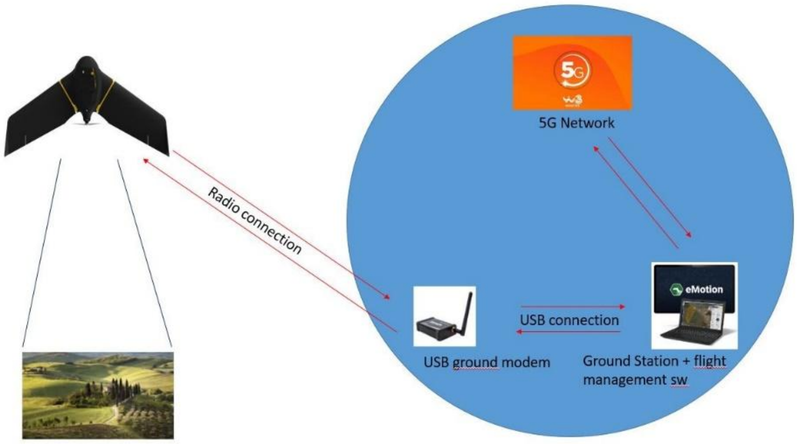

Figure 16. UAV monitoring, assessing and forecasting in 5G diagram

3.2.5 Scenarios shared extra hardware

Both in this initial emergency scenario and in the subsequent second scenario where preventive monitoring activities of critical hilly areas will be carried out, it is advisable to foresee an additional two UAVs for support activities in planning and video-photographic documentation of the scheduled missions, through dedicated aerial filming. Specifically, two UAV models have been identified: a DJI Mini 4 Pro and a DJI Mavic 3 Enterprise Thermal, both with the capability to connect to a 5G network to transmit video streaming remotely.

The DJI Mini 4 Pro is a UAV with a take-off weight of less than 249 grams; therefore, it is classified as C0 and can be used in preliminary operational contexts to plan subsequent missions with heavier UAVs. According to current regulations, this harmless UAV allows, among other things, flying over uninvolved people in urban contexts without the need to rigidly perimeter the underlying operation area with suitable personnel to prevent overflight of people not involved in the activities. Precisely due to this feature of being able to fly over people, the DJI Mini 4 Pro is ideal both for conducting any preliminary surveys for missions with UAVs in any inhabited or uninhabited area and, being equipped with a good quality optical sensor, suitable for aerial filming to document the missions undertaken in both scenarios.

The DJI Mavic 3 Enterprise Thermal, on the other hand, is a C2-classified UAV. With this type of UAV, according to current regulations, it is not possible to fly over crowds, people/vehicles/vessels, but it is possible to fly "close" to uninformed people. Therefore, to carry out the flight missions, it is necessary to create a suitable "buffer" area to avoid flying over uninvolved people. This type of UAV, equipped with a high-performance camera, is suitable for use in sparsely populated hilly areas (Pilot 1 zone) and allows for either having a backup UAV for the DJI MATRIX 30T intended to conduct the first pilot or having a second UAV for aerial filming to document the missions undertaken in both scenarios.

Table 2. Tentative list of assets to be purchased for deployment of the use case

Asset
DJI Matrice 30T
DJI Care Enterprise Plus renewed (M30T)
DJI Battery TB30
DJI RC Plus Strap and Waist Support Kit
DJI M30 1671 Propeller
DJI Mavic 3 Thermal - Care 2 Years
DJI Mavic 3 Ent USB-C Power Adp(100W)
DJI Mavic 3 Enterprise Battery Kit

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DJI Mavic 3 Enterprise RTK Module
DJI Mavic 3 Enterprise Propellers
DJI Mavic 3 Enterprise Speaker
DJI Mini 4 Pro Fly More Combo (DJI RC 2)
128GB Lexar MicroSDXC Gold V60 U3 A1
DJI Care Refresh Plan 1 Year (Mini 4 Pro)
DJI Mini 3 Pro Propeller
DJI Mini 4 Pro Intelligent Flight Battery
AgEagle eBee X
d-flight registration
UAV Control and BVLOS flight planning software DROMT
Platform for streaming video and 5G data transmission DROMT
Aerial Photogrammetry Software DROMT
Upgrade Certificates for 10 Pilots
128GB Lexar MicroSDXC Gold V60 U3 A1

3.2.6 Training course

Contacts have been made with the Department of Environmental, Territorial, and Infrastructure Engineering (DIATI) at the Polytechnic University of Torino to allow the Pilots of the Drones Unit of the City of Torino to deepen the knowledge already developed over the past years of operation by participating in a refresher and training course on topics such as aerial photogrammetry, UAS structures (quadcopters, hexacopters, and fixed-wing), and standardization of processes for UAV image acquisition with specific scientific support.

The aforementioned advanced course will be attended by a number of pilots from the Drones Unit of the City of Torino who already possess specific flying qualifications and will begin in the autumn of 2024.

4. SPECTRUM REGULATORY AND TECHNICAL ENVIRONMENT FOR POTENTIAL RADIO FREQUENCY BANDS TO BE USED FOR UAV OPERATION

UAVs rely heavily on wireless communications and, consequently, on the allocation of radiofrequency (RF) spectrum to their operation. One of the key duties of Latvia's Electronic Communications Office, known as VASES, is the management of the country's RF spectrum. Given that RF spectrum is a limited resource that is crucial to providing wireless services in general, VASES is responsible for ensuring that it is used in the best interests of people and businesses in Latvia. VASES authorise the use of the RF spectrum either by granting licence to use the RF spectrum under the Electronic Communications Law of Latvia[2] or by making regulations exempting the use of equipment from the requirement to hold such a licence.

RF spectrum is required to operate UAVs for a variety of purposes, including:

1. Command and control: for the remote pilot to control the UAVs and send navigation commands.

[2] Likumi lv 2022, *Elektronisko sakaru likums*, Latvijas Republikas tiesību akti, accessed 5 April 2024, <https://likumi.lv/ta/id/334345-elektronisko-sakaru-likums>

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2. Relaying of payload data: facilitating the transmission of data and video from the UAVs to the remote pilot/operator.
3. Electronic Conspicuity: implementing technology to notify other airspace users of the UAVs' position and flight trajectory.
4. Detect and Avoid: providing the UAVs with the ability to identify and evade obstacles or other aircraft; and
5. Communications, navigation, and surveillance: depending on the airspace in which the UAVs is being flown and on the capability of other systems on the UAVs, Air Traffic Controllers may need to maintain oversight and control of the flight (Ofcom, 2022).[3]

To achieve the goal of the 5G4LIVES project, cellular connectivity, particularly 5G, will be used as the crucial communications channel to control the UAVs and send/receive live video/data feed. Within the project the use of UAVs is intended for the beyond visual line of sight (BVLOS) flight mode and EVLOS. The main safe operation component of UAV BVLOS is the ability of the UAV operator to control UAVs and to send commands to them in any phase of flight when they are out of sight. When piloting a UAV using a cellular network (LTE/5G), the cellular network provides the essential communication channel in this situation. It is important to note that for the use of RF bands (including 5G) for commercial use in public land mobile networks in Latvia, it is necessary to obtain an appropriate RF usage rights and RF assignment licence.

The airborne use of certain radio equipment in Latvia is also possible under existing licence exemption regulations, and probably will be necessary within this project. Licence exemption regulations provide the technical and operational requirements that equipment must meet to be used without a licence. Requirements are set out in the National Radiofrequency Plan of Latvia.[4] This includes specific frequencies and appropriate technical requirements for such categories of radio devices as model control devices, WAS/RLAN and short-range devices (SRDs).

Commonly used licence-exempt RF bands for UAV's control and command are:

1. 2.4 GHz: This RF band is commonly used for the control and command link between the UAV and the ground control station. It provides a good balance between range and penetration through obstacles.
2. 5.8 GHz: Another popular RF band for C2 links due to its higher data rates and less interference compared to 2.4 GHz. It is often used for transmitting real-time control signals and telemetry data. This band is also widely used for video transmission from the UAV to the ground station. It offers higher data rates and better resistance to interference compared to lower RF bands.

Also, Global Navigation Satellite Systems (GNSS), such as the Global Positioning System (GPS), play a crucial role in UAV operations. These systems provide accurate positioning, navigation, and timing information to UAVs, enabling them to perform various tasks efficiently.

4.1 RF BANDS USED FOR PUBLIC LAND MOBILE NETWORKS

In Europe several RF bands have been harmonized for terrestrial systems capable of providing electronic communication services (IMT). However, depending on national circumstances allocation and amount of RF spectrum available for IMT may differ between administrations / CEPT member states.

According to the National Radiofrequency Plan of Latvia, bands identified for IMT (including 5G) for public land mobile network use in Latvia, are listed in Table 3 under technological neutrality framework. This means that RF bands

[3] Spectrum for Unmanned Aircraft Systems (UAS) Approach to authorising the use of radio equipment on UAS, CONSULTATION, Ofcom (2022)

[4] Likumi lv 2023, *Nacionālais radiofrekvenču plāns*, Latvijas Republikas tiesību akti, accessed 5 April 2024, <https://likumi.lv/ta/id/338729-nacionalais-radiofrekvencu-plans>

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may be used by any technology but according to the table of allocations of National Radiofrequency Plan of Latvia complying with the technical conditions set out in radio interface specifications (Annex 2 of the NRP). The same principle of technological neutrality is used when assigning rights of use of the spectrum by the Public Utilities Commission of Latvia (hereinafter - the Regulator).

Table 3. Summary of IMT RF Bands in Latvia

IMT RF band in Latvia	Harmonized IMT RF band in Europe	Rights of use of RF band are assigned in Latvia	Harmonized technical conditions in RF bands harmonized for MFCN for aerial UE operation**
450,0 – 457,5 MHz / 460,0 – 467,5 MHz	No	Yes	No
703,0 – 733,0 MHz / 738,0 – 788,0 MHz	Yes	Yes	Yes
791,0 – 821,0 MHz / 832,0 – 862,0 MHz	Yes	Yes	Yes
880,0 – 915,0 MHz / 925,0 – 960,0 MHz	Yes	Yes	Yes
1432,0 – 1472,0 MHz and 1492,0 – 1512,0 MHz	Yes	Yes	No
1710,0 – 1785,0 MHz / 1805,0 – 1880,0 MHz	Yes	Yes	Yes
1900,0 – 1920,0 MHz*	No	No	No
1920,0 – 1980,0 MHz / 2110,0 – 2170,0 MHz	Yes	Yes	Yes
2300,0 – 2360,0 MHz	No	Yes	No
2500,0 – 2690,0 MHz	Yes	Yes	Yes
3400,0 – 3800,0 MHz	Yes	Yes	No
25,1 – 27,5 GHz	Yes	No	No
* 1,9 GHz band will be allocated to other applications			
** According to ECC/DEC/(22)07[5]			

Table 3 provides a summary of the IMT RF bands in Latvia for public land mobile networks, harmonized IMT RF bands in Europe, as well as harmonized technical conditions in the RF bands harmonized for MFCN UAV operation.

It should be noted that the primary RF bands used for the deployment of 5G in Latvia are the so-called 700 MHz and 3.6 GHz bands, but currently these bands are not considered usable for the Latvian part of the project. The reason for this is that these bands are currently used by LMT's commercial network and if the technical configuration of the network were to be adapted for UAV operation, it would jeopardize the services of existing customers. Therefore, during the implementation of the project, alternative solutions and alternative RF bands will be sought, in which the 5G network for UAV operation will be deployed. The most suitable RF band where rights of use of the spectrum has been

[5] ECO Documentation Database 2022, *ECC/DEC/(22)07*, European communications office, accessed 7 April 2024, <https://docdb.cept.org/document/28575>

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already assigned and the band is already used for other than 5G technology in LMT network will be evaluated at the later stage in the project when developing D2.2. “Study on minimum 5G requirements".

4.2 RF BANDS FOR PUBLIC LAND MOBILE NETWORKS IN ITALY

This section provides an overview of the RF bands utilized for public land mobile networks (including 5G) in Italy.

4.2.1 RF bands used for public land mobile networks

In Europe several RF bands have been harmonized for terrestrial systems capable of providing electronic communication services (IMT). However, depending on national circumstances allocation and amount of RF spectrum available for IMT may differ between administrations / CEPT member states.

According to the National Radiofrequency Plan of Italy, bands identified for IMT (including 5G) for public land mobile network use in Italy, are listed in Table 4.

Table 4. Summary of IMT RF Bands in Italy for public land mobile networks

IMT RF band in Italy	Band name	Rights of use of RF band are assigned in Italy
703-733 MHz 758-788 MHz	FDD-B28	Yes
791-821 MHz 832-862 MHz	FDD-B20	Yes
880-915 MHz 925-960 MHz	FDD-B8	Yes
1452-1492 MHz	SDL-B32	Yes
1715-1785 MHz 1810-1880 MHz	FDD-B3	Yes
1920-1980 MHz 2110-2170 MHz	FDD-B1	Yes
2510-2600 MHz 2630-2690 MHz	FDD-B7/TFF-B38	Yes
3440-3500 MHz 3540-3600 MHz 3600-3800 MHz	TDD-N78 (*)	Yes
26500-27500MHz	TDD-N258 (**)	Yes
(*) n78 band is very wide and has not been completely assigned for mobile service yet. Below 3600 MHz is used for FWA service and is only partially owned by the Defense Ministry		
(**) also referred to as n257 as in Italy the band allocation overlaps both ranges		

4.3 COMMONLY USED RF BANDS FOR UAV’S OPERATION

4.3.1 2.4 GHz, 5.8 GHz, SRD RF bands

Industrially manufactured UAVs are intended for use in various countries around the world. Additionally, depending on the configuration of the UAVs and the diverse needs of UAV applications, various transmitting devices can be installed on UAVs, which use one or more RF bands. Considering that the distribution of RFs and usage regulations

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may vary from one country to another, it is important to ensure that the RF bands used in UAVs comply with the regulations applicable in the specific country's territory. Frequently, there are instances where multiple transmitting devices with alternative RF bands are installed on a UAV, requiring the selection of the appropriate RF band. Therefore, research and was carried out presenting a synthesis on the commonly used RF bands for UAVs operation within the territory of the Republic of Latvia, simultaneously ensuring compliance with RF usage regulations. In addition, the compiled information will be necessary for the preparation of procurement documentation.

In the territory of Latvia, RF bands are outlined in Cabinet of Ministers regulations of January 10, 2023, No. 3 (National Radiofrequency Plan of Latvia). Table 5 provides information about the commonly used licence-exempt RF bands utilized by the transmitting devices on UAVs.

Following the project’s goal, the RF bands permitted for outdoor use will be specified for UAV operations. See Annex 3 of the National Radiofrequency Plan of Latvia for other exempt-licence bands.

Table 5: Commonly used licence-exempt bands for UAVs operation

Name	RF range	Transmission power limit	Application
2.4 GHz*	2400 – 2483.5 MHz	≤ 100 mW e.i.r.p.	1. Remote Control: Commonly used for the control and command link between the UAV and the ground control station. 2. Telemetry Data: UAVs often transmit telemetry data back to the pilot or ground station, providing information such as altitude, speed, battery status, and GPS coordinates. 3. Live video feed from the UAV’s onboard camera in real-time.
5.8 GHz*	5725 – 5875 MHz	≤ 25 mW e.i.r.p.	1. Video Transmission. 2. Avoiding Interference – 5.8 GHz band is less congested compared to the 2.4 GHz band, which is commonly used for WiFi, Bluetooth, and other wireless devices. 3. Higher Bandwidth – 5.8 GHz band offers a higher bandwidth compared to the 2.4 GHz band, allowing for higher-quality video transmission with less latency.
SRD RF bands*	433.05 – 434.79 MHz 863 – 868.6 MHz 868.7 – 869.2 MHz 869.4 – 869.65 MHz 869.7 – 870 MHz	10 mW e.r.p. 25 mW e.r.p. 25 mW e.r.p. 500 mW e.r.p. 25 mW e.r.p.	1. Remote Control - send commands to the UAV for manoeuvring, navigation, and other flight operations. 2. Telemetry and Data Transmission. 3. Anti-Collision and traffic awareness systems and other purposes.
* For detailed technical requirements, see Part II of Annex 3 of the National Radio Frequency Plan of Latvia, Table No. 8.14.2.			

4.3.2 GNSS RF bands

In addition to the commonly used RF bands for UAVs operation, GNSS RF bands should be mentioned in this context. GNSS satellite constellations provide signals for precise navigation and geolocation worldwide, making them crucial for UAV positioning. Additionally, GNSS signals play a vital role in mobile communication networks, particularly in the time synchronization process.

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GNSS operates within the RF bands designated for the Radio Navigation Satellite Service (RNSS), as allocated by the International Telecommunication Union (ITU) GNSS RF bands are as follows:

1. 1559 – 1610 MHz, refer to as L1, E1, B1, G1.
2. 1215 – 1300 MHz, refer to as L2, E6, B3, G2.
3. 1164 – 1215 MHz, refer to as L5, E5, B2, G3.

GNSS RF bands allocation is shown in Figure A.

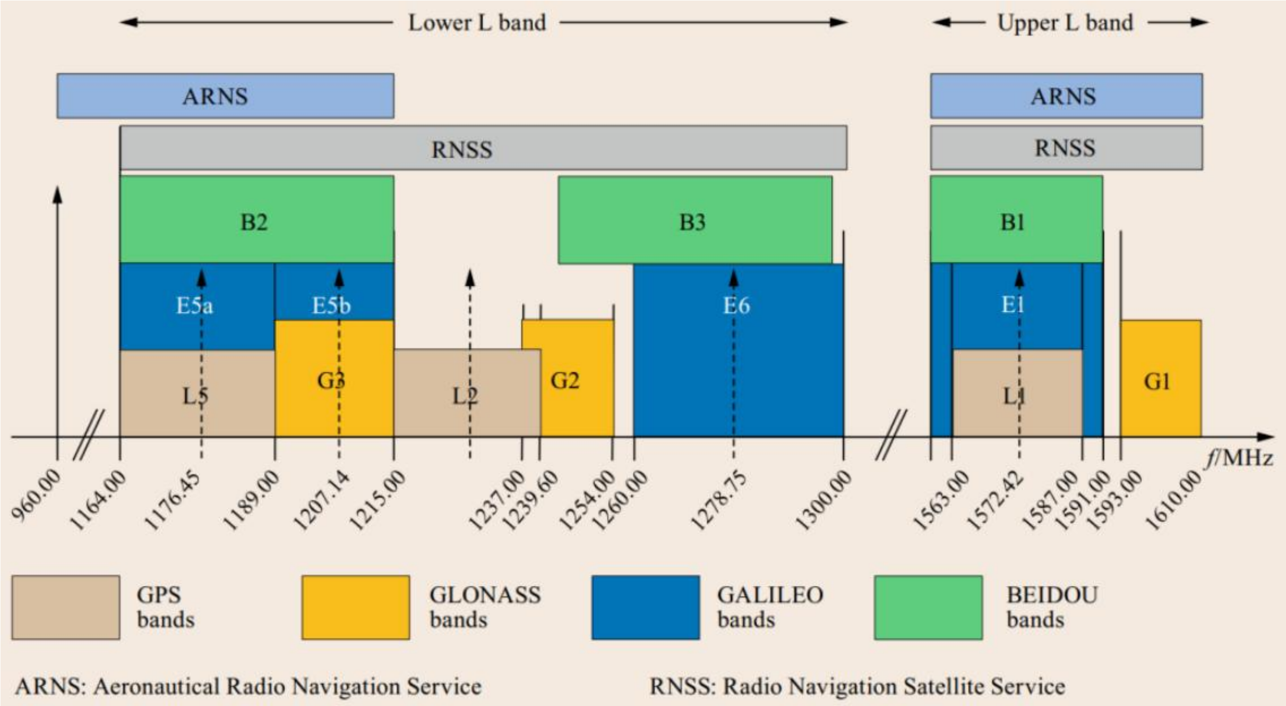

Figure 17. GNSS RF band allocation[6]

As shown in Figure 15, several global satellite systems operate simultaneously in the GNSS RF bands, which are managed by - the USA (GPS), the European Union (Galileo), the Russian Federation (GLONASS) and the People's Republic of China (BEIDOU). Employing diverse signalling methods enables the simultaneous utilization of multiple GNSS systems without encountering mutual interference. Furthermore, leveraging several GNSS systems concurrently yields enhanced accuracy, broader coverage, and heightened resilience to interference. Therefore, in the following phases of the project, including the preparation of the procurement documentation, it is essential to mention that the UAV's GNSS receiver must be able to work in at least two systems simultaneously, moreover, considering the geopolitical situation, the UAV's GNSS receiver should support for European countries reliable GNSS systems - GPS and Galileo.

4.4 General procedures for the use of RF bands in Latvia

This section outlines the general procedures for utilizing RF bands within the territory of Latvia. These procedures encompass various aspects, including the utilization of licence-exempt bands, compliance assessment of radio equipment, and the establishment of electronic communication networks. The section is divided into two subsections, each focusing on specific procedures and regulatory requirements.

[6] A. N. Ivan, IOPscience 2023, *Analysis of the impact of GNSS disruptions on aircraft operations at Romanian airports*, IOP Publishing, accessed 10 April 2024, <https://iopscience.iop.org/article/10.1088/1742-6596/2526/1/012096/pdf>

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The first subsection elaborates on the utilization of licence-exempt RF bands, emphasizing that radio equipment operating within these bands does not require individual licences. However, adherence to regulations governing radio equipment usage is essential.

The second subsection provides procedures for utilizing RF bands designated for public mobile networks. Key regulatory acts governing these procedures are highlighted, ensuring compliance with legal requirements and standards.

4.5 GENERAL PROCEDURE FOR USING LICENCE-EXEMPT BANDS

Licence-exempt bands, or so-called shared RF bands, mean that radio equipment operating within these RF bands does not require an individual RF licence to be obtained from the RF manager VASES, and a separate licence in paper or electronic form is not issued. However, even within these RF bands, there are rules and regulations for radio equipment. Therefore, the user of the radio device/equipment should pay attention to several important basic rules listed below (flowchart in Figure 16).

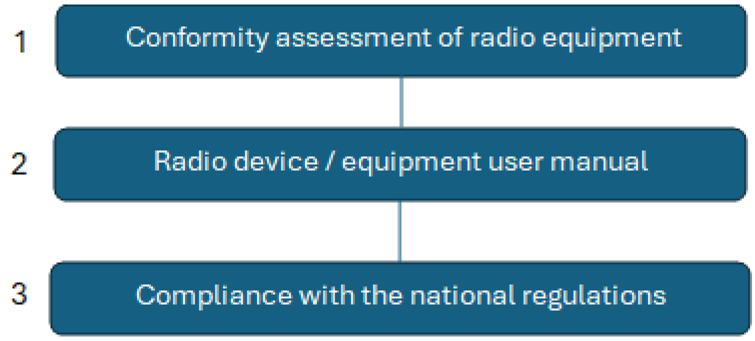

Figure 18. General procedure for licence-exempt RF band users

Flowchart explanations:

4.5.1 Conformity assessment of radio equipment

The CE marking on radio devices indicates compliance with relevant European Union (EU) regulations regarding electromagnetic compatibility (EMC) and Radio Equipment Directive (RED). Attention should be paid to the radio equipment installed on UAV purchased within the project, which should carry the CE marking and fulfil other relevant requirements.

4.5.2 Radio device / equipment user manual

Before using the radio device or equipment, the appropriate region/country in which the device will be used must be selected in its settings. Selecting the appropriate region significantly reduces the risk of using incompatible RF ranges, suffering from radio interference, and creating radio interference to other spectrum users. In the procurement of UAV's intended for the project, it is mandatory to specify the European region (territory of Latvia).

4.5.3 Compliance with the national regulations

Globally RF bands often are harmonized within a single region (for example, the European Union), but the application of RF may vary slightly in each of these countries. Therefore, it is crucial to get acquainted with the regulations of the specific country. In the territory of Latvia, these regulations are outlined in National Radiofrequency Plan of Latvia. The regulations specify conditions and restrictions regarding the use of radio spectrum, such as power limits, usage (indoors/outdoors) and other. In procuring UAV's for the project, it is mandatory to ensure that the RF bands utilized by the UAV's align with those specified in section 1.2. "Commonly used RF bands for UAV's operation".

4.6 GENERAL PROCEDURE FOR USING PUBLIC MOBILE NETWORK BANDS

This subsection describes the general procedures for the use of RF bands in public land mobile networks. Access to these bands for commercial use is limited in order to ensure efficient use of these frequency bands. To use these bands mobile operators must obtain the rights of use of the RF spectrum as well as individual frequency assignment licence (hereinafter - radio licence) before putting the base station in operation. The radio equipment used in mobile

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network must meet essential requirements (conformity assessment) as well as technical conditions set out in Annex 2 of the National Radiofrequency Plan of Latvia. When building and commissioning the base station, it's essential to adhere to construction regulations and conduct practical measurements to assess the impact of the electromagnetic field on public health.

It should be noted that some steps, provided in flowchart in Figure 17 could be carried out in parallel and this procedure flowchart is only for general understanding.

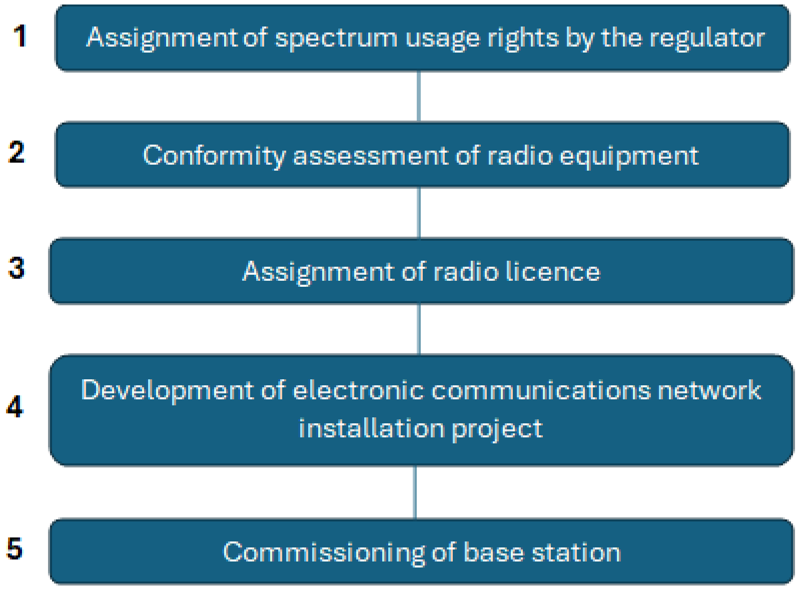

Figure 19. General procedure for using public mobile network bands

Flowchart explanations:

4.6.1 Assignment of spectrum usage rights by the regulator

Granting the rights of use of RF bands in the electronic communications sector are limited in frequency bands intended for public land mobile networks and are included in regulations of cabinet of Ministers No. 635 "Provisions of limited frequency bands" (11.10.2022).[7] The Regulator is the responsible organisation of granting rights of use of these RF bands. Regulator carries out public consultations with the telecommunications sector before granting rights of use of the frequency bands. In close cooperation with Regulator as well as telecommunications sector VASES as a RF spectrum management organisation provides an opinion to the issues related to the use of RF bands. The procedure of granting rights of use of the RF band is established by Regulator and typically it is an auction (other methods like competition also could be used).

4.6.2 Conformity assessment of radio equipment

Conformity assessment ensures that radio equipment meets essential requirements for effective RF usage, EMC, safety, and health without emissions of interference signals. The requirement to effectively use the RF spectrum without disturbing radio interference covers such equipment RF parameters as frequency stability, RF power, side-channel emissions, spurious domain emissions, receiver sensitivity, receiver selectivity, etc. Radio equipment is required to be with CE marking. It is mandatory for distribution in the EU and use in Latvia, although compliance with CE requirements alone does not permit use in Latvia without adhering to national regulations or obtaining necessary licences.

[7] Likumi lv 2022, *Ierobežoto radiofrekvenču joslu noteikumi*, Latvijas Republikas tiesību akti, accessed 21 April 2024, <https://likumi.lv/ta/id/336387-ierobezoto-radiofrekvencu-joslu-noteikumi>

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In Latvia, the Consumer Rights Protection Centre (CRPC) supervises radio equipment sales, and VASES oversees its use, focusing on spectrum compliance. Relevant laws include the Law on Conformity Assessment[8] and the Electronic Communications Law of Latvia, supported by various Cabinet of Ministers regulations detailing equipment conformity, EMC, and safety standards.

These regulations also govern the assessment, market offering, installation, use, and oversight of radio equipment.

1. Regulations of the Cabinet of Ministers, issued in accordance with Article 7 of the Law "On Compliance Assessment":
    - Regulations of the Cabinet of Ministers No. 215 (02.04.2024) "Rules for assessment of conformity of radio equipment, offering on the market, installation, use and monitoring";[9]
    - Regulations of the Cabinet of Ministers No. 208 (12.04.2016) "Rules of electromagnetic compatibility of equipment";[10]
    - Regulations of the Cabinet of Ministers No. 209 (12.04.2016) "Electrical safety regulations of equipment";[11]
    - etc. Regulations,
2. Regulatory acts in the field of consumer rights protection.

4.6.3 Assignment of radio licence

According to part one of Article 54 of the Electronic communications law of Latvia it is permitted to use the RF band for the operation of radio equipment after obtaining a licence for the use of the radio licence in VASES or in accordance with a general authorisation. The regulations of Cabinet of Ministers "Regulations regarding authorisations for the use of radio frequency assignments" (21.03.2023) [12] determines:

1. Types and term of validity of authorisations for the use of a radio licence, prerequisites for the issue and cancellation, operating conditions and restrictions on use of radio equipment.
2. the procedure for submitting and examining a request for a radio permit and cancelling a radio licence.
3. The order in which close range wireless access points are registered.

4.6.4 Development of electronic communications network installation project

Under Cabinet of Ministers regulations No. 501 (19.08.2014) [13] concerning the construction of electronic communications infrastructure, a detailed installation project is required for setting up an electronic communication network. The project must include:

1. An explanatory description and technical plan of the construction;
2. Network schematics, technical solutions, and hardware list;

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[8] Likumi lv 1996, *Par atbilstības novērtēšanu*, Latvijas Republikas tiesību akti, accessed 21 April 2024, <https://likumi.lv/doc.php?mode=DOC&id=63836>

[9] Likumi lv 2024, *Radioiekārtu atbilstības novērtēšanas, piedāvāšanas tirgū, uzstādīšanas, lietošanas un uzraudzības noteikumi*, Latvijas Republikas tiesību akti, accessed 21 April 2024, <https://likumi.lv/ta/id/351106-radioiekartu-atbilstibas-novertesanas-piedavasanas-tirgu-uzstadisanas-lietosanas-un-uzraudzibas-noteikumi>

[10] Likumi lv 2016, *Iekārtu elektromagnētiskās saderības noteikumi*, Latvijas Republikas tiesību akti, accessed 21 April 2024, <https://likumi.lv/ta/id/281513-iekartu-elektromagnetiskas-saderibas-noteikumi>

[11] Likumi lv 2016, *Iekārtu elektrodrošības noteikumi*, Latvijas Republikas tiesību akti, accessed 26 April 2024, <https://likumi.lv/ta/id/281514-iekartu-elektrodrosibas-noteikumi>

[12] Likumi lv 2023, *Radiofrekvences piešķīruma lietošanas atļauju noteikumi*, Latvijas Republikas tiesību akti, accessed 26 April 2024, <https://likumi.lv/ta/id/340434-radiofrekvences-pieskiruma-lietosanas-atlauju-noteikumi>

[13] Likumi lv 2014, *Elektronisko sakaru inženierbūvju būvnoteikumi*, Latvijas Republikas tiesību akti, accessed 26 April 2024, <https://likumi.lv/ta/id/269032-elektronisko-sakaru-inzenierbuvju-buvnoteikumi>

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3. Owner or legal possessor's written consent for network installation;
4. Layouts for cable, passive and active equipment, and electrical supply;
5. Coordination with relevant engineering network owners for infrastructure use and proximity compliance;
6. Labor and environmental protection measures;
7. Technical inspection report if using existing structures for base stations;
8. Antenna mast or support mounting solutions;
9. Antenna and radio equipment location plans;
10. Permission for RF use from VASES or shared radiofrequency allocation;
11. Antenna power parameters and directional diagrams;
12. Electromagnetic field intensity calculations for the surrounding area.

The network infrastructure element can commence operations once it is constructed according to the project.

4.6.5 Commissioning of base station

In accordance with Cabinet of Ministers regulations No. 501 (19.08.2014) after receiving a written request from the construction initiator, relevant institutions review and provide feedback on the electronic communications network's readiness for operation, compliance with the construction project, and adherence to regulatory standards.

The commissioning process begins with the construction initiator submitting a certificate of readiness, or demolition certificate for the engineering structure, to the local construction authority. This certificate should be accompanied by:

1. A cadastral survey file for electronic communication network buildings;
2. Updated sections of the construction project;
3. Opinions from issuing technical or special regulation institutions;
4. A construction work log and related documentation;
5. An executive measurement plan for engineering network locations specified in the project;
6. Inspection protocols and acceptance acts for technological equipment and systems, along with compliance certificates if required by safety regulations.

The certificate of readiness is confirmed in the construction information system by the construction initiator, contractor, responsible construction manager, construction supervisor (if applicable), and author supervisor (if applicable).

Mobile communications base stations are only accepted into operation after practical measurements of electromagnetic field levels are carried out with measuring devices that certify the uniformity of measurements in accordance with the procedures specified in the regulatory acts governing the field of measurement, and the assessment of the conformity of the measurement results at the Health Inspection in accordance with Cabinet of Ministers regulations No. 501 (19.08.2014).

The construction proponent then presents the network infrastructure element for approval to the construction board and invites the contractor responsible for the construction work.

4.7 General procedures for the use of RF bands in Italy

This section outlines the general procedures for utilizing RF bands within the territory of Italy. These procedures encompass various aspects, including the establishment of electronic communication networks, procedures for utilizing RF bands designated for public mobile networks. Key regulatory acts governing these procedures are highlighted, ensuring compliance with legal requirements and standards.

4.8 General procedure for using public mobile network bands in Italy

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This subsection describes the general procedures for the use of RF bands in public land mobile networks. Access to these bands for commercial use is limited in order to ensure efficient use of these frequency bands. To use these bands mobile operators must obtain the individual rights of use of the RF spectrum through frequency licence assignmentbefore putting the base station in operation. The radio equipment used in mobile network must meet essential requirements (conformity assessment) as well as technical conditions set out in Directive 2014/53/EU[14], transposed into Italian law by Legislative Decree No. 128 of June 22, 2016.[15] When building and commissioning the base station, it's essential to adhere to construction regulations and conduct practical measurements to assess the impact of the electromagnetic field on public health.

It should be noted that some steps, provided in flowchart in Figure 18 could be carried out in parallel and this procedure flowchart is only for general understanding.

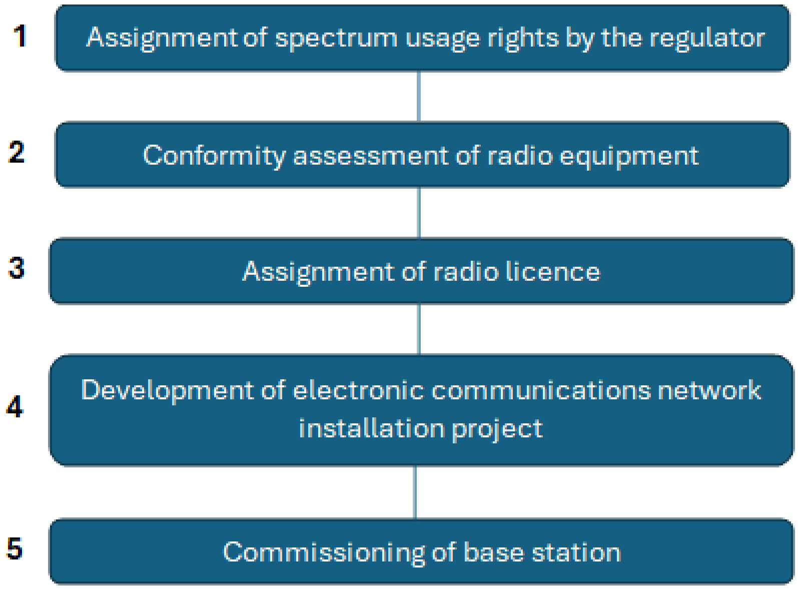

Figure 20: General procedure for using public mobile network bands in Italy

Flowchart explanations are described in more detailed in further subsections.

Assignment of spectrum usage rights by the regulator

Granting the rights of use of RF bands in the electronic communications sector are limited in frequency bands intended for public land mobile networks and compliant with Italian ECC (Legislative Decree 8 novembre 2021 , n. 207)[16] and to the Italian “Piano Nazionale di Ripartizione delle Frequenze” (PNRF). The MIMIT, a governative Ministry, is the responsible organisation of granting rights of use of these RF bands. AGCOM, the Italian NRA (national regulatory authority), carries out public consultations with the telecommunications sector before defining the framework to grant rights of use of the frequency bands. In close cooperation with MIMIT, AGCOM RF spectrum management department provides an opinion to the issues related to the use of RF bands. The procedure for assigning rights of use of the RF band is established by AGCOM and implemented by MIMIT and typically it is an auction (other methods like competition also could be used).

4.8.1 Conformity assessment of radio equipment

Conformity assessment ensures that radio equipment meets essential requirements for effective RF usage, EMC, safety, and health without emissions of interference signals. The requirement to effectively use the RF spectrum without

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[14] EUR-Lex, *Document 32014L0053*, European Union Law, acessed 8 April 2024, <https://eur-lex.europa.eu/legal-content/IT/TXT/?uri=CELEX%3A32014L0053>

[15] Normattiva, *DECRETO LEGISLATIVO 22 giugno 2016, n. 128*, Presidenza del Consiglio dei Ministri, acessed 8 April 2024, <https://www.normattiva.it/uri-res/N2Ls?urn:nir:stato:decreto.legislativo:2016-06-22;128!vig=>

[16] Gazzetta ufficiale, *DECRETO LEGISLATIVO 8 novembre 2021, n. 207*, Della Rupubblica Italiana, acessed 8 April 2024, <https://www.gazzettaufficiale.it/eli/id/2021/12/09/21G00230/sg>

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disturbing radio interference covers such equipment RF parameters as frequency stability, RF power, side-channel emissions, spurious domain emissions, receiver sensitivity, receiver selectivity, etc. Radio equipment is required to be with CE marking. It is mandatory for distribution in the EU and use in Italy, although compliance with CE requirements alone does not permit use in Italy without adhering to the above mentioned Legislative Decree No. 128 of June 22, 2016.

4.8.2 Usage of assigned radio licence

In order to create a new site for PLMN using all assigned bands/frequencies, the opinion of the ARPA (Regional Environmental Protection Agency) of the region where the site is to be created are requested.

The Arpa opinion aims to protect the citizen with regards to EMF (Electromagnetic Fields) and through the AIE (Electromagnetic Impact Analysis) there is a projection; the opinion can be both positive but also negative (e.g. proximity to schools).

4.8.3 Development of electronic communications network installation project

To install an electronic communication network in Italy, it is necessary to acquire a specific authorisation under Article 11 of the Italian ECC. The application for authorisation must include:

1. The description of the service;
2. The relevant part of the Italian territory;
3. The required duration of authorization (max 20 years);
4. An explanatory description and technical plan of the Network, including hardware inventory
5. The estimated launch date.
6. Contract with location owner.
7. Executive project including all technical specification for Radio system and civil works.
8. Restriction for safety in work, DL 81-08.
9. BTS map plan.

4.8.4 Commissioning of base station

To build a new base station for PLMN, the opinions of the municipality and region where the site is to be created are requested.

The Operator asks for the municipal/regional opinions about:

1. Landscape.
2. Hydrogeological risks.
3. Wooded areas.
4. Park.
5. Fine arts etc.

Once the opinions that insist on that area have been obtained through the maps (all design/architecture studios have them), Operator can start with the implementation through the nomination of a Works Management Director and tester and according to the project submitted to the municipality.

1. The standard procedure is:
2. CIL (communication of the start of civil works) is registered
3. the works are carried out
4. there will be a RSU (Structure Completed Report) + Testing (civil engineering)
5. the site goes "on air"
6. CFL (communication of the end of civil works) + CAI (activation system)

4.9 RF SPECTRUM CHALLENGES FOR UNMANNED AVIATION

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The operation of UAV presents several issues for radio spectrum management in terms of ensuring safe operation, efficient spectrum consumption and coexistence with common spectrum wireless technologies. RF spectrum has limitations when applied to dynamics UAV networks that require adaptive spectrum decisions and algorithms that provide seamless and reliable services.

As the 5G4LIVES project is intended for the BVLOS flights of UAV, the cellular connectivity has the potential to be a key component of BVLOS operations, providing a solution to range and interference issues that may be encountered with traditional RF datalinks. Figure 19 illustrates the use of typical wireless communications channels used for UAV's.

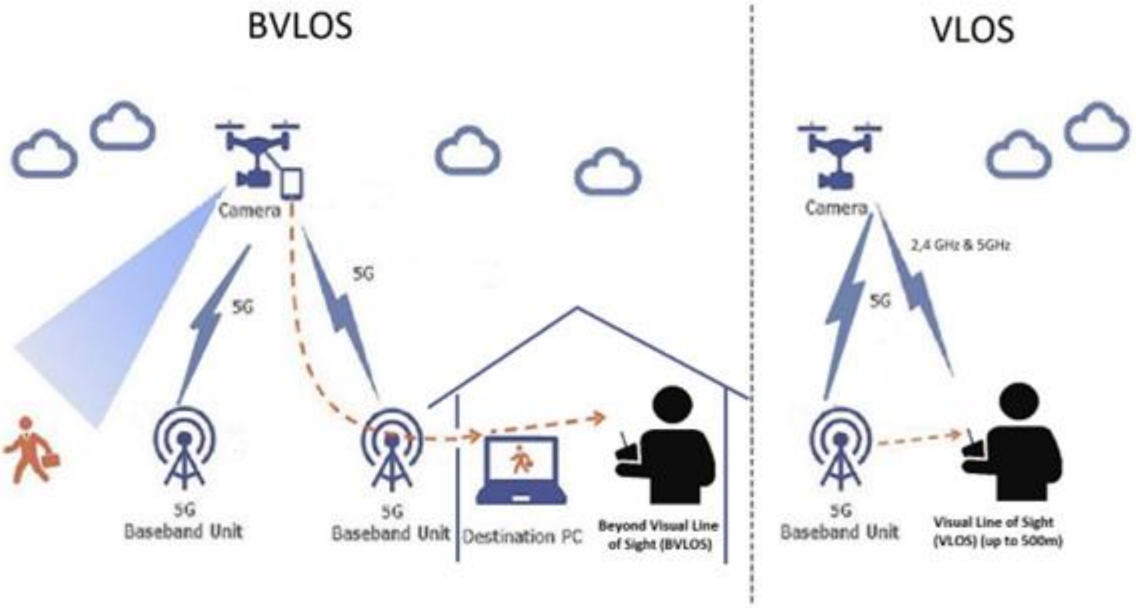

Figure 21. Communication channels for UAV command, control and payload

In order to use of 5G networks for UAV operation, operational and technical conditions for the use of UAVs for communications based on LTE and 5G NR bands harmonised for MFCN, according to ECC/DEC/(22)07 and summary listed above in Table 3. Current UAV models available on the market use Wifi technology as part of the connectivity channel to the base station.

In the event of a cellular network failure, a robust scheme must be in place to maintain communications with the UAV through alternative channels (typically licence-exempt bands 2.4 GHz and 5.8 GHz).

The 2.4 GHz and 5.8 GHz RF bands are widely used by modern wireless communication systems such as Wi-Fi, Bluetooth and other data networks that must also be taken into account. As these bands are licence-exempt, the permitted power levels are quite low, leading to relatively small, expected flight areas. Moreover, UAV pilots may encounter interference, particularly when operating in residential areas.

GNSS interference could be also an issue for UAV pilots, particularly in urban areas. It can jeopardize UAV's accuracy, stability, and safety, as well as lead it to lose control or crash. Interference of GNSS bands can be caused by radio, electrical or electronic equipment that does not meet the basic requirements of RED or jammers. Additionally, there has been a noticeable rise in GNSS signal interference in the Baltic Sea region since the hostilities in Ukraine.

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5. REGULATORY FRAMEWORK FOR PILOTED SOLUTIONS (UAV REGULATORY CONSTRAINTS)

As detailed in the previous Sections, the 5G4LIVES projects aims at using 5G technologies and UAV-based solutions for the public utility and, in particular, to deal with emergency scenarios.

In the last years, UAVs have been used to provide several civil applications for monitoring, mapping, package delivery, and surveillance, to name a few. However, in most cases the UAV operates in with the UAS operator in Visual Line Of Sight (VLOS) in a rural or controlled areas, providing a low risk to people and third parties.

On the contrary, the execution of UAV missions in urban and suburban areas is critical posing challenges in public safety, privacy and cybersecurity. In particular, the main problem regards public safety: a possible uncontrolled crash of the UAV on the ground may involve people and, in the worst case, it may cause casualties.

For these reasons, National Aviation Agencies, such as ENAC (Ente Nazionale per l'Aviazione Civile) in Italy and CAA (Civilās aviācijas aģentūra) in Latvia, strongly restrict the use of UAV over populated areas. Most of the operations in these areas are granted after a request of authorization and conducted in VLOS and over controlled ground areas, i.e. ensuring that no people are in the area involved by the operation.

In this project, one of the main challenges is to conduct operations in BVLOS (Beyond Visual Line Of Sight) also in urban and suburban areas. In the next sections, we will analyse the current UAV regulations applied at the EU level and, specifically, referring to the Italian and Latvian territory. After, we will analyse the different use-case scenarios schedule in Turin and in Riga discussing how they can be performed according to the European, Italian and Latvian regulations. In conclusion, we will introduce the methodology for planning and validating BVLOS flights and how can be tested in the different use-case scenarios.

5.1 CURRENT UAV REGULATIONS

In the EU area refers two regulations frameworks, that cover UAV operations in European Union, implementing regulation 947 (Implementing Regulation (EU) 947/2019) and delegated regulation 945 (Delegated Regulation (EU) 945/2019). Both regulatory documents are the main guidance for UAV operators refer to all legal aspects and policies in force, ensuring operations compliance. For the U-space environment, integration and operation following EU regulations to be considered: Commission Implementing Regulation (EU) 2021/665; Commission Implementing Regulation (EU) 2021/666.

For the 5G4LIVES Platform and implementing environment (respectively – for the pilots and integrations), Commission regulations 947/2019 and 945/2019 primary applied, since for the scalability potential as defined in Project proposal concept, and to consider of 5G4LIVES potential, the U-space regulatory framework should be considered.

1. Delegated Regulation 945 details the design and manufacturing standards and processes for Uncrewed Aircraft Systems (UAS). It establishes requirements to ensure that UAS products across the EU meet compliance, safety, reliability, standards.
2. Implementing Regulation 947 sets forth the procedures and rules for the operation of Uncrewed Aircraft Systems (UAS) as well as procedures for the personnel involved into UAV operations, including remote pilots, across EU states. Regulation 947 outlines the operational requirements to ensure safe and standardized UAS operations in all EU member states.
3. Implementing Regulation 2021/665 ensure procedures and requirements for providers of air traffic management/air navigation services and other air traffic management network functions in the U-space airspace designated in controlled airspace.

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4. Implementing Regulation 2021/666 sets specific procedures and requirements for manned aviation operating in U-space airspace, providing approach for interaction between manned aircraft and UAVs operating in specific environments.

The above-mentioned regulations can serve as existing roadmaps of EASA, using which one can present with a high degree of detail which regulatory aspects need to be taken into consideration in each specific case.

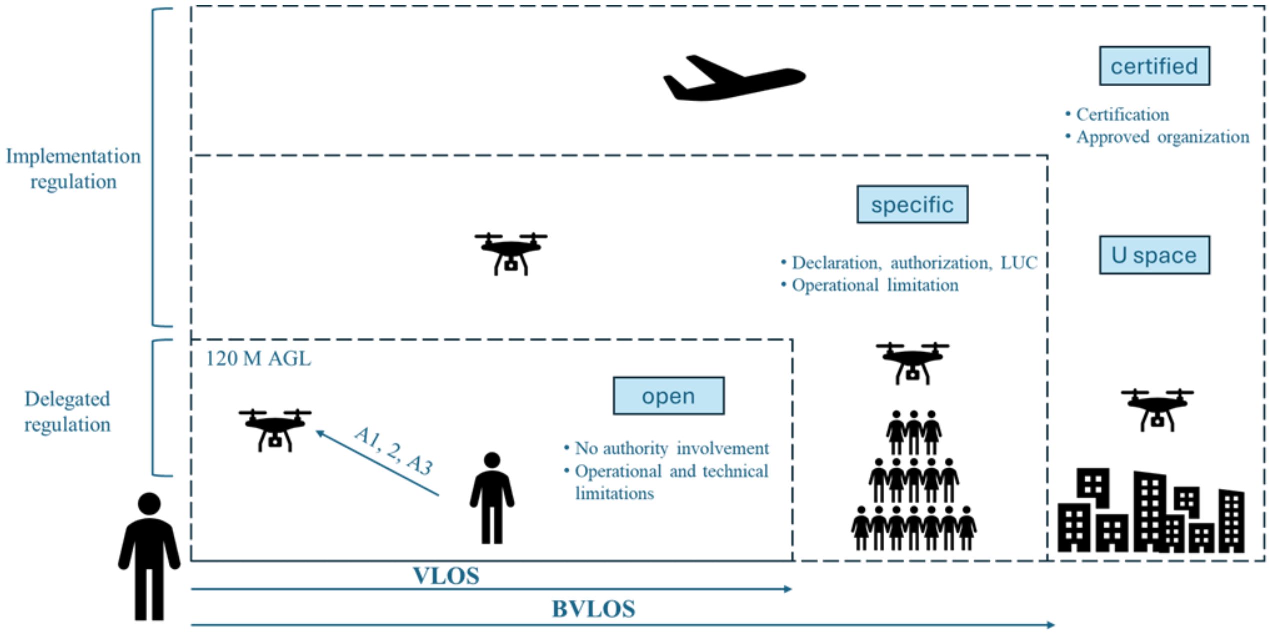

Figure 22. A conceptual regulatory framework of the EC for considering UAV implementation cases.

In addition to the aforementioned regulations that are currently active, the European Commission has been developing a range of frameworks, recommendations, and opinions regarding the development of UAVs in the European Union. These cover both integration and application aspects, as well as technical requirements for equipment, operation, and training. These frameworks encompass many crucial aspects that go well beyond just the development of UAV technologies. They consider societal acceptance of such technologies, economic impact, ethical aspects, the development of future competencies in the education sector, and more.

To denote the latest systems and services, and due to the lack of a definition and in line with the regulatory operation-centric approach, EASA has developed the concept of Innovative Aerial Services (IAS). IAS corresponds to a set of operations and/or services that benefit citizens and the aviation market, enabled by new airborne technologies. These operations and/or services include both the transportation of passengers and/or cargo and aerial operations (e.g., surveillance, inspections, mapping, telecommunication networking). IAS can be further divided into "aerial operations" (surveillance, inspection, imaging, etc.), as well as an entirely new emerging market called Innovative Air Mobility (IAM).

Figure 23. Concept scope of the Innovative Aerial Services

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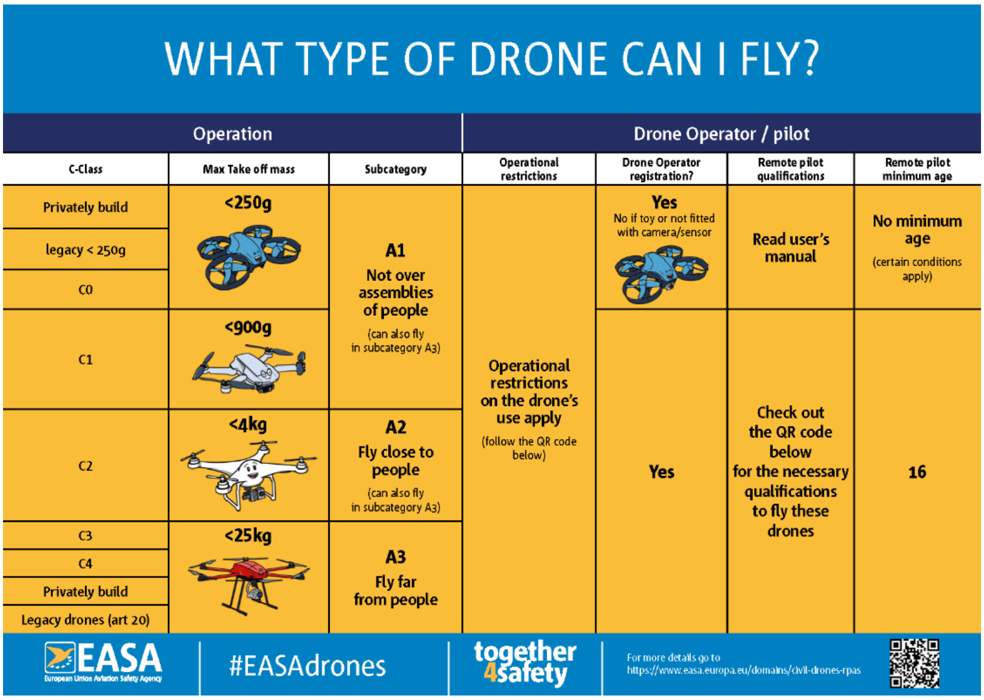
In the European countries the UAV regulation is based on the legislation published by EASA (European Aviation Safety Agency)[17] and it is up to the National Aviation Agencies (e.g. ENAC in Italy) or CAA in Latvia to ensure compliance with European legislation and clarify any details not covered by the EU legislation.

The EU UAV regulation adopted a risk-based approach, in which three risk-based categories of UAS operations are identified: Open, Specific, and Certified.

The Open category refers to the lower-risk civil UAV operations in which the safety is ensured by the UAV operator satisfying some operational requirements: all the operations are conducted in VLOS (Visual Line Of Sight) avoiding to fly over uninvolved people, except with harmless and low-mass UAVs (with MTOM < 900g). This category includes three subcategories, namely A1 (Fly over people but not assemblies of people. With MTOM < 900g), A2 (Fly close to people. with MTOM < 4kg), and A3 (Fly far from people. With MTOM < 25kg). Operational risks in the Open category are considered low and, therefore, no operational authorisation is required before starting a flight.


WHAT TYPE OF DRONE CAN I FLY?

Operation			Drone Operator / pilot			
C-Class	Max Take off mass	Subcategory	Operational restrictions	Drone Operator registration?	Remote pilot qualifications	Remote pilot minimum age
Privately build legacy < 250g C0	<250g	A1 Not over assemblies of people (can also fly in subcategory A3)	Operational restrictions on the drone's use apply (follow the QR code below)	Yes No if toy or not fitted with camera/sensor	Read user's manual	No minimum age (certain conditions apply)
C1	<900g			Yes	Check out the QR code below for the necessary qualifications to fly these drones	16
C2	<4kg	A2 Fly close to people (can also fly in subcategory A3)				
C3 C4 Privately build Legacy drones (art 20)	<25kg	A3 Fly far from people				

EASA European Union Aviation Safety Agency | #EASAdrones | together 4safety | For more details go to https://www.easa.europa.eu/domains/civil-drones-rpas

Figure 24. table reporting the different scenarios within the Open Category. Source [EASA]

The Specific category covers riskier UAV operations, where safety is ensured by the UAV operator by obtaining an authorization from the competent National Aviation Authority (ENAC in Italy) and CAA (Civilās aviācijas aģentūra) in Latvia before starting the operation. To obtain the authorization, the operator has to conduct a risk assessment, which will determine the main requirements necessary to conduct a safe operation. This category includes most of the civil operations that do not fall within the Open category, i.e. BVLOS (Beyond Visual Line Of Sight) flights, with a MTOM greater than 25kg, flying over populated areas, flying in non-conventional airspace, etc.

As previously defined, in order to fly within this category is required to obtain an authorization. Practically, the complexity of obtaining the authorization depends on the level of risk involved in the operation and we can identify three different scenarios:

1. Conducting an operation based on Standard Scenarios (STS), i.e. a predefined operation that can be conducted after submitting a declaration to the National Aviation Agency and without requesting and waiting for the authorization.

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[17] European Aviation Safety Agency, *Easy Access Rules for Unmanned Aircraft Systems (Regulations (EU) 2019/947 and 2019/945). (revision 2027)*, EASA, acessed 15 April 2024, <https://www.easa.europa.eu/en/document-library/easy-access-rules/easy-access-rules-unmanned-aircraft-systems-regulations-eu. Accessed: 2024-05-16>

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2. Conducting an operation based on a Predefined Risk Assessment (PDRA) scenario, i.e. a predefined scenario (with a greater risk than STS) on which a risk assessment is already conducted by the National Aviation Authority. The PDRA requires the authorization from the National Aviation Authority, but with a simplified process. In fact, the NAA already know the PDRA scenario, and the authorization process should be faster.
3. Conducting an operation not covered by STS and PDRA scenarios. This is the most complex scenario in which the UAV operator has to perform a risk assessment based on the SORA (Specific Operation Risk Assessment) process. The authorization for conducting the operation is granted after an in-depth analysis of the SORA from the NAA. The authorization process is more complex and slower. It often takes several iterations with NAA to meet safety requirements and conduct flight operations safely.

The Certified category covers operations with high risks and requires the certification of the UAV, as well as the licensing of the pilot. This category includes operations of passenger transport (air-taxi), dangerous goods, or UA. This category is reported for completeness, but in the following paragraphs it will never be taken into consideration, given that the use cases of the 5G4LIVES project do not fall into this category.

After this first analysis, it is clear that the authorization process becomes more complicated from the Open to the Certified category.

Nowadays, most of the civil operations that are generally conducted also for professional activities fall in the Open category requiring a pilot in VLOS. This choice is often preferred to conduct operations quickly and easily, without requiring a long waiting time for authorization and with requirements that are easily satisfied in most operations.

However, the VLOS requirement is a strong restriction with UAVs. The advantage of using UAVs for surveillance and monitoring is their ability to cover large areas in a short time with a unique point of view, and without being limited by artificial and natural barriers. Therefore, to benefit from the advantages and unique characteristics of UAVs, the flight operator should operate in BVLOS (Beyond Visual line Of Sight).

The BVLOS flight can be conducted only within the Specific category. Nowadays, conducting BVLOS flights is a challenge due to the requirements imposed by NAAs. The scenario is even more challenging if you want to operate in urban and sub-urban environments, as in the 5G4LIVES project.

According to the European Regulatory framework, within the Specific category the BVLOS flight can be conducted in the following scenarios[18]:

1. European Standard Scenario STS-02: BVLOS flight operation (up to 1km) over controlled ground area, i.e. no uninvolved people in the operational area. This scenario requires the use of a UAV with the C6 Identification Label.

2. European PDRA-S02: BVLOS flight operation (up to 1km) over controlled ground area

3. European PDRA-G01: BVLOS flight operation with airspace observer (technically is a EVLOS) in an uncontrolled airspace over sparsely populated areas.

4. European PDRA-G02: BVLOS flight operation within the C2 link range (radio line of sight) in reserved/segregated airspace over sparsely populated areas.

[18] European Aviation Safety Agency, *Easy Access Rules for Unmanned Aircraft Systems (Regulations (EU) 2019/947 and 2019/945). (revision 2027)*, EASA, acessed 15 April 2024, <https://www.easa.europa.eu/en/document-library/easy-access-rules/easy-access-rules-unmanned-aircraft-systems-regulations-eu. Accessed: 2024-05-16>

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5. European PDRA-G03: BVLOS flight operation within the C2 link range (radio line of sight) operating close to obstacles over sparsely populated areas.

6. Other scenarios: any other scenario can be taken into consideration but requires a risk assessment using the SORA process.

In the list above, only the main features that concern the operation in BVLOS are shown. Each scenario has different requirements of the UAV, operator and adoption of different risk mitigations that must be ensured to execute a safe operation.

In all the previous scenarios, the UAS operator has to verify also that the operational area has no aerial restrictions, i.e. it is in a no-flight area or has flight altitude restrictions. This occurrence can be verified by using specific maps provided by the NAAs in all the European countries, such as D-Flight in Italy, and the Electronic Unmanned Aircraft Restrictions Viewer (eUARV), which provides the aeronautical information necessary for the operation of Unmanned Aircraft (UA) in Latvia. In case of operation in a no-flight area, the UAS operator should ask for the permission to fly to the institution/organization that impose the restriction. In some scenarios the issuance of a NOTAM may be required.

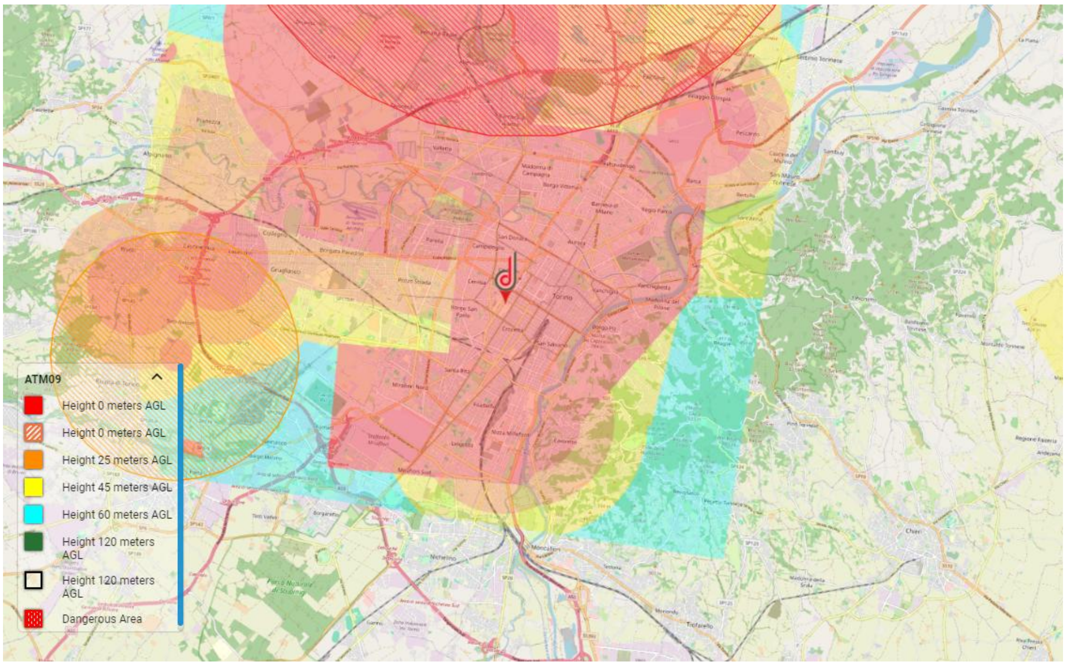

Figure 25. Visualization of no fly zones and altitude restriction in the turin metropolitan area visualized in the d-flight portal

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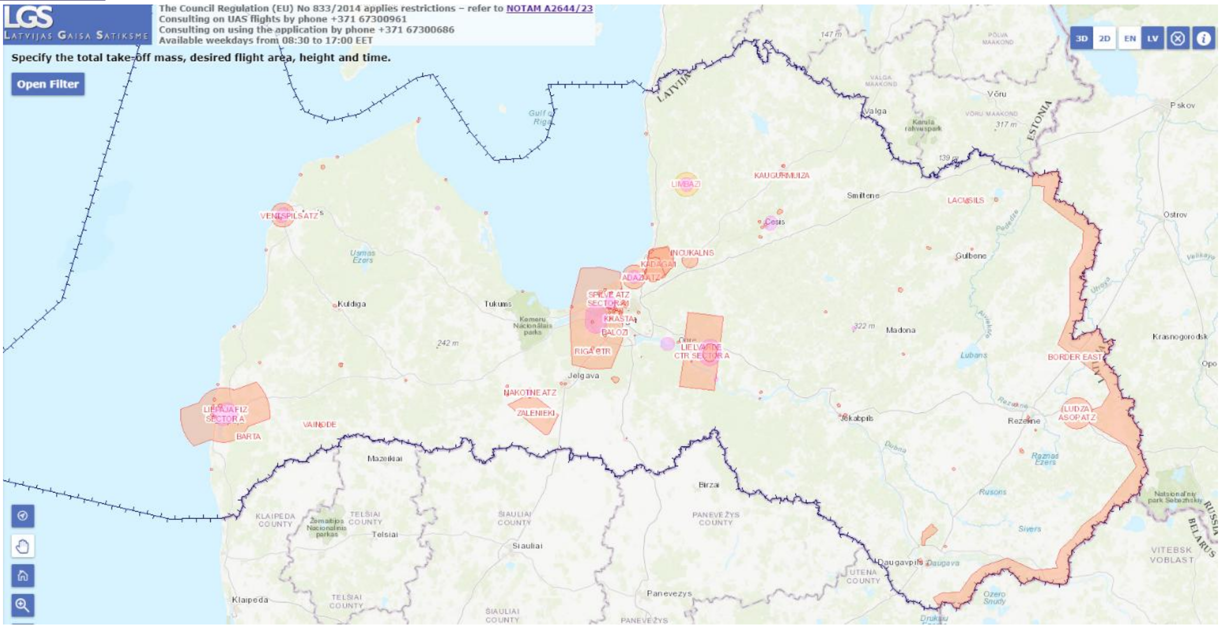

Figure 26. Visualization of no fly zones and altitude restriction in LATVIA visualized in the airspace.lv PORTAL

Within the Italian scenario, the regulatory requirements may undergo variations when state aircraft (Aeromobili di Stato) are used, as they may have concessions from ENAC for the execution of operations with UAVs. This privileged condition is valid for UAVs of the police forces, firefighters and other entities that operate to deal with emergencies.

In the next Section we will analyse each use case scenario, considering the type of UAV, the flight mode and the overflight area. The use-case scenarios identified in this document mainly fall in the Specific category.

5.2 Riga use-case

5.2.1 Flight plans

There are three flight plans, one for Vecu beach and two for Kisezers lake. These plans are described in previous 3.1. section about use-cases to be tested. Flight plans are prepared for approximate characteristics of the possible UAV options. Before starting the tests, flight permission will be obtained from the Civil Aviation Agency. The application form is available on the Civil Aviation Agency web-page. Operating permits (like airspace use permits) must be obtained regardless of the purpose of the flights or the status of the UAV user. A natural person who flies an UAV for recreational purposes is also required to obtain an operating permit if the flights are to be performed in derogation from the conditions and restrictions set for the open category.

5.2.2 Flight permission

The risk assessment mentioned in Article 11 of Regulation (EU) 2019/947 will serve as the foundation for the preparation of the application for an operational authorization. It must be submitted with the following documents:

1. A reference to a "Predefined Risk Assessment" or an operational risk assessment conducted in compliance with the SORA methodology.
2. A list of risk-reduction strategies that includes enough details to enable an evaluation of how well the strategies match the risks (per the SORA approach).
3. An operations handbook that includes details on the UAS operator, the unmanned operations, the roles and responsibilities of the personnel engaged in the operation, the training given, and technical details about the UAS.
4. Verification that the necessary insurance will be in place before the flights start.
5. Evidence of payment for the service in line with the Public Chargeable Services Price List published by the Civil Aviation Agency.

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Additional restrictions

Flight plan "Vecaku beach" is planned in RIGA Airport controlled zone RIGA CTR and part of flight plan "Kisezers lake. Flight towards Jaunciems" partially is planned in RIGA CTR and in Aerodrome Traffic Zone – SPILVE ATZ SECTOR B. In these zones UAVs operates under certain restrictions, with a maximum flight altitude of 50 meters and a maximum takeoff mass (MTOM) of 2 kilograms.

In that case, more flight zones restrictions must be requested, for example, no flight zones for other UAS.

Besides flight permission UAS operator also have to verify that the operational area has no aerial restrictions, i.e. it is in a no-flight area or has flight altitude restrictions. As mentioned before in case of Republic of Latvia this occurrence can be verified by using specific map provided by SJSC "Latvijas gaisa satiksme". From 2 January 2020, a new service is available - the eUARV, which provides the aeronautical information necessary for the operation of UA.

Before operating an UA flight the obligation of a remote pilot is to familiarize himself/herself with the aeronautical information available on the website https://ais.lgs.lv

eUARV represents both static and dynamic elements of the airspace structure, the active time of which may affect the operation of UA flights. If a permission is required to perform UA flights, the procedures for the permission obtaining is indicated.

For example, eUARV represents:

1. permanent active airspace structure elements;
2. dynamic elements of the airspace structure for which UA flights are prohibited during their active operation (at a time when they are not active, UA flights may be operated);
3. UA flight restrictions near certified aerodromes and certified heliports;
4. UA flight restrictions around different infrastructure objects where UA flights can be performed at a specified distance around infrastructure objects only with the permission of the owner of the object.

The principles of Flexible Use of Airspace have been introduced into the airspace of the Republic of Latvia, which requires the remote pilot, when planning a UA flight, to take into account that the activation of dynamic airspace structure elements is known at least one day in advance (airspace use plan for the next day is available by 1400 UTC at the latest).

5.3 Turino use case

This section discusses how the use case scenarios can be conducted considering the regulatory framework. First of all, based on the experience (and lessons learned) of the Italian partners in carrying out flight operations using UAVs, we will try to fall back into the STS and PDRA scenarios to avoid authorization problems.

In fact, it is not easy to estimate the time required for the authorization of a SORA and, often, the NAA tends to impose constraints that lead back to the PDRA scenarios (already in line with the safety requirements).

5.3.1 1st scenario

The first scenario includes the use of a quadcopter UAV with a MTOM < 4kg operating in a suburban area that is sparsely populated.

Considering these characteristics, the flight operation is Specific and can be conducted within one the European PDRA scenarios: PDRA-G01 or PDRA-G02. After a preliminary analysis, both the PDRA scenarios are suitable for the first use-case, depending on the operational characteristics adopted:

Considering the PDRA-G01 scenario we have the following features:

1. BVLOS flight up to 1km, or on a longer distance with the use of airspace observer.
2. Uncontrolled airspace below 120m (over sparsely populated area).
3. with a UAS that meets the technical requirements defined in the PDRA, such as the adoption of a flight termination system.

Considering the PDRA-G02 scenario we have the following features:

1. BVLOS within the range of the direct C2 link (radio line of sight).
2. In reserved/segregated airspace over sparsely populated area.
3. with a UAS that meets the technical requirements defined in the PDRA, such as the adoption of a flight termination system.

Comparing the PDRA-G01 and PDRA-G02 scenarios we note that are both suitable for the 1s use-case. The scenarios differ in the flight mode and on the airspace characteristic.

The best PDRA scenario will be selected during the project in preparation of the demonstration flights.

UAV SPECIFICATIONS

The UAV that will be used to carry out the first scenario is the DJI Matrice M30, with the following characteristics:

1. Maximum Take Off Mass (MTOM): 4069 g
2. Maximum dimension: 668 mm
3. Maximum horizontal velocity: 23 m/s (limited during the operations in the use-cases)
4. Maximum hovering time: 36 min

OPERATIONAL AREA

As discussed in the section about the Turin use-case, the hilly area of the city of Turin is taken into account. In particular, the specific operational area will be selected considering compatibility with the PDRA-G01 and PDRA-G02 mentioned above.

First of all, we will consider the constraints of the airspace. Checking on D-flight, some areas of the hill have a maximum altitude limitation set at 45 or 60 meters. However, the remaining part of the hill is free from any restrictions, therefore with a maximum altitude of 120m.

The operational area will be selected also considering the constraints on the ground. The PDRA-G01 and PDRA-G02 require to fly over a sparsely populated area, requirement satisfied in most of the hilly area, with the exception of small residential areas and busy roads which will be avoided.

5.3.2 2nd scenario

The second scenario includes the use of a fixed wing UAV with a MTOM < 2kg operating in a suburban area that is sparsely populated. Considering these characteristics, the flight operation is Specific and can be conducted considering the standard scenario STS-02. This scenario is selected because it includes a BVLOS operation with a UAV with a C6 Class identification label. The main characteristics of this scenario are listed as follows with some considerations:

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1. BVLOS flight up to 1km distance, or 2km if airspace observer is used: considering the operational area selected for the use-case, a BVLOS up to 1 km is the best choice to demonstrate the possibility of conducting a BVLOS flight.
2. below 120m: checking on the D-Flight portal, no restrictions on the airspace are identified in the operational area.
3. with a UAS bearing a C6 Class identification label: the selected fixed wing UAV has this label.
4. ensure no involved person is present in the controlled ground area: the selected area includes roads and some residential buildings. For this reason, the flight plan will be selected considering this constraint, or, if not possible, we will properly control the ground area.
5. over a controlled ground area within a sparsely populated area: the selected area meets this requirement.

We remind to[19] for the details about the STS-02 scenario.

With a preliminary analysis, the STS-02 standard scenario is the best one for the 2nd use-case scenario: the operational area, the aircraft and the pilot (with a proper pilot license) meet all the requirements. However, a more in-depth analysis will be conducted during the project in preparation with the demonstration activity.

UAV SPECIFICATIONS

The UAV that will be used to carry out the first scenario is the AgEagle eBee X, with the following characteristics:

1. Maximum Take Off Mass (MTOM): about 1600 g.
2. Maximum dimension: 1160 mm (wingspan).
3. Maximum horizontal velocity: 30 m/s (limited during the operations in the use-cases).
4. Maximum flight time: 90 min.
5. EU C2 and C6 identification class label.

OPERATIONAL AREA

Similarly to the first use-case, also this use-case is conducted in the hilly area of the city of Turin. For this reason, similar considerations are made about the selection of the operational area.

Regarding the airspace, according with D-flight, some areas of the hill have a maximum altitude limitation set at 45 or 60 meters.

Differently, the ground area has to be selected considering the requirements of the STS-02 scenario. In fact, operations within this scenario require a controlled ground area. However, the hill has several green areas and woods that can be controlled, ensuring to do not fly over people not involved in the flight operations.

5.4 OTHER REGULATORY CONSTRAINTS

As previously defined, the use of UAVs poses several challenges in public safety, privacy and cybersecurity, to name a few. While the risk related to public safety is mitigated by the UAV regulations, the other issues require further analysis and in-depth analysis.

[19] European Aviation Safety Agency, *Easy Access Rules for Unmanned Aircraft Systems (Regulations (EU) 2019/947 and 2019/945). (revision 2027)*, EASA, acessed 15 April 2024, <https://www.easa.europa.eu/en/document-library/easy-access-rules/easy-access-rules-unmanned-aircraft-systems-regulations-eu. Accessed: 2024-05-16>

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Regarding the privacy issue, at the European level some guidelines are explained by European drone regulation (EU) 2019/947, and (EU) 2019/945, which concerns technical specifications for UAVs.

The European Drone Regulation defines some rules that European Member States must adhere to. First, the Protection of personal data according to the well-known UE 2016/679 (GDPR): UAVs are systems with a camera and an internal memory, able to acquire and save personal data. Fors this reason, the UAV system has to be considered as any other video-recording system.

For instance, UAV operators must obtain the consent of the individuals concerned before collecting, recording, or transmitting personal data through the use of UAVs. In public spaces, people can be informed by using specific signs reporting the GDPR informative for privacy and data protection. In fact, individuals have the right to privacy and the protection of their personal data concerning the use of UAVs, and they must be informed clearly and transparently about how their data is used and processed.

However, in addition to European legislation, each European state may have its own regulations that must be respected.

5.4.1 Methodology for planning and validations of BVLOS flight

From the analysis carried out in the previous paragraphs it is clear that flight operations are currently limited, in particular those in BVLOS mode. At the moment BVLOS operations are only permitted over controlled ground areas ensuring that in the event of an accident, no uninvolved people are within the operational area.

This limitation arises from the risk assessment methodology proposed within SORA which is mainly qualitative. In fact, the SORA process evaluates the risk in the overall operating scenario, without analysing the operational area in detail. To give an example, SORA limits operations in urban areas because they are populated. However, although urban areas are critical, safety areas can be identified where the risk on the ground is reduced.

In order to overcome this limitation, a solution is the adoption of a high-fidelity risk assessment. For this purpose, one of the goal within the 5G4LIVES project is the development of a Methodology for planning and validating BVLOS flight, in which the core of the methodology is the adoption of a high fidelity risk assessment approach that is able to assess the ground risk of a UAV operation in a quantitative approach. The high fidelity risk assessment makes use of population density data to estimate the distribution of people on the ground, and, then, estimate the number of people that can be involved in an impact with the UAV after an uncontrolled crash.

The methodology will include the following functionalities:

1. Use of risk maps to quantify the risk over large areas. The risk map can be used by UAS operators to have an estimation about the distribution of the ground risk in the operational area. The risk map can be computed both offline (mission planning) and online during the mission execution.
2. Definition of a safe flight by using a risk-aware path planning approach that searches for a safe path minimizing the risk and the flight time. Also this functionality can be used offline (mission planning) and online (mission update based on the updated risk map).
3. Validation of a flight mission. Given a pre-defined route, manually planned by the UAS operator, the methodology computes the resulting risk determining if it is adequate or not.

Moreover, according with the goals of 5G4LIVES project, the methodology will exploit the 5G technology for enhancing functionalities:

1. Real-time transmission of the UAV's position, required to provide an online evaluation of the risk and an updated route.

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2. Evaluation of a 5G coverage map, in order to design a flight mission that optimizes the quality of the mobile signal.

The last feature assumes a considerable importance with connected UAV. In fact, the UAV should perform a path that is safe from the ground risk point of view, but also guaranteeing an adequate and continuous connection with the mobile network, required to communicate with the ground segment.

The methodology here described is a risk-informed decision making tool that introduces several benefits both for UAS operators and NAAs.

On one hand, UAS operators can use the methodology for designing a safe UAS operation and assessing the risk with a high fidelity risk assessment. Moreover, the methodology can be used as a risk mitigation strategy M2 to SORA, providing a quantitavice risk assessment.

On the other hand, NAAs can also benefit from the methodology, because they can exploit the tool to verify the risk of a flight mission submitted for an authorization request. Obviously, this requires a review of the methodology and of the tool by the National Aviation Authority.

We also point out that, even if the proposed method will be tested in Turin, the proposed approach meets the requirement of the regulatory framework and is valid at the European level.

For a detailed description of the methodology, the definition of its requirements, and a preliminary plan of the implementation, refer to the Deliverable D2.1.

After the implementation, the methodology will be tested in the use-cases that will take place in Turin, Italy. In particular, the methodology will be used to evaluate the risk in the operational area, as well as to design a flight mission in compliance with the regulatory framework and with an adequate level of risk. The output of the risk assessment methodology will differ a lot considering the quadcopter of the use-case 1 and the fixed-wing aircraft used in the use-case 2, since the risk depends on the UAS characteristics.

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6. PRELIMINARY KPIS

The Project's application outlines general KPIs generated for future performance assessment, generally associated with the Network's performance and UAV performance. These include:

1. Latency (the value is expected to be lower than 50 ms).
2. Peak data rate: the peak data rate is up to 1.5 Gbps assuming one device camped on the cell.
3. UAV KPIs.
4. Degree accuracy when tracking UAV.
5. Streaming quality.
6. Usability (app and interface).

At the same time, the Project Objectives outlined in the application serve as the basis for creating specific KPIs, which can be one of the main metrics for measuring the achievement of both Project goals and measurable values, serving as the defining parameters for Scenario design and evaluating its performance during pilots.

Table 6. Preliminary set of KPIs

KPI	Measurement Unit	Description	Relation to PO
Reduction in response time	Minutes	Average time taken to respond to emergency incidents.	Improve effectiveness of lifesaving and rescue operations
Success rate of Interventions	Percentage	Percentage of successful life-saving interventions and rescues with UAS in operation	Improve effectiveness of lifesaving and rescue operations
UAV deployment rate	Percentage	Percentage of incidents where UAS were deployed.	Improve effectiveness of lifesaving and rescue operations
Lives saved or injuries prevented	Count	Number of lives saved, or injuries prevented with UAS in operation	Improve effectiveness of lifesaving and rescue operations
Operation success rate	Percentage	Ratio of UAV mission, completed without any reported failures	Improve effectiveness of lifesaving and rescue operations
Decision-making time	Minutes / Seconds	Average time taken for lifeguards to make critical decisions	Enhance lifesaving and health protection services
Accuracy of predictions	Percentage	The ratio of situations that developed into incidents after recognition and prevented incidents after recognition	Enhance lifesaving and health protection services
Fatality/injury reduction rate	Percentage	Percentage reduction in fatalities or injuries on public beaches	Enhance lifesaving and health protection services

For the developed Scenario, it is necessary to consider KPIs directly specified in the Project as well as those that evaluate the performance, reliability, stability of the 5G network, operational indicators of UAVs, efficiency of the developed Scenario, security, safety, and reliability.

The detailed values of KPIs will be determined within work package 3.

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7. GAP ASSESMENT

One of the main outcomes impacting the sustainable exploitation of the 5G4LIVES project results is the ability to scale use cases, technologies, and developed/tested methodologies at the European Union level. It is necessary to consider not only the aspects of existing legal documents and frameworks but also many other factors that influence the broad integration of automated innovative solutions related to critical tasks, such as saving lives and search & rescue operations.

The results of the 5G4LIVES project can be categorized into critical areas, which may be influenced by regulations and legislative changes related to technological development:

1. Active participation and acceptance from society.
2. Optimized use of technologies.
3. Promoting the human dimension.

7.1 ACTIVE PARTICIPATION AND ACCEPTANCE FROM SOCIETY

As stated in research of acceptance of UAVs by EU citizens, “A Drone Strategy 2.0 for a Smart and Sustainable Unmanned Aircraft Eco-System in Europe” the social benefits of UAV operations should be highlighted as they would justify support from national and local public authorities to further their development. The main benefits which can secure public acceptance would first and foremost be emergency medical transport, transport of medical products and other first aid and rescue applications.

In this context, the 5G4LIVES platform is a development with a high potential for societal acceptance, as it directly impacts the effectiveness of rescue operations and preventive activities aimed at ensuring people's safety.

At the same time, there are clear challenges that need to be taken into account despite the overall benefits of integrating UAVs into the 5G4LIVES platform. These challenges directly or indirectly affect society and contribute to certain barriers to acceptance.

It is clear that the fact that the UAVs operated at a low and medium altitude over populated areas also raise safety concerns. EU citizens want to limit their own exposure to all possible risks, whether related to safety, noise, security, and environmental impact (including the protection of the wildlife), as well as other concerns related for instance to cyber-security. On the economic side, the issue of affordability is of key importance. IAM should not be seen as a service for a small part of the population only. Public acceptance will also be based on the price of the service offered by IAM operators.

7.1.1 Challenges Identified with Societal Acceptance of the 5G4LIVES Project Results

Existing challenges (SA-C):

1. SA-C-1: Privacy aspects of the population related to the collection and processing of information by UAVs, GDPR.
2. SA-C-2: Safety and reliability of UAV systems conducting flights over groups of people and over populated infrastructure.
3. SA-C-3: Cybersecurity of 5G4LIVES systems and data protection, protection against cyber threats.
4. SA-C-4: Noise produced by UAVs.
5. SA-C-5: Impact on the environment and nature, especially near wildlife.
6. SA-C-6: Battery disposal and associated pollution issues.

Noise is a key factor which has been highlighted as a major obstacle to UAV integration. This is due not only to the actual noise UAVs produce (often a high-pitched tone), but also to the ways in which noise is perceived – such as disruption of people’s tranquility and people’s familiarity with and acceptance levels of UAVs, or surrounding noise levels). In cities, the ambient noise levels of conventional vehicles may make UAV noise less apparent if flown along main roads at very low altitude. However, their proximity to residential areas, and the increasing uptake of quieter electric ground vehicles, may make UAVs more noticeable and create strong, localized pushback as the market expands.

To help avoid this, the Commission will fund the development by EASA of an online platform as a "pilot project Sustainable IAM Hub" that will provide support to authorities, cities, industry, and other stakeholders for IAM implementation. This European cross-sectorial governance platform for IAM should enable engagement, alignment, and coordination between the different stakeholders. Furthermore, when developing the IAM regulatory framework, EASA could examine possible alleviations for specific use cases or operations that would be in the direct interest of the public.

In the Riga location use cases, the sound factor poses a challenge for the integration of the 5G4LIVES platform and should be considered when selecting parameters for automatic flight (corridors and routes), especially during the summer period. This is because the operating location is directly in recreational areas, and increased noise generated by UAVs can be a barrier to public acceptance in these leisure zones.

Anticipated future challenges are mainly related to technological advancements, particularly the capabilities of artificial intelligence, image processing and analysis systems, and other technologies that have seen widespread development. Another significant factor is automation and digitization, leading to the replacement of humans with systems.

Suggested challenges:

1. SA-C-7: Widespread implementation of artificial intelligence, automation of recognition systems, and as a result, threats associated with the correctness of AI usage.
2. SA-C-8: Replacement of humans with automated systems and digital tools, leading to non-acceptance due to threats associated with changes in the labor market and the availability of jobs, necessitating new competencies for workers related to the application of digital and automated systems.
3. SA-C-9: Integration of advanced automation and digitization systems into managed aviation, emergence of presumed and anticipated UAM systems – automated unmanned SAR systems, delivery UAVs, etc., leading to increased complexity in the requirements for interaction among all future participants in UAM concepts.

Specifics challenges:

1. SA-C-10: Integration of highly automated systems into services where system usage implies a specific outcome of the operation or action, system reliability being of high priority. For data collection and reliability analysis, numerous usage cases are required.
2. SA-C-11: Understanding and procedures related to how system usage impacts decision-making and whether erroneous actions are solely the responsibility of the human when using the system

7.2 Gaps Identified for the 5G4LIVES Platform (SA-G)

The identified gaps related to the integration and scaling of the 5G4LIVES platform are primarily associated with the relative unistructural and fragmentation of existing legislation in the areas of certification and classification. Despite this, for organizing pilot projects, the current common EU and national requirements and regulations can be used with sufficient flexibility.

Gaps:

1. SA-G-1: Sizes and weight for the categorization of UAVs, scenario of operations, and the corresponding regulatory framework for operation – when integrating specific payload tools for search & rescue operations.
2. SA-G-2: Lack of overall integration of unmanned systems into the operational space – potential for dynamic scenario changes, and the absence of a harmonized U-space with accepted standards.
3. SA-G-2: Technical and safety regulatory gaps preventing 'certified' operations, such as the operation of specific categories of UAVs in urban areas.
4. SA-G-3: Lack of clear, effective, and comprehensive insurance solutions.

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7.2.1 Opportunities Initiated by the 5G4LIVES Platform

Identified challenges and gaps create certain windows of opportunity that pertain to all aspects of the developing platform, including societal acceptance of technological solutions and operational methods. First and foremost, this involves obtaining test results, and most importantly, results from pilot integrations and demonstrations, which are crucial for addressing existing and future gaps and challenges.

When society sees positive outcomes from the implementation of UAVs and automation, and these results are widely publicized and explained, the acceptance of such systems will increase. This will involve a society that understands the benefits, such as improved safety (preventive measures) and rescue operations.

In turn, at the level of legislative bodies, government institutions, and high-level stakeholders, positive implementation cases will create a key-based drive for accelerating the removal of barriers and bottlenecks in scaling the obtained results. This will also drive the development and adoption of new legislative frameworks to overcome operational barriers for UAVs. Live testing and demonstrations are key to harnessing, developing, and accelerating the take-up of the most cutting-edge technological solutions to manage UAVs and innovative air mobility.

Opportunities (SA-O):

1. SA-O-1: Acceleration of the development, adaptation, and integration of use-case driven regulations.
2. SA-O-2: Testing various technological and methodological solutions for optimization.
3. Opportunity for local decision-makers to rethink their development projects with a new orientation, aimed at improving the quality and safety of life for their populations.
4. SA-O-3: Creation of new jobs.
5. SA-O-4: Stimulation of innovation and high-tech projects aimed at improving quality of life.
6. SA-O-4: Promotion of the implementation of next-generation 5G communication technologies.
7. SA-O-5: Creation of new products and services, including technological solutions and telecommunication services, oriented towards industrial solutions.

7.3 Optimized Use of Technologies

The 5G4LIVES platform combines high-tech solutions (existing or prospective), current methodologies, and innovative operational principles, all considering a high degree of process automation. The readiness and reliability of technologies are key aspects for the successful implementation of pilot projects, and the application of optimal technologies that ensure the planned KPIs is a priority. It is worth noting that for the development of the platform, it is important to consider not only existing and market-available technologies but also experimental developments and solutions with corresponding TRL levels. Additionally, the potential for scaling the project's results should be considered, including deployment across the EU, integration into complex operations, increasing the number of unmanned platforms operating simultaneously, and more.

7.3.1 Identified Technological Challenges of the 5G4LIVES Platform (UT-C)

Existing challenges **(UT-C)**:

1. UT-C-1: Security of all data collected, processed, and stored on the platform, ensuring it is not transmitted to external parties by any component of the system.
2. UT-C-2: European regulations are too strict and complicated to enable the easy implementation of experimental activities.
3. UT-C-3: The need to integrate complex security systems for specific categories of operations and UAVs.
4. UT-C-4: The lagging development in the regulation of use cases that are more interesting from a business case point of view.
5. UT-C-5: The necessity for precise real-time location and positioning of UAVs.

6. UT-C-6: Lack of centralized and harmonized guidelines for the deployment of 5G networks for the integration of BVLOS operations and public case studies, including network requirements and performance.
7. UT-C-7: A limited number of ready-to-use UAV solutions that are fully and directly controlled over the 5G network (not via a docking station) and that transmit payload data directly through the 5G network (not via a docking station).

Suggested challanges:

1. UT-C-8: Low and inconsistent readiness of regulation and procedures corresponding to operating platforms and UTM management.
2. UT-C-9: Lack of interfaces and information standards common to ATM and UTM.
3. UT-C-10: Difficulties in solutions for exchanging airspace reservation data and dynamically updating data in real-time for all ATM/UTM participants.

7.3.2 Gaps (UT-G)

1. UT-G-1: Differences in local regulations regarding the use of network communication frequencies and permission procedures.
2. UT-G-2: Regulations have not provided sufficient clarity on the future evolution of the UTM service provision framework with specific reference to U-space in controlled airspace.
3. UT-G-3: The U-space Regulations in their current versions are not designed to enable scalable traffic.
4. UT-G-4: Technical requirements are not harmonized between countries, it is a competitive disadvantage for European companies in UAVs and related services industry.

7.3.3 Opportunities (UT-O)

1. UT-O-1: Development of experimental systems and corresponding case studies using EU support programs.
2. UT-O-2: Creation of positive case studies and corresponding "toolsets" for scaling and consideration by policymakers and stakeholders.
3. UT-O-3: Stimulating the development of U-space and demonstrating the benefits of implementing corresponding components on market development, enhancing safety.
4. UT-O-:4 Creating new products and services that improve quality of life and stimulate market development and related services, expanding the UAV industry integrated into critical tasks for societal security.

7.3.4 Promoting the human dimension

The 5G4LIVES platform entails the use of automated systems, unmanned platforms, digital solutions for operation and management. These components presuppose the presence of competencies and corresponding training for all levels of users and stakeholders, as well as integrators. Users need to be provided with training, including the creation of new training programs for future competencies, in line with the system's scalability and the integration of new technical platforms. This applies not only to operators of unmanned systems but also to users, such as rescuers, police officers - these users must be able to effectively use the information received and interact accordingly; the respective procedures and algorithms of these users' work should be properly modernized and adapted.

Stakeholders and integrators, in turn, must understand the cost-benefit aspects of integration, optimize the application of systems at the tactical level, adjusting relevant scenarios and use cases, highlight the effectiveness of system application for the community in terms of acceptance and trust, collect and process feedback from users for improvements and ensuring the stability of integrated systems. Integrators, based on cases and pilot projects, create roadmaps and deployment recommendations for systems, taking into account the environment, use cases, and KPIs.

Competent authorities should have the necessary competences that reflect the highly digital and automated nature of the technologies underpinning UAV operations and U-space services provision as well as the necessary number of regulatory experts in UAV and UAV operations at both local and national authorities level to address industry needs.

The development of skills and competence will a key factor to maintain European leadership by ensuring that the different UAV segments can cope with complex regulatory requirements, i.e. certification of UAV operators, SORA,

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certification of Common Information Services and Uspace service providers. Without a highly educated, qualified and experienced workforce on the ground and in the air, operational safety cannot be achieved.

Challenges (HD-C):

1. HD-C-1: Development of a training module for pilot projects within 5G4LIVES.
2. HD-C-2: Lack of clear recommendations for operating within the 5G network ecosystem and corresponding training (at all user levels).
3. HD-C-3: Increased complexity (potentially) of competencies for users during the development and integration of U-space and the need for corresponding training.
4. HD-C-4: Discrepancies in local UAV operator training programs and corresponding methodologies.

Opportunities (HD-O):

1. HD-O-1: Creation of new training services with case-study elements.
2. HD-O-2: Utilization of the experience of the 5G4LIVES platform as an integration toolset and provision of integration and deployment service.
3. HD-O-3: Development of new competencies and expertise impacting the development of industries and economic sectors related to the 5G4LIVES platform - digitalization, automated systems, unmanned platforms, etc.

7.4 FUTURE PROVISION.

To address existing issues in the industry, remove barriers to the development of unmanned technologies, and secure leading positions for Europe, the European Commission has developed the Drone Strategy 2.0 development strategy.

The European Drone Strategy 2.0, adopted since 2022 by the Commission, sets out a vision for the further development of the European UAV market. It builds on the EU's safety framework for operating and setting the technical requirements of UAV, which is the world's most advanced. The new Strategy lays out how Europe can pursue large-scale commercial UAV operations while offering new opportunities in the sector.

Thanks to the EU's comprehensive regulatory framework, UAV s have flown safely for hundreds of thousands of hours in Europe's skies, for example surveying infrastructure, monitoring oil spills, or sampling soil. Projects on using UAV s for medical air deliveries, transporting medical samples between healthcare services are also making good progress. The implementation of the 'U-space' in January 2023, a European system unique in the world to manage UAV traffic safely, will lay the ground for increased operations.

Before pushing ahead with these innovative technologies, the Commission wants to ensure that society supports UAVs. To address concerns over noise, safety and privacy, the Strategy therefore calls for national, regional and local municipalities to ensure that UAV services are aligned with citizens' needs.

The Strategy envisions the following UAV services becoming part of European life by 2030:

1. Emergency services, mapping, imaging, inspection and surveillance within the applicable legal frameworks by civil UAVs, as well as the urgent delivery of small consignments, such as biological samples or medicines.
2. Innovative Air Mobility services, such as air taxis, providing regular transport services for passengers, initially with a pilot on board, but with the ultimate aim of fully automating operations.

Unleashing the potential of the EU UAV market and services requires the identification of critical technology building blocks, such as artificial intelligence, robotics, semi-conductors and EU space services and mobile telecommunications. This will help the EU build an innovative and competitive UAV sector, reducing strategic

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dependencies. The Strategy also identifies areas for synergies between civil and defense UAVs, and for increased C-UAS capabilities and system resilience.

The Commission launch work on the Strategy's 19 operational, technical and financial flagship actions to build the right regulatory and commercial environment for tomorrow's UAV air space and market:

1. Adopting common rules for airworthiness, and new training requirements for remote and eVTOL (manned electric Vertical Take Off and Landing) aircraft pilots.
2. Funding the creation of an online platform to support local stakeholders and industry implementing sustainable Innovative Air Mobility.
3. Developing a Strategic Drone Technology Roadmap to identify priority areas for research and innovation, to reduce existing strategic dependencies and avoid new ones arising.
4. Defining criteria for a voluntary cybersecurity-approved UAV label.

This work will prepare the way for large-scale commercial operations and ensure that Europe benefits from synergies between the civil, security and military use of UAVs and related technologies, including C-UAS solutions.

Table 7. Flagships for the development of the strategy and corresponding activities and legislative changes

Flagship action 1	The Commission intends to adopt amendments to the Standardised European Rules of the Air and the Air Traffic Management/Air Navigation Services Regulation to safely integrate UAV and piloted eVTOL operations.
Flagship action 2	The Commission will continue to promote coordinated research on integrated Communication, Navigation and Surveillance technologies to ensure the convergence between ATM and U-space environments.
Flagship action 3	The Commission intends to adopt new European standard scenarios for low to medium risk aerial operations.
Flagship action 4	The Commission intends to adopt rules for the 'certified' category of UAV operations, addressing the initial and continued airworthiness of UAVs subject to certification; and the operational requirements applicable to manned VTOL-capable aircraft.
Flagship action 5	The Commission intends to adopt rules for the design and operations of vertiports under the scope of the EASA Basic Regulation
Flagship action 6	The Commission intends to develop balanced economic and financial requirements for licensing of UAV operators.
Flagship action 7	The Commission will fund the creation of an online platform to support a sustainable IAM implementation by authorities, communities, municipalities, industry and stakeholders.
Flagship action 8	The Commission intends to adopt new training and competences requirements for remote pilots and pilots of VTOL aircraft.
Flagship action 9	The Commission intends to continue to provide funding for R&I on UAVs and their integration into the airspace under the Horizon Europe programme and the European Defence Fund.
Flagship action 10	The Commission intends to set up a coordinated series of calls under the existing EU instruments and EIB loans to support a new flagship project on "UAV technologies".
Flagship action 11	The Commission will consider possible amendments to the existing financing/funding framework to ensure a consistent approach in support of dual-use research and innovation to improve synergies between civil and defence instruments.

Flagship action 12	The Commission intends to develop a Strategic Drone Technology Roadmap in order to identify priority areas to boost research and innovation, reduce existing strategic dependencies and avoid the emergence of new ones.
Flagship action 13	The Commission intends to coordinate with other relevant EU actors a common approach with the aim of providing sufficient radio frequencies spectrum for UAV operations.
Flagship action 14	The Commission intends to set up an EU network on civil-defence UAV testing centres to facilitate exchanges between civilian and defence sectors.
Flagship action 15	The Commission will encourage all relevant actors to further align certification requirements for civil and military applications towards those set by EASA while considering military specificities and existing military certification standards.
Flagship action 16	The Commission intends to adopt new standard scenarios for civil operations that could facilitate corresponding military use cases.
Flagship action 17	The Commission intends to adopt a C-UAS package
Flagship action 18	The Commission intends to adopt an amendment to the aviation security rules aiming to ensure that aviation authorities and airports increase their resilience when faced with the risks posed by UAVs
Flagship action 19	The Commission intends to define criteria for a voluntary "European Trusted Drone" label

To develop outcomes, future scaling opportunities, and the provision of new commercial services, as well as integrating outputs into the EU level, 5G4LIVES will consider the presented strategy and its activities. These activities are accounted for in future scenarios and actions for the development and scaling of the 5G4LIVES platform.

Matrixes of the identified challenges, gaps, opportunities

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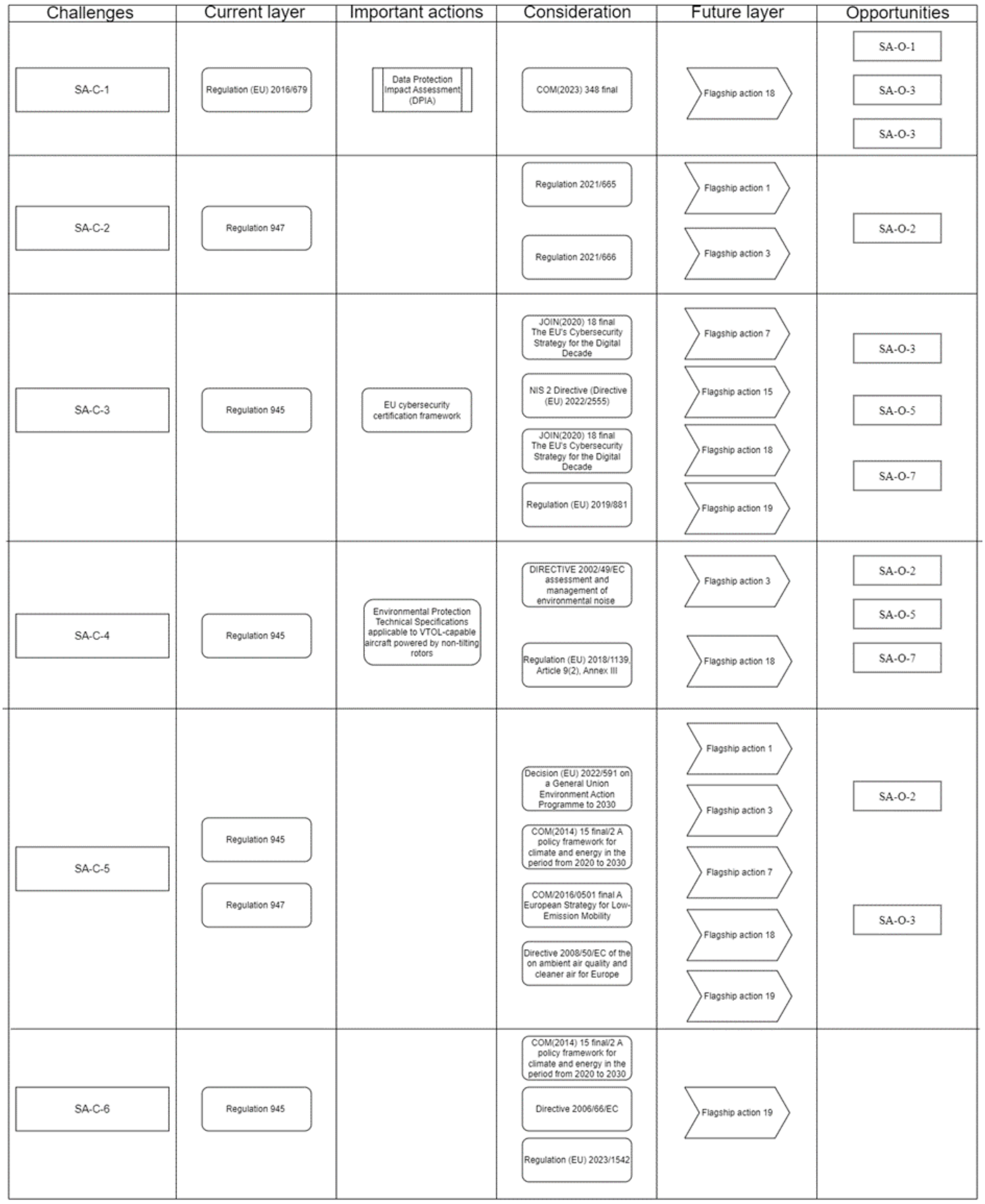

Figure 27. Social acceptance challenges relations with regulatory and future actions

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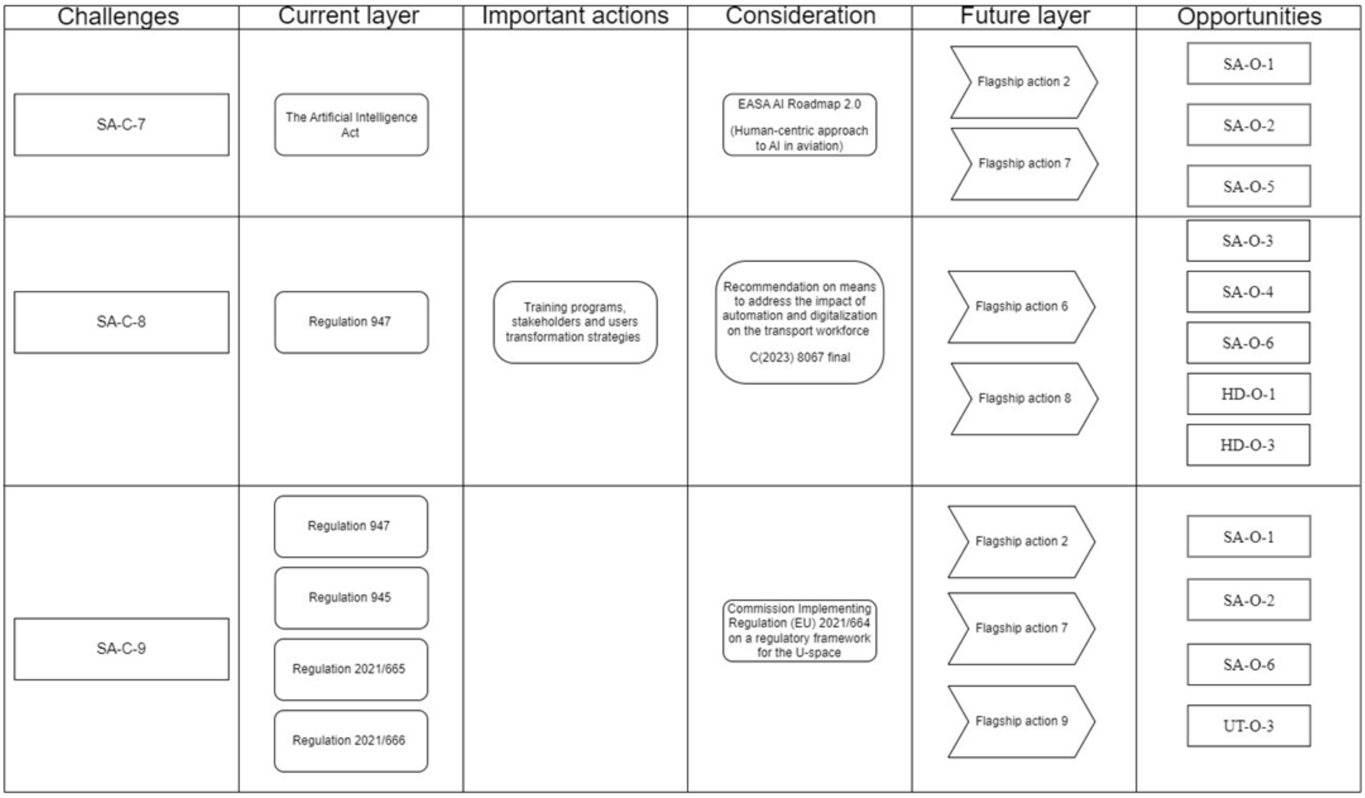

Figure 28. Social acceptance suggested challenges relations with regulatory and future actions

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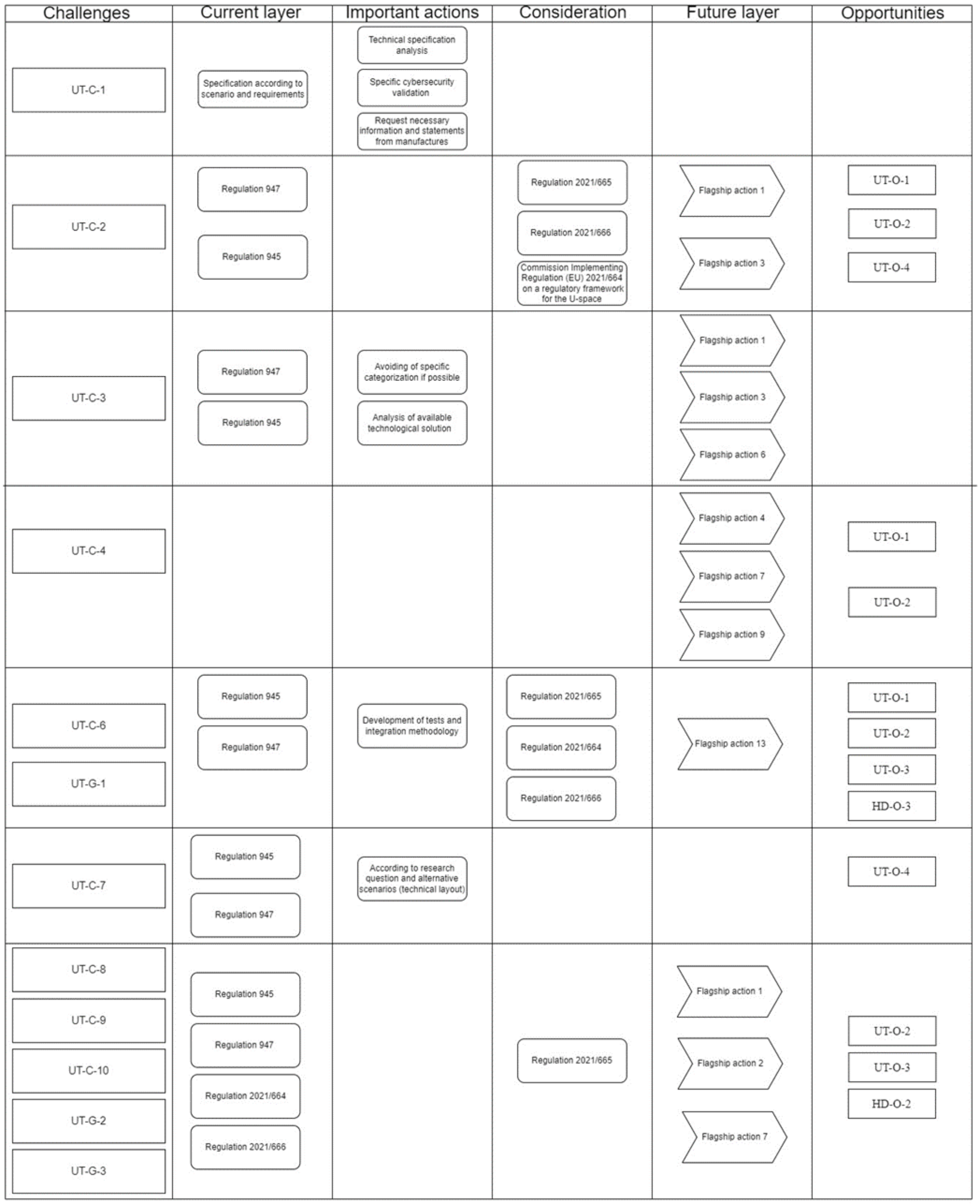

Figure 29. Technological challenges and gaps relations with regulatory and future actions

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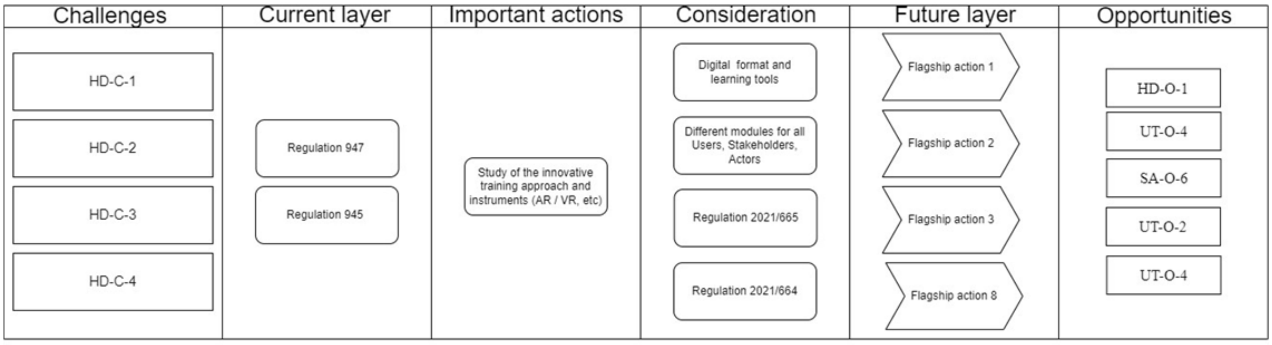

Figure 30. Promoting the human dimension challenges relations with regulatory and future actions

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8. CONCLUSIONS AND RECOMMENDATIONS

I. Technical conditions for UAV operation currently are not harmonized for all IMT frequency bands in Europe.

II. The Regulator govern the allocation of RF bands for mobile networks, primarily through auctions.

III. Licence for use of radio equipment is issued by VASES under specific regulations, requiring compliance with regulatory acts.

IV. Detailed installation projects are required for setting up electronic communication networks, ensuring compliance with regulations, safety measures, and environmental protection. Projects must include technical plans, equipment lists and etc.

V. The 2.4 GHz and 5.8 GHz RF bands are licence-exempt, with permitted power levels being quite low, resulting in relatively small, expected flight areas.

VI. User of the radio device/equipment should pay attention to several important basic rules related to conformity assessment of the radio equipment - check the CE marking on radio device or equipment, find the declaration of the conformity, read the user manual, ensure compliance with the regulations for the use of licence-exempt bands in the territory of Latvia.

VII. Leveraging several GNSS systems concurrently yields enhanced accuracy, broader coverage, and heightened resilience to interference. Therefore, UAV's GNSS receiver must be able to work in at least two systems simultaneously, moreover, considering the geopolitical situation, the UAV's GNSS receiver should support for European countries reliable GNSS systems - GPS and Galileo.

VIII. National Aviation Authorities (NAAs) strongly restrict the use of UAV in BVLOS that is often permitted under specific conditions such as over a controlled ground area in a sparsely populated environment, with the adoption of airspace observer or in a segregated airspace.

IX. The adoption of standard scenarios (STS) or PDRA (Pre-defined Risk Assessment) may be convenient to speed-up the authorization process, but requires that specific operational constraints are satisfied. On the contrary, the authorization process conducting the SORA from scratch may involve several iterations with the National Aviation Agency and, often, the NAA imposes some safety constraints resulting in a scenario very similar to those defined in the PDRAs or STSs.

X. The methodology for planning and validating BVLOS flight missions is a promising risk-informed tool to be used by UAS operators to plan safe routes or to validate a pre-defined flight mission. The methodology will be developed considering the European Drone Regulation and can be used as a mitigation strategy within the SORA process. Thus, the methodology will be valid at the European level.

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9. REFERENCES

I. A. N. Ivan, IOPscience 2023, *Analysis of the impact of GNSS disruptions on aircraft operations at Romanian airpor*ts, IOP Publishing, accessed 10 April 2024, <https://iopscience.iop.org/article/10.1088/1742-6596/2526/1/012096/pdf>

II. ECO Documentation Database 2022, *ECC/DEC/(22)07*, European communications office, accessed 7 April 2024, <https://docdb.cept.org/document/28575>

III. EUR-Lex, *Document 32014L0053*, European Union Law, acessed 8 April 2024, <https://eur-lex.europa.eu/legal-content/IT/TXT/?uri=CELEX%3A32014L0053>;

IV. European Aviation Safety Agency, Easy Access Rules for Unmanned Aircraft Systems (Regulations (EU) 2019/947 and 2019/945). (revision 2027), EASA, acessed 15 April 2024, <https://www.easa.europa.eu/en/document-library/easy-access-rules/easy-access-rules-unmanned-aircraft-systems-regulations-eu. Accessed: 2024-05-16>

V. Google maps 2024, 5G4LIVES - Monitoring points of the hill from the ground, Google, accessed 5 April 2024, <https://www.google.com/maps/d/u/0/viewer?mid=1zvhYIHCEnpABe0IP8CukH0A8oymQOlE&hl=it&ll=45.053762929433105%2C7.727517331589149&z=13>

VI. Likumi lv 2014, Elektronisko sakaru inženierbūvju būvnoteikumi, Latvijas Republikas tiesību akti, accessed 26 April 2024, <https://likumi.lv/ta/id/269032-elektronisko-sakaru-inzenierbuvju-buvnoteikumi>

VII. Likumi lv 2016, Iekārtu elektrodrošības noteikumi, Latvijas Republikas tiesību akti, accessed 26 April 2024, <https://likumi.lv/ta/id/281514-iekartu-elektrodrosibas-noteikumi>

VIII. Likumi lv 2016, Iekārtu elektromagnētiskās saderības noteikumi, Latvijas Republikas tiesību akti, accessed 21 April 2024, <https://likumi.lv/ta/id/281513-iekartu-elektromagnetiskas-saderibas-noteikumi>

IX. Likumi lv 2022, *Elektronisko sakaru likums*, Latvijas Republikas tiesību akti, accessed 5 April 2024, <https://likumi.lv/ta/id/334345-elektronisko-sakaru-likums>;

X. Likumi lv 2023, *Nacionālais radiofrekvenču plāns*, Latvijas Republikas tiesību akti, accessed 5 April 2024, <https://likumi.lv/ta/id/338729-nacionalais-radiofrekvencu-plans>;

XI. Likumi lv 2023, Radiofrekvences piešķīruma lietošanas atļauju noteikumi, Latvijas Republikas tiesību akti, accessed 26 April 2024, <https://likumi.lv/ta/id/340434-radiofrekvences-pieskiruma-lietosanas-atlauju-noteikumi>

XII. Likumi lv 2024, Radioiekārtu atbilstības novērtēšanas, piedāvāšanas tirgū, uzstādīšanas, lietošanas un uzraudzības noteikumi, Latvijas Republikas tiesību akti, accessed 21 April 2024, <https://likumi.lv/ta/id/351106-radioiekartu-atbilstibas-novertesanas-piedavasanas-tirgu-uzstadisanas-lietosanas-un-uzraudzibas-noteikumi>

XIII. Normattiva, DECRETO LEGISLATIVO 22 giugno 2016, n. 128, Presidenza del Consiglio dei Ministri, acessed 8 April 2024, <https://www.normattiva.it/uri-res/N2Ls?urn:nir:stato:decreto.legislativo:2016-06-22;128!vig>

XIV. Spectrum for Unmanned Aircraft Systems (UAS) Approach to authorising the use of radio equipment on UAS, CONSULTATION, Ofcom (2022)

XV. Commission staff working document; Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions ‘A Drone Strategy 2.0 for a Smart and Sustainable Unmanned Aircraft Eco-System in Europe’ {COM (2022) 652 final}

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