"5G for Drone-based Vertical Applications"

D5.6 Report on activities related to commercial exploitation and partnership development

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Executive summary

The hereby Deliverable D5.6 presents the 5G!Drones project activities related to three primary aspects of exploitation of project results and partnership development: the collaboration within the scientific communities, the investigation of possibilities for the commercial exploitation of the project's outcomes, and the collaboration with international innovation communities in the area of 5G communication.

Within the first area, the following initiatives are presented: 6 granted research projects initiated jointly by 5G!Drones partners and resulting from the cooperation within the framework of the 5G!Drones project; the partnership of the Municipality of Egaleo dedicated to development and implementation of their "Smart City 2020-2030" vision, with inclusion of the outcomes of the involvement in the 5G!Drones project; 4 bilateral cooperation activities of the 5G!Drones partners; 2 further 5G!Drones project follow-up partnerships with 3rd parties.

The second part of the deliverable is devoted to investigation of possibilities regarding commercial exploitation of 14 outcomes that have been developed during the 5G!Drones project. They have been categorized by their owners as commercially exploitable and their current maturity (Technology Readiness Level – TRL) varies between TRL3 and TRL9. For each of the presented outcomes provided are: a high-level description based on its commercial value together with perspectives of commercial exploitation including a Strengths, Weaknesses, Opportunities and Threats analysis and a plan of commercialization. In case of the 3 outcomes, which reached maturity from TRL7 to TRL9 – namely: Telemetry U-space Service Provider's service by Droneradar, Mission Critical Platform integrating Drone as a Service on 5G network by Airbus, and Unmanned Aerial Vehicle Remote Identifier tracker by Involi, an analysis based on Value Proposition canvas is also provided.

In the context of the third domain, the activity within 2 international innovation communities in 5G communication is reported. The 5G!Drones project consortium has participated in 2 boards and 10 work groups of 5G Infrastructure Public Private Partnership (5G PPP), a joint initiative of the European Commission and European Information and Communication Technology industry, and Aerial Connectivity Joint Activity (ACJA), a joint activity of two industrial innovation alliances in the domain of telecommunication, Global System for Mobile Communications Association (GSMA) and unmanned aviation, Global Unmanned Traffic Management Association (GUTMA). The major consortium contributions include the work on standardization, 5G and beyond network architectures, the Public Land Mobile Networks and Unmanned Aviation Systems Traffic Management system integration, security aspects, vision and societal changes, Unmanned Aerial Vehicles' trials, tests measurements and Key Performance Indicators validation. The detailed contributions are described in the 5G!Drones project Deliverable D5.4.

The document is concluded with the overall assessment of the effectiveness of 5G!Drones project activities related to commercial exploitation and partnership development and future perspectives.

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List of acronyms and abbreviations

3GPP	3rd Generation Partnership Project
5G	5th Generation Cellular Technology
5GC	5G Core
5G PPP	5G Infrastructure Public Private Partnership
5QI	5G Quality Indicator
ACJA	Aerial Connectivity Joint Activity
ADS-B	Automatic Dependent Surveillance–Broadcast
AI	Artificial Intelligence
AIM	Aeronautical Information Management
AIP	Aeronautical Information Publication
ANSP	Air Navigation Service Provider
AoA	Angle of Arrival
AoD	Angle of Departure
API	Application Programming Interface
ASTM	American Society for Testing and Materials
ATM	Air Traffic Management
AUP	Airspace Use Plan
B5G	Beyond 5G
BDVA	Big Data Value Association
BI	Business Intelligence
BVLOS	Beyond Visual Line Of Sight
CAM	Connected and Automated Mobility
CAPIF	Common API Framework
CARA	Criticality and Risk Assessment
CARS	Common Altitude Reference System
CCC	Command-and-Control Centre
CE	Conformité Européenne
CIS	Common Information Service
CONOPS	Concept of Operations
COP	Common Operational Picture
DAIRO	Data, AI and Robotics Association
DIH	Digital Innovation Hub

DIY	Do It Yourself
Dx.y	Deliverable y of WP x
eMBB	enhanced Mobile BroadBand
eVTOL	electric Vertical Take-Off and Landing
FAA	Federal Aviation Administration
FCC	Federal Communications Commission (USA)
GNSS	Global Navigation Satellite Systems
GSMA	Global System for Mobile Communications Association
GSO	Geo-Stationary Orbit
GUTMA	Global Unmanned Traffic Management Association
HAPS	High Altitude Platform System
ICT	Information and Communication Technology
ID	IDentifier
INPI	Institut National de la Propriété Industrielle (France)
IoT	Internet of Things
KPI	Key Performance Indicator
LAU	Local Administrative Unit
LED	Light-Emitting Diode
LEO	Low Earth Orbit
LoRaWAN	Long Range Wide Area Network
LTE	Long-Term Evolution
LXC	LinuX Containers
MEO	Medium Earth Orbit
MASPS	Minimum Aviation System Performance Standards
MOPS	Minimum Operational Performance Specifications
MTOW	Maximum Take-Off Weight
NB IoT	NarrowBand IoT
NEF	Network Exposure Function
NetApps	Network Applications
NGSO	Non-Geo-Stationary Orbit
NOTAM	NOtice To Air Missions
NTN	Non-Terrestrial Network
PDRA	Participatory Disaster Risk Assessment
PMR	Private Mobile Radio

PoC	Proof of Concept
PPDR	Public Protection & Disaster Relief
PRS	Positioning Reference Signal
PTT	Push-To-Talk
R&D	Research & Development
RAN	Radio Access Network
RAT	Radio Access Technology
RTT	Round Trip Time
SBA	Service-Based Architecture
SDR	Software-Defined Radio
SLAM	Simultaneous Localization And Mapping
SLC	Secure Land Communications
SME	Small and Medium-sized Enterprises
SMS	Short Message Service
SNS	Smart Networks and Services
SORA	Specific Operations Risk Assessment
SWOT	Strengths, Weaknesses, Opportunities and Threats
TDoA	Time Difference Of Arrival
TN	Terrestrial Network
TRL	Technology Readiness Level
UAS	Unmanned Aerial System
UAV	Unmanned Aerial Vehicle
URLLC	Ultra-Reliable Low Latency Communications
USSP	U-space Service Provider
UTM	Unmanned Aircraft System Traffic Management
WP	Work Package

1 Introduction

1.1 Objectives of the document

The scope of the Deliverable D5.6 is manifold: the presentation of cooperation and partnerships established thanks to the activities in the project – both in the commercial and scientific areas as well as presentation of the commercially exploitable outcomes of the 5G!Drones project with the perspectives of their market launch; finally, the presentation of collaboration with international innovation communities in the area of 5G communication is outlined.

This document is complementary to other parallel documents: Deliverable D5.4 “Report on contribution to standardisation and international fora – 2nd version” [1] and Deliverable D5.5 “Final report on communication, showcasing, dissemination and exploitation” [2]. While some mutual overlaps are inevitable, the document hereby intends to show how the 5G!Drones project has become a platform conducive to the development of business and research partnerships among the project participants, both mutual and with the research and innovation ecosystem, and to the development of commercial products.

1.2 Structure of the document

The document is structured into main sections as follows:

- Collaboration within the scientific communities, which includes the information on successful research undertakings jointly initiated by 5G!Drones partners: granted projects, bilateral cooperation activities, partnerships – especially for 5G!Drones follow-up, digital innovation hubs, etc. – section 2;
- Investigation of possibilities for the commercial exploitation of the selected project outcomes – section 3;
- Collaboration with international innovation communities in the area of 5G communication, which profited of the experiences gained during the 5G!Drones project – section 4;
- Summary and conclusion – section 5.

2 Collaboration within the scientific communities

Collaboration within scientific communities in the 5G!Drones project has manifested itself in manifold ways: through the successful initiatives of further joint EU-granted research projects of some project partners, continuation of cooperation through the implementation of the Smart City strategy of the Municipality of Egaleo and the use of project outcomes to enrich the implementation of this strategy, development of bilateral cooperation of some partners in the implementation of certain research topics, involvement of project partners and results in the development of new generation digital services in Greece and the organization of a digital innovation hub. Therefore, the 5G!Drones project, in addition to the direct implementation of its scope and goals, has also become a source of inspiration for new ventures and activities, bringing further benefits.

2.1 EU research projects

The 5G!Drones project has become a platform for developing and tightening the cooperation of the project partners, as a result of which new research initiatives were initiated and implemented. These include joint research projects supported by the European Union's programs like Horizon Europe or Single European Sky Air Traffic Management Research – Joint Undertaking (SESAR – JU), which is a common framework of the European Commission's Horizon 2020 or Horizon Europe program, Eurocontrol and commercial units.

2.1.1 ICARUS

The project Integrated Common Altitude Reference system for U–space (ICARUS)[1] developed an altimetry solution based on Global Navigation Satellite Systems (GNSS). It addressed the necessity of having the common altitude reference system for safe coexistence and operations of manned aviation and drones; the latter flying in very low-level airspace, especially in urban environments. Operating at very low altitudes, the drones rely on the digital terrain maps for obstacles clearance, while the manned aircrafts altitude determination is based on barometric sensors. Thus, a U-space service for altitude translation between geodetic measurements system and barometric reference system and vice-versa needs to be provided, as a part of interface between Unmanned Aircraft System Traffic Management (UTM) and Air Traffic Management (ATM) systems. The ICARUS concept was validated in a real operational environment and a final Concept of Operations (CONOPS) was generated.

Project timeframe: start date – 1 May 2020, end date – 31 July 2022.

5G!Drones partners involved in the project: **Droneradar**, **Thales** (through its joint venture Telespazio).

2.1.2 GOF 2.0

The project GOF (Gulf of Finland) 2.0 Integrated Urban Airspace Validation[2] is dedicated to demonstration of operational validity of safe, secure, and sustainable serving combined Unmanned Aerial Systems (UAS), electric Vertical Take-Off and Landing (eVTOL), and manned operations in a unified, dense urban airspace. These combined operations will use existing ATM and U-space services and systems. During the demonstrations, the GOF 2.0 architecture is being validated in terms of its support for the assurance of highly automated real-time aerial vehicles separation in dense airspace. The scope of GOF 2.0 ecosystem also includes the assessment of the question of telecom networks for air-ground communication and the sharing of the information about their coverage. The final goal is to build the vision of safe integration of manned and unmanned aviation without degradation of safety and security of current airspace operations or their disruption.

Project timeframe: start date – 1 January 2021, end date – 31 December 2022.

[1] https://www.u-spaceicarus.eu
[2] https://gof2.eu

5G!Drones partners involved in the project: **Airbus** (through its unit Airbus Urban Mobility), **CAFA Tech**, **Droneradar**, **Frequentis**, **Robots Expert**, **Unmanned Life**.

2.1.3 EVOLVED-5G

5th Generation End-to-end Network, Experimentation, System Integration, and Showcasing (5GENESIS)[3] Athens Platform's evolution continues by providing further support in research actions and projects towards 6G. The platform participates in 5G PPP Experimentation and Validation Openness for Long-term evolution of VErtical inDustries in 5G era and beyond (EVOLVED-5G)[4] project, through which it is further upgraded with open core networks, such Open5GS, in order to support network programmability through standardized exposed Application Programming Interfaces (APIs), such as Network Exposure Function (NEF) and Common API Framework (CAPIF). Programmability in the 5G Core (5GC) enables operators to open telecom network capabilities and services to third-party developers, allowing them to establish innovative network-aware vertical applications. This openness is materialized through the 5G Service-Based Architecture (SBA) that exposes the network intelligence to the vertical applications through standardized APIs. Building upon the application empowerment that the programmable APIs can offer unleashing new business potentials, the ecosystem of Network Applications (NetApps) emerges to stand as a facilitating middleware between the network and applications. This study presents the architectural and implementation aspects of an open all-encompassing framework for NetApps considering their entire lifecycle spanning from their development to their final publication in the market. These additional activities will further evolve the currently available 5G!Drones/Open5GENESIS experimentation framework resulting in more advanced experimentation capabilities.

Project timeframe: start date – 1 January 2021, end date – 31 December 2023.

5G!Drones partners involved in the project: **National Centre of Scientific Research "*Demokritos*"**, **CAFA Tech**, **Cosmote**, **Infolysis**, **Unmanned Life**.

2.1.4 ETHER

The project sElf-evolving terrestrial/non-Terrestrial Hybrid nEtwoRks (ETHER) is going to provide a framework for the Terrestrial/Non-Terrestrial Network (TN/NTN) ecosystem that involves terrestrial mobile core networks and terrestrial Radio Access Networks (RANs), High Altitude Platform Systems (HAPS), and satellites, especially non-geostationary ones, such as Medium/Low Earth Orbit (MEO/LEO) ones. ETHER relies on unified Radio Access Technology (RAT) advancements that enable broadband connectivity from every corner of the world even with handheld devices; intelligent management of the 3D network resources for meeting predefined Key Performance Indicators (KPIs), allowing the network to self-adapt to rapidly evolving traffic conditions and situations on the ground without human intervention; distributed 3D computing and caching medium enabling the reduction of response delays by alleviating congestions towards cloud data centre. The envisioned use cases include horizontal handovers (i.e. intra-RAT, e.g. MEO↔MEO) for delay-tolerant Internet of Things (IoT) services, unified RAN for direct handheld device access at the Ka band supporting vertical handovers (i.e. inter-RAT, e.g. TN↔NTN), and air-space safety-critical network access (for manned and unmanned aircrafts).

Project timeframe: expected start date – 1 January 2023, expected end date – 31 December 2025.

5G!Drones partners involved in the project: **Orange Polska**, **National Centre of Scientific Research "*Demokritos*"**.

[3] **https://5genesis.eu/**
[4] **https://evolved-5g.eu/**

2.1.5 6G-NTN

6G Non-Terrestrial Network project (6G-NTN) is dedicated to defining and validating enabling technologies for 6G NTN solutions to prepare the standardization activities in the 3rd Generation Partnership Project (3GPP) – release 20 onwards – e and promote the necessary enablers at the regulatory level. It aims at researching and developing innovative technical, business, regulatory, and standardization enablers. The main objectives are to achieve full and seamless integration of the NTN component into the 6G system and establish European leadership in this domain. The vision is to extend coverage, resilience, and sustainability of next generation mobile networks, meeting needs and expectations of both vertical and consumer market segments, while unleashing new value chains and creating broad societal impact.

The proposed concept of full-fledged integration of the NTN component into 6G leverages multiple key project outcomes that will pave the way for a service roll-out in the 2030-35 timeframe: a sustainable and resilient 3D multi-layered – Geo-Stationary Orbit (GSO) and Non-Geo-Stationary Orbit (NGSO) satellites, HAPS, drones – network architecture; a software defined payload adapted to all flying platforms and all frequency bands; a very low Earth orbiting space segment; a flexible waveform supporting terrestrial and non-terrestrial deployments; the support of smartphones and vehicle/drone mounted terminals; the use of new spectrum (i.e. C and Q/V bands) in coexistence with the terrestrial network component; high accuracy and reliable positioning solutions.

The newly designed NTN component will deliver: i.e. Ultra-Reliable Low Latency Communications (URLLC) services (latency <10 ms) and advanced enhanced Mobile BroadBand (eMBB) services (data rate up to several hundred of Mbps) to vehicle- or drone-mounted ultra-small size devices, and battery activated nomadic terminals; improved eMBB services to smartphones; short emergency messaging services to smartphones in light indoor/in-vehicle environments; and high accuracy (<10 cm) and reliable location service to both devices categories.

Project timeframe: expected start date – 1 January 2023, expected end date – 31 December 2025.

5G!Drones partners involved in the project: **Orange France**, **Thales**

2.1.6 6G-SANDBOX

5GENESIS[5] Athens platform participated in the recent SNS call/Stream C for experimentation of Beyond 5G (B5G) evolution and 6G technologies, and achieved to get funded for 6G-SANDBOX project, aiming at developing EU-wide experimentation platforms, which can incorporate promising technical 6G enablers for their further validation. Key aspects for 6G-SANDBOX are the reusability and ability to evolve experimental platforms over the lifetime of the SNS programme. Accessibility and openness with well-defined and clearly documented technological and business interfaces are also considered key assets of the infrastructures to be evolved from the developed ones by 5G PPP projects, such as 5G!Drones.

Project timeframe: expected start date – 1 January 2023, expected end date – 31 December 2025.

5G!Drones partners involved in the project: **National Centre of Scientific Research "*Demokritos*"**, **Cosmote**. **Infolysis**.

2.2 Partnerships and activities around the Smart City vision of the Municipality of Egaleo

The Municipality of Egaleo is very active in the field of technological development, which is manifested by the ambition of implementation of the Egaleo Smart City vision in tight partnership and cooperation

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

with the scientific and research communities of Greece. To implement the vision, the Egaleo "Smart City 2020-2030" strategy is based on four fundamental pillars:

1. Economy and development;
2. Energy and environment;
3. Society and living;
4. Digital governance.

The first pillar is dedicated to the following aspects:

- Smart city infrastructure (lighting, vehicle traffic, air quality, noise levels, waste management, energy consumption, water management, vehicle fleet tracking, Wi-Fi spots).
- Smart City Control Centre (creation of specialized space; digitization and mapping of critical urban equipment, such as: waste, recycling and bio-waste bins, municipal lighting facility networks; collection, management and visualization of large urban data scale – Big Data; drawing conclusions and making decisions).
- Wireless networks and 5th generation systems (involvement in HORIZON 2020 projects: 5GENESIS[6], 5G-ESSENCE[7], 5G!Drones; pilot applications at the municipal stadium of Egaleo "*Stavros Mavrothalassitis*"; actions to install new and expand existing 5G networks infrastructure, in selected areas of the city; development of new business models by the city's businesses and technology organizations; hosting new businesses developing innovative services; creating new jobs).
- Standard Smart Pedestrian (development of smart micro-infrastructure management platform; smart benches, smart lamps, wireless Wi-Fi network, smart waste bins, energy consumption detection sensors, etc.; promotion of contracted businesses through smart signs; development of intelligent and personalized information applications for the visitors of the area).
- Entrepreneurship support applications (development and distribution of digital tools to the business world of the city or new entities interested in the city as a business destination; development of freely accessible online education, training and capacity building tools; operation of register of beneficiaries and interested parties; providing information through digital Artificial Intelligence (AI)-driven interaction tools and automated responses; development and promotion of digital content for the promotion of partner businesses).

The second pillar includes the following functions:

- Smart waste and lighting management (complete online platform for locating waste bins, recycling, bio-waste, collection scheduling; personalized LED update and information, intelligent lighting management, NB IoT).
- Intelligent management of parking spaces (integrated online platform for guidance of free parking spaces; update on current traffic regulations and conditions).
- Intelligent traffic management (measurement of traffic data, vehicle speed and average traffic speed Identifying traffic congestion and predicting load and mobility needs).
- Smart municipal mobility (application development for information on the municipal transport timetable and real-time monitoring of the location of vehicles and adjacent stops).

[6] ibidem
[7] **https://www.5g-essence-h2020.eu/**

- Municipal vehicle fleet upgrade (supply of new electric vehicles for the gradual expansion of its green environmental footprint).
- Environmental observatory (installation of a network of detectors for CO_2 and NO_x, temperature, humidity, brightness and noise pollution; operation of a decision support system, air quality inference and prediction of future levels and critical quality indicators).

The third, society-oriented pillar is devoted to:

- Digital transformation of the "*Baroutadiko*" municipal grove (creating a virtual reality digital museum; virtual tours; development of fire protection network remote management applications – fire safety, water supply, irrigation and electric lighting).
- Protection of cultural heritage (digital repository of knowledge and culture that will include the rich cultural stock of the municipality, electronically accessible via the internet).
- Model digital training and education centre (programs of information, creative employment for children, but also to older citizens).
- Educational programs for minorities (online training programs).
- Applications to support weaker social groups (design and development of assistance applications for persons with disabilities, etc.).

The fourth pillar is composed of the following actions:

- Simplification and standardization of the operation of the municipality (electronic handling of documents – paperless office; development of a platform to strengthen communication between the municipality and citizens; unification of fragmented electronic services for citizens in a single point, development of digital tools for "*Open Data*" and "*Open Processes*", development of problem-solving applications: daily life, personalized information through smart notifications, electronic payments).
- Participatory city governance (open consultation processes and models, participatory project and budget preparation processes; digital channels of communication with citizens and businesses and utilization of the feedback received; serving citizens' digital requests, free and valid information about the work of the Municipality Utilization of open data and processes and their visualization).
- Digital commission for the "*Egaleo of the future*" (with participation of all critical factors of the local society and economy: administrative leadership of the city, executives, private companies and residents).

2.2.1 Smart City platform in Egaleo

The development of the Egaleo Smart City platform[8] is driven, among others, by the Municipality of Egaleo's participation in EU-sponsored research projects, and made possible by continuous partnership and cooperation with the University of West Attica[9], whose two campuses are located in Egaleo, and the National Centre of Scientific Research "*Demokritos*"[10].

Currently, the Egaleo Smart City platform's part exposed to the citizens (cf. Figure 1) supports the following domains or activities, which clearly address the above strategy:

- City guide maps (digital guide, recreation and walks, Egaleo MyGIS);

[8] **https://smart.dotsoft.gr/**
[9] **https://www.uniwa.gr/en/**
[10] **https://www.demokritos.gr/**

- Digital governance (consultations with citizens, citizens' requests, digital certificates, repository of municipality's surveys);
- Recreation and culture (virtual tour in municipal grove, Asia Minor culture, digital guest book, games and contests, voluntary actions, municipal library).
- Business Intelligence (BI) platform (A decision support platform with a continuous improvement of the services of the Municipality of Egaleo. This platform includes tools, techniques, and technologies for the analysis of all the city's data and the extraction of useful knowledge that will be used in the process of making business and strategic decisions, in a historical, current and forecast context).
- Interface subsystem and other user applications (The interface subsystem and other user applications cover the user's communication and interaction points with the City platform. These include: the interface of smart mobile devices, the ChatBot interface and social network interfaces).

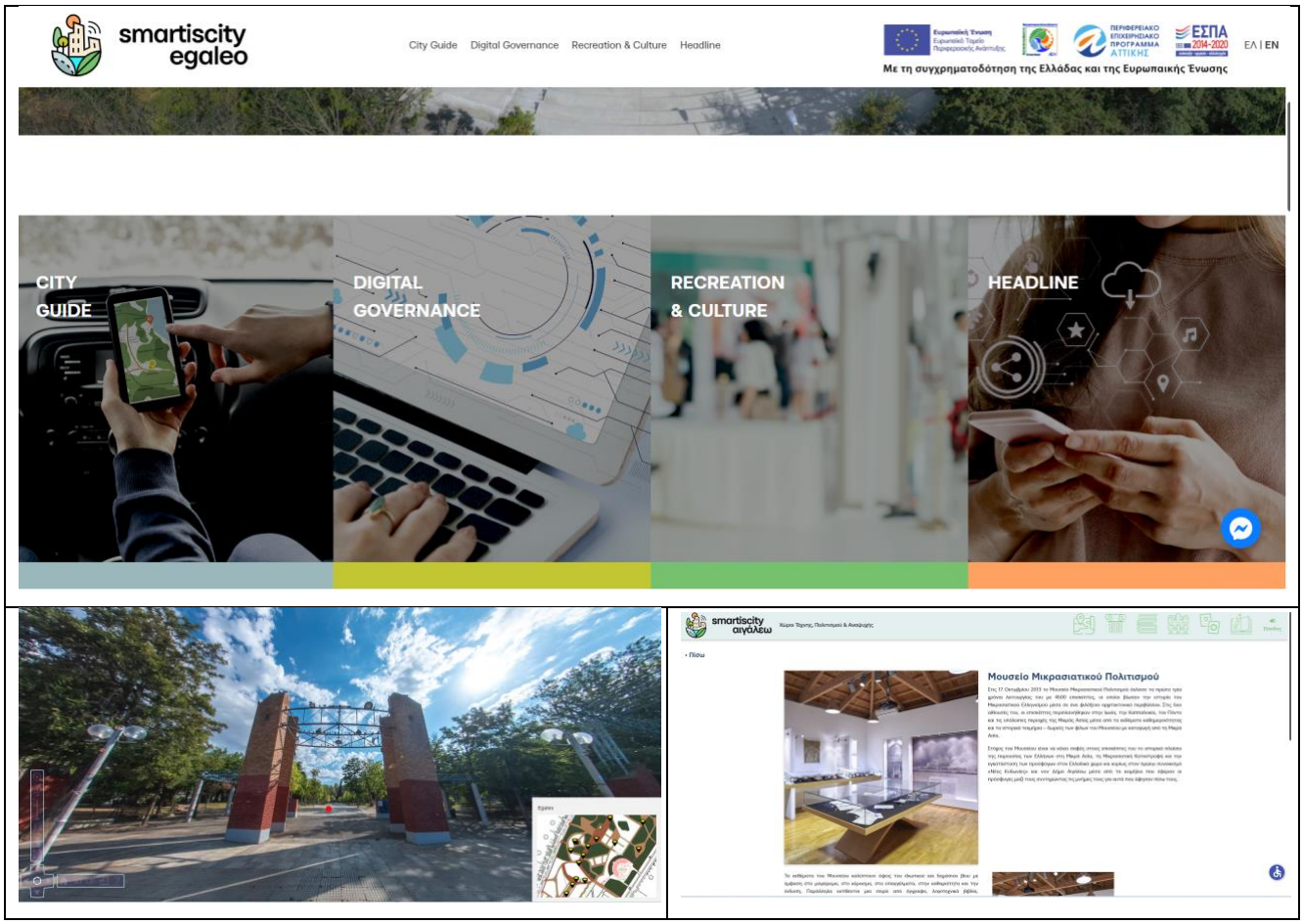

Figure 1 – Egaleo Smart City public website

Based on the experiences of the 5G!Drones project, it is planned to extend the Egaleo Smart City platform with the drones' use cases – mainly related to the situational awareness and civil protection: the municipal police of Egaleo will be able to build the comprehensive vision of the situation, especially in case of critical events, such as wildfires in summer periods, especially in the area of the "*Baroutadiko*" municipal grove. The Smart City platform will be fed with real-time data transmitted from drones, where the information will be correlated and combined with data from other sources. In that case, the

Command-and-Control Centre (CCC) of the municipality will have the Common Operational Picture (COP) for any emergency (cf. Figure 2).

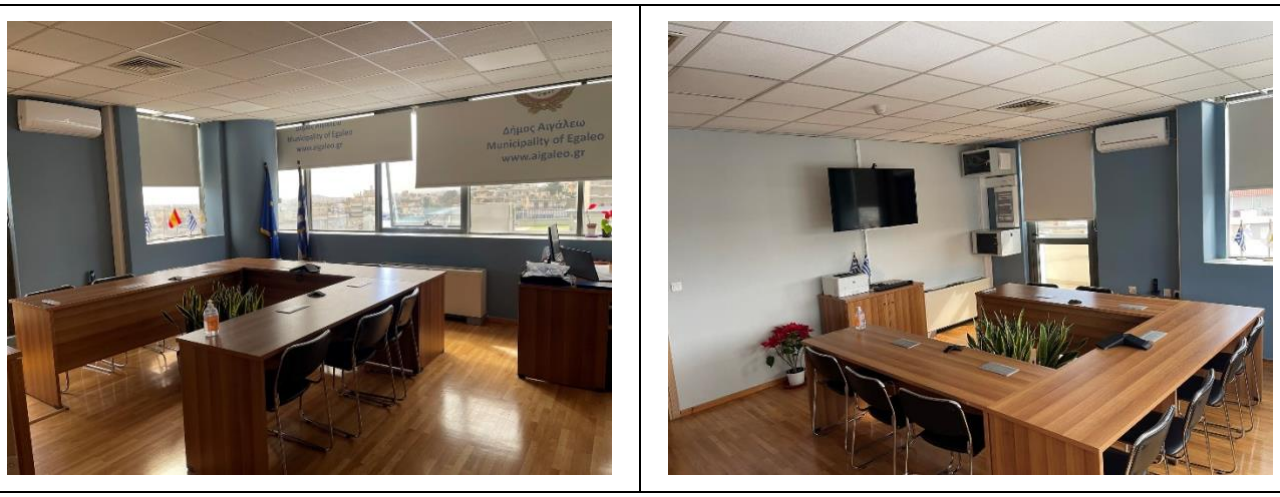

Figure 2 – Municipal Command-and-Control Centre in Egaleo

2.2.2 Smart Square initiative in Egaleo

The second initiative to follow the "Smart City 2020-2030" strategy is the Smart Square (cf. Figure 3), which is located at the entrance of "*Baroutadiko*" grove[11] and has been intertwined with the everyday life of the citizens. Therefore, the upgrade of the functions and the experience that the grove offers to the visitor, through the development of a holistic digital infrastructure, is one of the main priorities of the Municipality, a move which is fully harmonized with its pursuit to implement a "*smart*" technologically and functional city. Therefore, the application of "*smart*" solutions based on Internet of Things (IoT) technology, initially in a small part of the park, is a harbinger of their wide application in the whole park and the city afterwards.

The implemented solutions are:

- Points of free Internet access (Wi-Fi) for citizens and visitors of the park;
- Control of the number of residents and visitors;
- Record air quality and noise pollution levels;
- Colour, sharp high-resolution screens for informing citizens and visitors.

The centralized management and visualization of the data is done through a platform. The platform provides a homogenized environment for control and management of the smart devices as well as the smart "*Smart City*" subsystems/applications. The single platform ensures compatibility with heterogeneous data of every type of technology used in the context of the smart city.

For the transmission of the information recorded by the environmental stations, a suitable network is designed and installed, considering the needs of the municipality's future applications. To support environmental sensors, a LoRaWAN gateway and LoRaWAN server software is used. The delivered solution provides features of high security, high service availability and immediate scalability.

[11] https://www.google.com/maps/@37.9936171,23.6758668,3a,75y,26.45h,94.54t/data=!3m7!1e1!3m5!1sWkXulWIL2mx9YSuOpgn5yQ!2e0!6shttps:%2F%2Fstreetviewpixels-pa.googleapis.com%2Fv1%2Fthumbnail%3Fpanoid%3DWkXulWIL2mx9YSuOpgn5yQ%26cb_client%3Dmaps_sv.tactile.gps%26w%3D203%26h%3D100%26yaw%3D31.927935%26pitch%3D0%26thumbfov%3D100!7i13312!8i6656

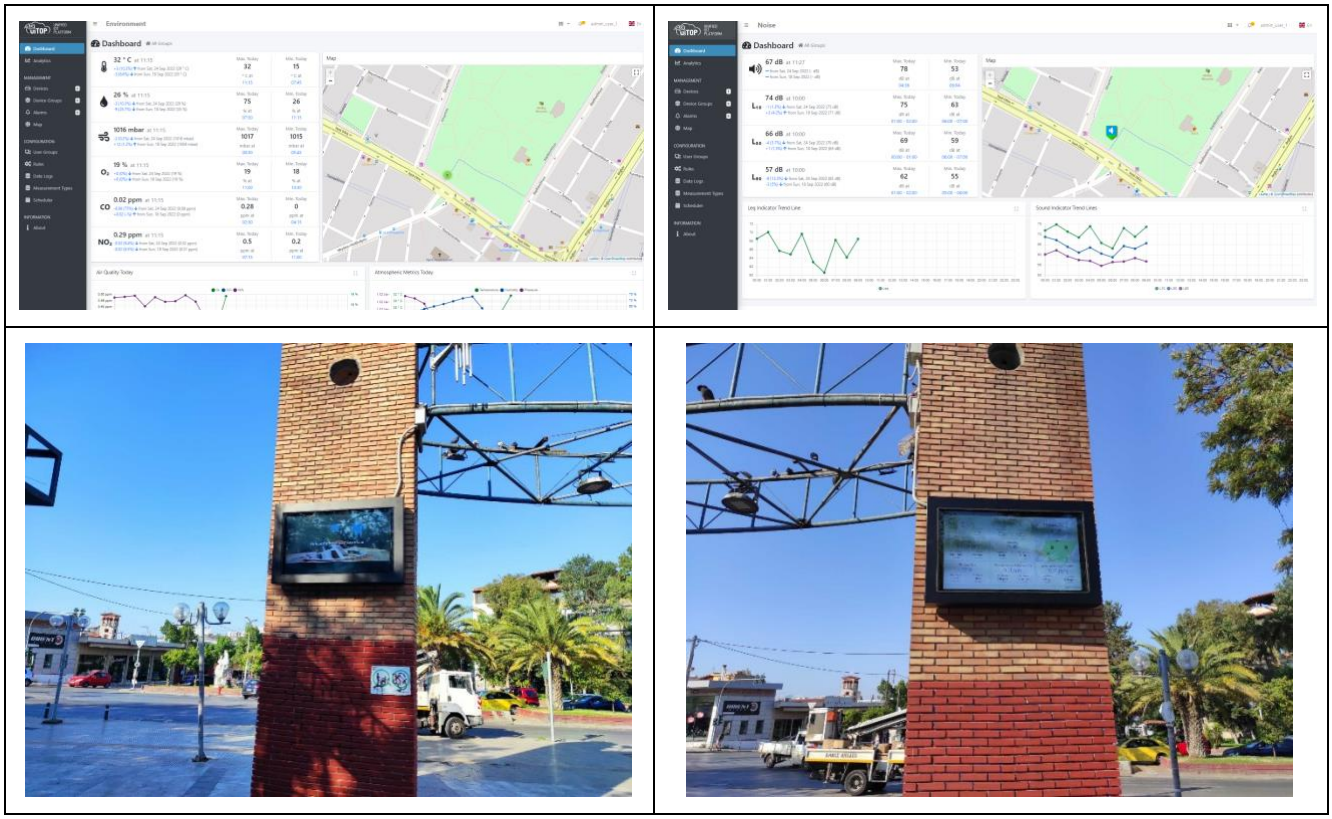

Figure 3 – Smart Square at the entrance of "*Baroutadiko*" grove in Egaleo

2.2.3 Entrepreneurship hub in Egaleo

The entrepreneurship hub in Egaleo[12], which is the third venture to address the above "Smart City 2020-2030" strategy of Egaleo, is located at the municipal stadium of Egaleo "*Stavros Mavrothalassitis*"[13]. It is dedicated as a "sandbox" to host technology start-ups developing innovative concepts. For the Municipality of Egaleo, the purpose of the entrepreneurship hub is to acquire an integrated support structure for innovation and start-up entrepreneurship, through which sustainable, innovative, and fast-growing businesses will emerge. All this with a view to establish a sequence of complementary actions that promote entrepreneurship and innovation, capable of meeting the needs of all participants in the ecosystem and seeking mutual osmosis, from the initial stage of their employment to the maturation of new and ambitious business initiatives.

Based on the 5GENESIS[14] Athens test facility, which includes the Egaleo football stadium site, it offers the complete trial facility able to support the prototypes of 5G-based solutions (cf. Figure 4). While the 5G-ESSENCE[15] project's outcomes, trialled at the Egaleo stadium, focused the 5G edge network acceleration at a stadium and brought related experiences for the hub, the involvement in the 5G!Drones project will bring the profit of the test platform preparation to support trialling of innovative telecommunications solutions' prototypes using drones.

[12] https://hub.egaleo.gr/
[13] https://www.google.com/maps/place/Stavros+Mavrothalassitis+Stadium/@37.9871066,23.6756127,17.79z/data=!4m5!3m4!1s0x14a1bca24ced518d:0x39f9cfe759db7785!8m2!3d37.987151!4d23.6759799
[14] https://5genesis.eu/
[15] https://www.5g-essence-h2020.eu/

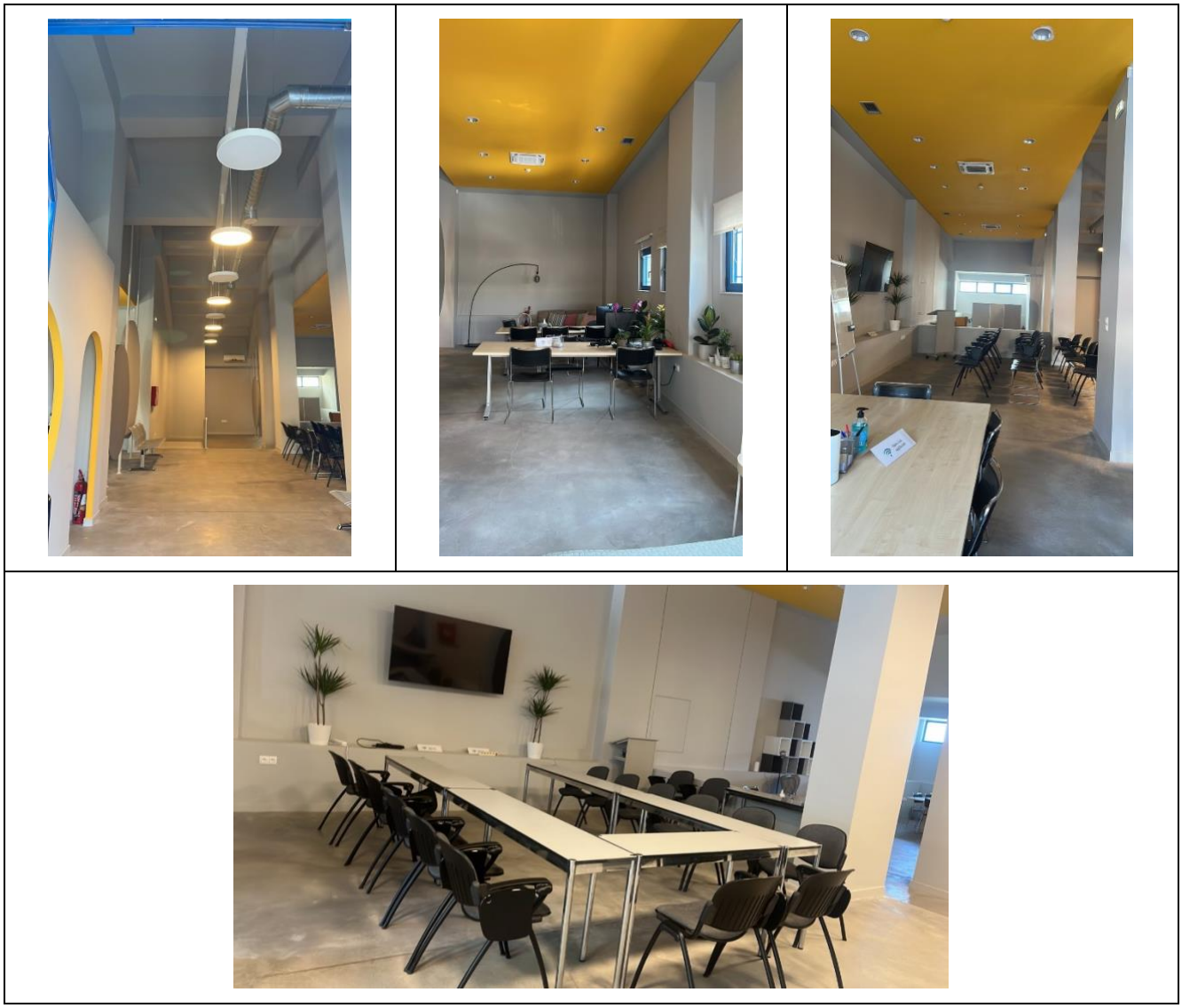

Figure 4 – Entrepreneurship hub in Egaleo

2.3 5G!Drones partners' mutual partnerships

The 5G!Drones project has also become a cooperation-triggering platform for project partners' joint activities on specific research and development issues.

2.3.1 Trajectory planning (EURECOM and Thales)

EURECOM and Thales worked together to provide a global solution for trajectory planning for a set of drones. Given departure and arrival geographical coordinates for a set of drones, the solution is able to define trajectories optimized in terms of network quality, distance and energy, and to update them according to on-flight received cellular data over 5G. In order to get real-time updates, a method was developed for updating the used neural networks quickly, through forward and backward propagation performed on subsets of data quite far from the initial trajectories.

2.3.2 Trajectory planning (Thales and University of Oulu)

Thales collaborated with University of Oulu by providing them with an open-source LTE deployment. Indeed, at the time, University of Oulu was trying to test different RAN deployments for their platform. The proposed deployment is based on srsLTE[16], an open-source radio software solution, 5G-EmPOWER[17], an open-source RAN controller, and NextEPC[18], an open-source core network. 5G-EmPOWER allows for the deployment of slicing on top of srsLTE. This deployment was provided to the team of the University of Oulu in the form of LXC containers, and must be combined to a Software Defined Radio (SDR) equipment, like an Ettus USRP[19] for instance. Thales also provided support to the team of the University of Oulu for the deployment and utilization of the containers.

2.3.3 Adaptive scheduling algorithm for RAN slicing (EURECOM and Thales)

Thales also collaborated with EURECOM to work on a research subject: the development of an adaptive scheduling algorithm for 5G RAN slicing. This study was performed within the scope of an internship in Thales and aims at optimizing resource allocation in the RAN on both inter-slice and intra-slice levels. Major goals of the algorithm are to avoid resource waste and optimize throughput within slices, keeping in mind the slice isolation constraint. In order to define this algorithm and its implementation, Thales based its work on EURECOM's open-source ecosystem, Mosaic5G[20]. In particular, EURECOM provided some support to Thales on their RAN platform, OpenAirInterface[21]. At that time, 5G slicing was not available in this open-source environment, so the study has been conducted on the LTE version of the software, implementing slicing, keeping in mind that it could be adapted to future 5G architecture.

2.3.4 Memorandum of continued collaboration (Municipality of Egaleo and National Centre of Scientific Research "*Demokritos*")

The National Centre of Scientific Research "*Demokritos*" and Municipality of Egaleo have agreed to sign a memorandum of collaboration to reassure the sustainability of the collaboration that was performed between the two parties during the activities of the 5G!Drones project. More specifically, the memorandum lists all the innovation activities that can be performed jointly either at National Centre of Scientific Research "*Demokritos*" or at Municipality of Egaleo premises, also including field trials and showcasing events, like the ones performed during the 5G!Drones project. The activities will foster also the initiative taken by Municipality of Egaleo to establish an entrepreneurship hub in Egaleo[22] in order to support entrepreneurship by Egaleo young citizens. This collaboration was also flourished during the last months of the project, where the hub hosted the showcasing event of 5G!Drones project that took place in Athens[23].

2.4 5G!Drones partners' partnerships with 3rd parties established thanks to involvement in 5G!Drones' activities

5G Ventures signed a memorandum of partnership with the National Centre of Scientific Research "*Demokritos*". The agreement is part of the strategy for the development of an ecosystem that will support the development of new generation digital services in Greece. 5G Ventures Société Anonyme ("5G Ventures SA") has been established pursuant to Article 93 of Law n. 4727/2020 (Government Gazette A' 184) and is a direct subsidiary of the Hellenic Corporation of Assets and Participations

[16] https://www.srslte.com/
[17] https://5g-empower.io/
[18] https://nextepc.org/
[19] https://www.ettus.com/
[20] https://mosaic5g.io/
[21] https://openairinterface.org/
[22] https://hub.egaleo.gr/
[23] https://www.youtube.com/watch?v=-LLJbj19Bx4

(HCAP SA). The purpose of the 5G Ventures SA is the establishment and management of Phaistos Investment Fund[24], based on the provisions of Article 7 of Law no. 2992/2002 (Government Gazette A' 54), according to prevailing market conditions, with guarantees for full transparency and accountability and complying with International Financial Reporting Standards (IFRS). The objective of the Phaistos Investment Fund is the public investment in businesses that are actively involved in 5G-related research and/or development of products and/or services in Greece, in sectors such as transport and logistics, manufacturing, public goods and utilities, health, tourism, information and media. As a result, 5G!Drones/5GENESIS[25] Athens Platform through this collaboration will be able to support the development of services and products for the 5G ecosystem.

According to the agreement, companies hosted at the "*Lefkippos*" Technology Park[26] and spin-offs of the National Centre of Scientific Research "*Demokritos*" could be examined by 5G Ventures for a potential investment through Phaistos Investment Fund.

The National Centre of Scientific Research "*Demokritos*" will contribute, as part of incubation and acceleration programmes, in supporting businesses where Phaistos has invested, offering on a case-by-case basis:

- Access to the pilot 5G Standalone and Non-Standalone networks (5GENESIS[27] and 5G!Drones) developed by the National Centre of Scientific Research "*Demokritos*";
- Development, in cooperation with 5G Ventures, of testbeds for testing applications, services and technologies developed by Phaistos' investees;
- Access to libraries, electronic knowledge bases, and excellence & innovation centres such as the Digital Innovation Hub and the Technology Parks of National Centre of Scientific Research "*Demokritos*".

5G Ventures and the National Centre of Scientific Research "*Demokritos*" will exchange information about technology & science, best practices on innovation -emphasizing on open innovation models-, issues connected with the development of ecosystems, and promoting entrepreneurship. The agreement also includes:

- Provision of guidance and mentoring to enterprises;
- Organizing seminars and workshops by 5G Ventures staff or Phaistos' investees, for the staff of the National Centre of Scientific Research "*Demokritos*";
- Organizing lectures by the scientific personnel of the National Centre of Scientific Research "*Demokritos*" in seminars and workshops organized by 5G Ventures, where undergraduate and postgraduate students can attend. The lectures will focus on subjects such as entrepreneurship, investments, technology utilization, product and service development, marketing, and sales;
- Promotion partnerships with enterprises, the National Centre of Scientific Research "*Demokritos*", and the industry;
- Networking companies where Phaistos has invested in, with scientific partners of the National Centre of Scientific Research "*Demokritos*" and developing and supporting Research & Development centres of the particular enterprises;
- Networking with venture capital funds and private investors.

[24] **https://5gventures.gr/**
[25] **https://5genesis.eu/**
[26] **http://lefkippos.demokritos.gr/**
[27] **https://5genesis.eu/**

In the light of the above, and especially due to the 5G!Drones project activities, a collaboration with the company of Matternet[28] has already been materialised with the planning and, at a later stage, execution of trials by the company. It is leading activities in the urban drone delivery market, utilising the Matternet M2 drone system. The M2 drone has achieved Type Certification by the Federal Aviation Administration (FAA). As the first non-military unmanned aircraft to achieve Type Certification in the USA, this gives Matternet a strong competitive advantage in the drone delivery market. The completion of the four-year rigorous evaluation by the FAA proves the safety and reliability of the M2 aircraft, a key step in scaling USA commercial drone operations. Within the following months Matternet will perform trials in Athens Platform, utilizing the experimentation and performance tools developed within the project, in order to assess the business opportunity of integrating 5G systems on its Unmanned Aerial Vehicles (UAVs) fleet.

Finally, in order to foster its collaboration with National Centre of Scientific Research "*Demokritos*", Matternet established a Greek subsidiary at the "*Lefkippos*" Technology Park[29] that is located within the National Centre of Scientific Research "*Demokritos*" campus. This collaboration between Matternet and the National Centre of Scientific Research "*Demokritos*" was well-accepted by the media and announced at the most popular Greek newspapers, like Kathimerini[30].

2.5 Other initiatives

National Centre of Scientific Research "*Demokritos*" established Ahedd, a digital innovation hub, which fosters the development of an ecosystem matching the business needs of Small and Medium-sized Enterprises (SMEs) and organisations to commercial-ready solutions. Ahedd is registered in the European Commission Digital Innovation Hubs (DIHs) catalogue and is also a Big Data Value Association (BDVA)/Data, AI and Robotics Association (DAIRO) gold-labelled i-space.

Ahedd Digital Innovation Hub is an ecosystem of research and corporate entities that have exceptional know-how in offering digital transformation and innovation solutions using AI, 5G, Big Data and IoT technologies as horizontal enablers.

Ahedd acts as a one-stop-shop for enterprises looking to enrich their competitive advantage portfolio and for public entities that need to improve their processes and services, offering business support through experimentation facilities, like 5GENESIS[31] Athens Platform, for testing new technologies before investing, as well as through training, networking and acceleration services.

[28] **https://mttr.net/**
[29] **http://lefkippos.demokritos.gr/**
[30] **https://www.kathimerini.gr/economy/561891472/prosgeionontai-stin-ellada-ta-drones-tis-matternet/**
[31] **https://5genesis.eu/**

3 Investigation of possibilities for the commercial exploitation

Some of the previously announced project outcomes have been qualified by their owners as having a potential for commercial exploitation. This chapter presents the used approach to the outcomes' investigation process, and then presents the individual outcomes in the context of their commercial exploitability development.

3.1 5G!Drones' outcomes commercial exploitation

In the document D5.2 "Report on communication, showcasing, dissemination and exploitation achievements and plan for the second term of the project" [3], the project 5G!Drones has presented the initial list of the project outcomes. Some of them have been qualified by their owners for further commercial exploitation (cf. Table 1).

Table 1 – Extract of the initial list of 5G!Drones outcomes in D5.2 [3] with outcomes further qualified for commercial exploitation filtered

#	Outcome	Project result category	Exploitable type	End customer
1	5G!Drones USPACE Adaptor	Prototype	Product Development	Integrator
3	Mission Critical Services platform integrating Drone As A Service on 5G network	Prototype	Product Development	Public Safety Authorities - Firefighters, Emergency services, Police
13	Networked Remote ID tracker	Demonstrator	Start-ups	Vertical Industry
20	Post-storm analysis of power lines	Prototype	Business Development	Vertical Industry
24	5G Hydradrone platform for inspection operations	Demonstrator	Product Development	Vertical Industry
25	UMS software platform's capabilities in: - a. Autonomous drone swarm management - b. Object detection through video analysis - c. Enabling use cases like on-demand connectivity by providing network connectivity through drones	Demonstrator	Business Development	Vertical Industry
29	UMS simulation testbed	Prototype	Research Achievements	Vertical Industry
32	Mission Critical Services	Prototype	Product Development	Public Safety Authorities - Firefighters, Emergency services, Police
37	Localization of a drone	Patent	Product Development	Drone companies, Telecom Operator

3.1.1 Final list of the project outcomes qualified for commercial exploitation

It should be noted that the filtered D5.2 outcomes list presented in Table 1 shows both individual outcomes and wider categories to which finally belong separate outcomes or products (having their owners) to be assessed and described individually. Hence, the list of final project outcomes with their names, owners and mapping to the initial list in D5.2 is provided in Table 2. These outcomes will be further presented in this chapter.

Table 2 – Final list of 5G!Drones individual outcomes qualified for commercial exploitation

D5.2 outcome ID	Outcome name	Outcome owner	Section number
1	Telemetry USSP service	Droneradar	3.2

D5.2 outcome ID	Outcome name	Outcome owner	Section number
1	Drone flight plan authorisation USSP service	Droneradar	3.3
1	Geo-zone/AIM USSP service	Droneradar	3.4
1	U-space adapter	Frequentis	3.5
3	Mission Critical platform integrating Drone as a Service on 5G network	Airbus	3.6
13	LEMAN Remote ID tracker	Involi	3.7
20	Post-storm inspection of power lines	Hepta and Flaperon	3.8
24	5G hybrid platform for inspection operations	Alerion	3.9
25a	Autonomous drone swarm management	Unmanned Systems	3.10
25b	Object detection through video analysis	Unmanned Systems	3.11
25c	Unmanned network extension service	Unmanned Systems	3.12
29	UMS simulation testbed	Unmanned Systems	3.13
32	Mission Critical Services	Thales	3.14
37	Localization of a drone	Orange	3.15

3.1.2 Methodology of presentation

The commercially exploitable outcomes of the 5G!Drones project will be further presented according to the following template:

- High-level description of the outcome from the point of view of its commercial value;
- Perspectives of commercial exploitation of the outcome including Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis;
- Plan of commercialization of the outcome.

In case of outcomes with Technology Readiness Level (TRL) equal to 7, 8 or 9, the analysis based on Value Proposition canvas is provided, based on the Deliverable D5.2 [3].

3.1.3 Technological maturity classification criteria

To ensure a uniform assessment of the maturity of individual solutions described in this chapter, the TRL[32] scale was used in accordance with the definition of the European Union (cf. Table 3 below).

Table 3 – TRL scale according to the EU Horizon 2020 programme [4]

TRL	Description
1	Basic principles observed
2	Technology concept formulated
3	Experimental proof of concept
4	Technology validated in lab
5	Technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)
6	Technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)
7	System prototype demonstration in operational environment

[32] https://ec.europa.eu/research/participants/data/ref/h2020/other/wp/2018-2020/annexes/h2020-wp1820-annex-g-trl_en.pdf

TRL	Description
8	System complete and qualified
9	Actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)

3.2 Droneradar – Telemetry USSP service

3.2.1 High-level description of the outcome from the point of view of its commercial value

Dedicated to U-space Service Providers (USSPs), the Telemetry USSP service is a functional module of Droneradar's UTM platform, whose main purpose is to generate and provide common situational awareness in terms of current and up to date locations of all monitored UAVs. It is capable of collecting telemetry data from UAVs (telemetry reporters) as well as to publish their locations to interested parties (telemetry consumers) through its well defined and standardized APIs.

It is compliant with EU U-space regulation 2021/666 and implements SERA.6005 requirements related to electronic conspicuity and e-identification. It was implemented based and according to GOF 2.0 and SESAR PJ34 projects' recommendations.

Key features are:

- Available API for reporting positions from different UASes - during the 5G!Drones project it was integrated with CAFA Tech, Unmanned Life and Hepta/Flaperon);
- Available API for publishing telemetry data for external systems (telemetry consumers) – during the project it was interconnected with SmartSIS Frequentis UTM to exchange telemetry data (bidirectional);
- Available normalization and de-multilateration functions (to provide common altitude reference heights and avoid data duplication).

3.2.2 Perspectives of commercial exploitation of the outcome

The Telemetry service is already available as a legacy part of Droneradar's UTM system but currently it is being adjusted to meet current specifications and recommendations. It will be developed to provide more sophisticated telemetry handling operations as well as to follow the on-going standardization of the telemetry exchange specifications.

Owner	Droneradar			
Description	Telemetry USSP service			
	Outcome type	Prototype	**Outcome category**	Compliance with legal requirement
	Current TRL category	TRL7 – System prototype demonstration in operational environment		
End customer	U-space services users and providers.			
Target markets	USSPs.			

Innovations	Robust technology to provide on-line telemetry services, including real-time de-duplication, Criticality and Risk Assessment (CARA) recalculations, etc.
Product competition	There are competitors providing similar products. Among them are mainly providers of systems and solutions for U-space services.

SWOT analysis	
Opportunities: • Electronic conspicuity and e-identification imposed by legal requirement.	Threats: • New, more established entrants to provide competitive solutions. • Standardization process still on-going.
Weaknesses: • Lack of standardization/certification of telemetry devices for UASes – the data has limited reliability.	Strengths: • Experience gathered from real life implementations. • Proven performance and functionality. • Good technical know-how about solutions inside the company (gathered during first commercial implementation of UTM system). • Additional features, which can be exploited.

3.2.3 Plan of commercialization of the outcome

Current TRL7 means that the feature development is still ongoing. This is mostly due to the fact that related standardization is still on-going. On the other hand, earlier versions prove their performance and capabilities.

Wider commercial exploitation of Telemetry USSP Service and its capabilities can be expected, when the U-space services standardization and its business adoption become more mature.

The experience gathered based on 5G!Drones project shows that 5G network-based localization capabilities can at least complement the legacy localization technologies – GNSS, Automatic Dependent Surveillance–Broadcast (ADS-B), etc. – in terms e.g., of backup/fail-safe solution to provide UASes telemetry information. This feature is planned to be more extensively evaluated in the future.

The Telemetry USSP service is expected also to be utilized by 3rd party service providers, when the localization and identification of UASes would be necessary, e.g., possibility of identification of UASes (confirmation of which UASes, when and where were present). This can be used, for instance, in case of claims, when the “anonymous” UAS breaches an individual’s privacy and would allow to verify its identity (ownership, etc.). This would become a serious issue, when UAS missions become more popular and frequent.

Value Proposition canvas-based analysis of the Telemetry USSP service by Droneradar:

CUSTOMER	VALUE PROPOSITION
FUNCTIONS/JOBS: • Obligation to provide telemetry data according to current regulations (electronic conspicuity and e-	PRODUCTS & SERVICES: • Telemetry listener to accept majority of telemetry data sources (ADS-B, GNSS, etc.).

identification). • Observe the situation around during the mission. • Monitoring the Beyond Visual Line Of Sight (BVLOS) missions. • Identification of UAVs.	• Publish telemetry data related to all monitored UASes and airplanes in the area. • Exchange of telemetry data with other interconnected telemetry services. • Support for e-identification services.
PAINS: • Multilatency of telemetry data (e.g., for ADS-B systems). • Lack of common altitude reference system (altitude is relative). • Checking tracking history for investigation purposes.	PAIN RELIEVERS: • Multilatency elimination capabilities • Possibility to "normalize" altitude readings with Common Altitude Reference System (CARS). • Tracking history can be checked e.g., to identify a suspected drone, which was flying in a certain area, at a certain time.
GAINS: • Source of reliable telemetry data. • Complete situational awareness. • Easy access to telemetry information. • Easy reporting of telemetry data.	GAIN CREATORS: • Adjusting the telemetry data, e.g., applying CARS. • Provides telemetry for all UASes as well airplanes in controlled areas, regardless of their telemetry enabling technology. • Well defined APIs to access telemetry data (telemetry publisher). • Well defined APIs to provide the telemetry data (telemetry listener).

3.3 Droneradar – Drone Flight Plan authorisation USSP service

3.3.1 High-level description of the outcome from the point of view of its commercial value

The Drone Flight Plan authorisation USSP service is another functional component of Droneradar's UTM platform. Its main purpose is to receive from end users (UAS operators) the mission's plans so as to perform required flight authorisations.

The Drone Flight Plan component follows and implements EU U-space regulation 2021/664 in the scope of flight authorisation services. It ensures that authorised UAS operations are free of intersection in space and time with any other notified UAS flight authorization within the same portion of U-space airspace. It implements data models and service specifications as specified by GOF 2.0 and SESAR PJ34 projects.

Key features are:

- Checking if the UAS flight authorisation request is complete and correct and submitted in accordance with requirements
- Accepting the UAS flight authorisation request, if the flight under the UAS flight authorisation is free of intersection in space and time with any other notified UAS flight authorisations within the same U-space airspace in accordance with the priority rules

- Notification to the UAS operator about the acceptance or rejection of the UAS flight authorisation request

3.3.2 Perspectives of commercial exploitation of the outcome

The Drone Flight Plan service is already available as a legacy part of Droneradar's UTM system but currently it is being adjusted to meet current specifications and recommendations. It will be developed to provide more sophisticated operations like: resolving planned mission conflicts, suggesting alternate missions, consulting weather and other aeronautical sources of information, etc.

<table>
<tr><td>Owner</td><td colspan="4">Droneradar</td></tr>
<tr><td rowspan="3">Description</td><td colspan="4">Drone Flight Plan</td></tr>
<tr><td>Outcome type</td><td>Prototype</td><td>Outcome category</td><td>Compliance with legal requirement</td></tr>
<tr><td>Current TRL category</td><td colspan="3">TRL5 – Technology validated in relevant environment</td></tr>
<tr><td>End customer</td><td colspan="4">Every U-space user (pilots, operators, etc.).</td></tr>
<tr><td>Target markets</td><td colspan="4">USSPs.</td></tr>
<tr><td>Innovations</td><td colspan="4">Unique, dedicated process of automatic handling of authorisations requests.</td></tr>
<tr><td>Product competition</td><td colspan="4">There are competitors providing similar products. Among them are mainly providers of systems and solutions for U-space services.</td></tr>
<tr><td colspan="5">SWOT analysis</td></tr>
<tr><td colspan="2">Opportunities:
Handling of flight authorization requests imposed by legal requirements.</td><td colspan="3">Threats:
New, more established entrants to provide competitive solutions.
Standardization process still on-going.</td></tr>
<tr><td colspan="2">Weaknesses:
Currently, the flight authorization process is semi-automatic, some checks need to be performed manually/off-line.</td><td colspan="3">Strengths:
Experience gathered from real life implementations.
Proven performance and functionality.
Good technical know-how about solutions inside the company (gathered during the first commercial implementation of the UTM system).
Additional features, which can be exploited.</td></tr>
</table>

3.3.3 Plan of commercialization of the outcome

Current TRL5 means that the feature development is still ongoing. This is mostly because related standardization is still on-going and complementary services must be available to make this process as automatic as possible.

Wider commercial exploitation of Drone Flight Plan service and its capabilities can be expected, when the U-space services standardization and its business adoption become more mature, especially when the interoperability between different USSPs is considered.
The Drone Flight Plan is a key enabler for registering and authorising the flight missions and in the nearest future development and business implementations should assure that the appropriate exchange of cross USSP missions' information between different USSPs is properly provided and maintained.

3.4 Droneradar – Geo-zone/AIM USSP service

3.4.1 High-level description of the outcome from the point of view of its commercial value

The Geo-zone/Aeronautical Information Management (AIM) USSP service is another functional component of Droneradar's UTM platform. Its main purpose is to provide situational awareness information about the airspace configuration including aeronautical information – Aeronautical Information Publication (AIP), Airspace Use Plan (AUP), NOtice To Air Missions (NOTAM), etc. and ad-hoc, locally introduced limitations. It is the main and only source of this information for all pilots and UAV operators.

The Geo-zone/AIM component follows and implements the Articles 15 of EU U-space regulation 2019/947.

Key features are:

- Providing information on the applicable operational conditions and airspace constraints within the U-space airspace;
- Providing information about UAS geographical zones, relevant to the U-space airspace;
- Providing temporary restrictions applicable to airspace use within the U-space airspace;
- Providing the interface for automatic geo-zone exchange with UASes as defined in EU regulation 2019/945.

3.4.2 Perspectives of commercial exploitation of the outcome

The Geo-zone/AIM service is currently under development. It will become part of Droneradar's UTM system.

Owner	Droneradar			
Description	Geo-zone/AIM			
	Outcome type	Prototype	**Outcome category**	Compliance with legal requirement
	Current TRL category	TRL5 – Technology validated in relevant environment		
End customer	Every U-space user (pilots, operators, etc.).			
Target markets	USSPs, local administration units.			
Innovations	Geo-zone management process.			

Product competition	There are competitors providing similar products. Among them are mainly providers of systems and solutions for U-space services.
SWOT analysis	
Opportunities: • Management of geo-zones is required by legal entities and all local administration units responsible for U-space management would require such tools.	Threats: • New, more established entrants to provide competitive solutions. • Standardization process still on-going.
Weaknesses: • The Geo-zone concept is still immature and not validated at scale.	Strengths: • Experience gathered from real life implementations. • Proven performance and functionality. • Good technical know-how about solutions inside the company (gathered during first commercial implementation of UTM system). • Additional features, which can be exploited.

3.4.3 Plan of commercialization of the outcome

Current TRL5 means that the feature development is still ongoing. Within the coming years Geo-zone management platforms will become standard for all administration entities responsible for U-space airspace management and configuration.
The Geo-zone/AIM USSP service is expected to become one of the most important and crucial tools for future U-space airspace administrators, Local Administrative Units (LAUs). It will be the key enabler that would allow to define and implement the airspace usage rules and conditions for U-space airspaces. It will be used by every LAU so as to maintain their airspace resources.

3.5 Frequentis – U-space adapter

3.5.1 High-level description of the outcome from the point of view of its commercial value

The Frequentis U-space adapter is an interface for stakeholders to integrate into the U-space domain. This component was enhanced, integrated and tested in the 5G!Drones project to evaluate its performance as an interface of required UTM services on top of the 5G-related services. The U-space adapter shall focus all relevant U-space actors and the respective interfaces in one component. Its primary role is to act as Common Information Service (CIS) provider, which receives and distributes U-space data.

The U-space adapter follows and implements EU U-space regulation 2021/664 in the scope of traffic information service, flight authorisation service, geo-awareness service.

It implements data models and service specifications as also specified by GOF 2.0 and SESAR PJ34 projects.

3.5.2 Perspectives of commercial exploitation of the outcome

The Frequentis U-space adapter interface is currently under development and planned to be part of the Frequentis UTM system. The components and interfaces, which contribute to the Frequentis U-space adapter within the 5G!Drones project, will be an integral part of the Frequentis UTM product suite.

<table>
<tr><td>Owner</td><td colspan="4">Frequentis</td></tr>
<tr><td rowspan="3">Description</td><td colspan="4">U-space Adapter</td></tr>
<tr><td>Outcome type</td><td>Prototype</td><td>Outcome category</td><td>Business Development</td></tr>
<tr><td>Current TRL category</td><td colspan="3">TRL6 – Technology demonstrated in relevant environment</td></tr>
<tr><td>End customer</td><td colspan="4">Integrators</td></tr>
<tr><td>Target markets</td><td colspan="4">USSPs, UTM stakeholders.</td></tr>
<tr><td>Innovations</td><td colspan="4">Interface connecting U-space and UTM stakeholders with 5G applications.</td></tr>
<tr><td>Product competition</td><td colspan="4">There are competitors providing similar products. UTM providers as well as USSPs.</td></tr>
<tr><td colspan="5">SWOT analysis</td></tr>
<tr><td colspan="2">Opportunities:
Air Navigation Service Providers (ANSPs) follow the U-space regulations and procure UTM solutions.
Industry needs to integrate to U-space to enable drone operations.
Public safety customers enhance their capabilities via drones, direct integration to airspace authorities needed.</td><td colspan="3">Threats:
Competition from multiple different vendors, both established ATM as well as “start-up” style companies – market is currently very competitive and volatile.
Details for implementation of standards are still ongoing.</td></tr>
<tr><td colspan="2">Weaknesses:
Integration processes and documentation can still be improved and streamlined.
Resiliency/data validation can be improved further.</td><td colspan="3">Strengths:
Working integration with multiple partners validated in multiple research projects.
Based on EU regulation standards, following experiences collected in initial prototype and first commercial applications.
Extendibility and scalability enabled by the implementation concepts.</td></tr>
</table>

3.5.3 Plan of commercialization of the outcome

Current TRL6 shows that the development is still ongoing, while its validation will be continued in research environments as well as commercial applications. The component is planned to be a vital part of the Frequentis UTM offering.

3.6 Airbus – Mission Critical platform integrating Drone as a Service on 5G network

3.6.1 High-level description of the outcome from the point of view of its commercial value

The mission critical platform integrating Drone as a Service on 5G network is all about secure group collaboration with the ability to leverage drone assets. It brings professional communications to smart devices becoming part of the professional world – voice, data, video, and location services are all at hand with the reliability and security that professional users expect and natively integrating drones that are more and more used by first responders.

This 5G native platform scales flexibly from simple Push-To-Talk (PTT) to an extensive group collaboration solution, which takes advantage of smart device capabilities in a secure and controlled way. It offers a full variety of different communication methods from instant PTT to video and location sharing, and it also gives tools to professionally manage users and groups.

Providing integrated applications, including voice services, instant messaging, video communication, location mapping and emergency calls, and adding the capability to augment situational awareness through drone aerial view, this solution meets the diverse needs of public safety organizations as well as the ones of transport, utility, industry, and corporate sectors.

The outcome's key features are:

- Talk, send multimedia messages or live video to your group: Bring professional group communications into your smart device. It only takes a touch of a button on your smartphone to talk, send multimedia messages or even live video to your group.
- Send or receive real-time video: Real-time video from the field gives a better situational picture. Instead of reacting to what has already happened, you can be one step ahead.
- Share a tactical map of an operation: A tactical map can give you a comprehensive overview of an operation. Group member details are shown, which helps plan and execute the right response.
- Drone integration: Share real time video capture by drone and locate drone in real time among first responders on tactical map.

3.6.2 Perspectives of commercial exploitation of the outcome

The current vision:

<table>
<tr><td>Owner</td><td colspan="4">Airbus</td></tr>
<tr><td rowspan="3">Description</td><td colspan="4">Mission Critical Platform integrating Drone as a Service on 5G network</td></tr>
<tr><td>Outcome type</td><td>Prototype</td><td>Outcome category</td><td>Business Development</td></tr>
<tr><td>Current TRL category</td><td colspan="3">TRL7 – System prototype demonstration in operational environment</td></tr>
</table>

End customer	Mission Critical and Business Critical end users.
Target markets	Public safety, Public Protection and Disaster Relief (PPDR), transport & utilities, critical national infrastructures.
Innovations	The platform is 5G-native/Cloud-native, can exploit every advanced 5G features, can manage 5G Quality Indicators (5QIs), which is a *grande premiere* at the European level, slices, MEC, … It is benefiting from modern, resilient and evolutive architecture. Besides, it bases upon extremely interfaceable components, supporting connection to any kind of IoT devices or 3rd parties' elements, and is optimized for leveraging drone assets.
Product competition	There are so far no competitors on this type of advanced product, but there are legacy offers unable to exploit 5G features. According to the implementation these legacy solutions can present technical interfaces that may allow drone integration but with no optimization.

SWOT analysis	
Opportunities: • Deployment of 5G national networks. • 5G for verticals and in particular PPDR. • Increasing adoption of drone assets by Mission critical and Business critical community.	Threats: • Regulations' constraints may limit technology usage (flight conditions, frequency bands allocated, ...). • Usage conditions are usually under multiple constraints, which may induce some accidents that may slow down technology adoption. • Technology price may be a hurdle.
Weaknesses: • The prototype is beyond the state of the art, but standards are not fixed and may evolve.	Strengths: • 5G native: can fully exploit 5G advanced techniques. • Ultra-low latency. • High-definition real time video streams. • Instant deployment (around 30 s from scratch). • Highly scalable. • Support 5G quality of Service management.

3.6.3 Plan of commercialization of the outcome

Current maturity is TRL7 (Technology Demonstration). The tasks carried on in the 5G!Drones project allowed confirming the readiness of Airbus secured communications products to support 5G and drones' technologies ensuring performances in accordance with public safety requirements as defined in 3GPP standardization development organization. Now, the plan consists in nurturing Airbus DS Secure Land Communications (SLC) products and solutions roadmap to build a competitive portfolio and to maintain leadership in the Private Mobile Radio (PMR)/PPDR industries. The innovations developed in the framework of the project will enhance the products already present in the portfolio

using a strangler pattern for introducing all the features according to their priority and the use case that potential customers want to cover.

Value Proposition canvas-based analysis of the Mission Critical platform integrating Drone as a Service on 5G network by Airbus:

CUSTOMER	VALUE PROPOSITION
FUNCTIONS/JOBS: • Mission critical and business critical. • Public Safety. • Public Protection and Disaster Relief. • Firefighting. • Ensuring security. • Saving lives. • Search and Rescue. • Maintenance Inspection.	PRODUCTS & SERVICES: • 5G secured communication platform integrating drones as a service.
PAINS: • Difficulties to share the information. • Difficulties to access geographical areas especially in case of large disaster. • Difficulties to assess a situation. • Difficulties to take the right decision with a partial overview. • Race against time.	PAIN RELIEVERS: • Easy sharing of the information using usual secured communication applications. • Rapid access to information through drone aerial assets. • Deployment: fast and automated.
GAINS: • Augmented situational awareness. • Real-time data sharing.	GAIN CREATORS: • Aerial situational awareness. • Instant service creation. • Ultra-resilience. • Ultra-low latency. • High definition videos.

3.7 Involi – LEMAN Remote ID tracker

3.7.1 High-level description of the outcome from the point of view of its commercial value

LEMAN remote ID tracker is a fully independent 4G drone tracker, equipped with GPS and independent battery. It helps UAV operators to be in line with European and other countries legal requirements for operating the drones. It is compliant with American Society for Testing and Materials (ASTM) standard F3411-19, ASD-STAN 4709-002 standard, EC Delegated Regulation 2019/945 and EU U-space Regulation 2021/664.

Key features are:

- Live and precise GNSS position data streamed to the central server by cellular network and broadcasted around the drone using Wi-Fi broadcasting allows operators to safely perform their operations along other aircraft.
- Facilitating the admission of Specific Operations Risk Assessment (SORA), Participatory Disaster Risk Assessment (PDRA) or other permits to fly, by assuring an alternative source of drone position, in case of problem with usual telemetry transmission.
- Easy integration through APIs with other third-party systems and platforms for drone flight management and supervision.

The product was developed and commercialised during the 5G!Drones project. The first product was only supporting the networked remote ID, but because of the requirements set by legislation, the broadcasting remote ID feature was added to the latest version.

3.7.2 Perspectives of commercial exploitation of the outcome

The LEMAN Remote ID tracker can be ordered in Involi's online shop since May 2022. Its lightweight, easy installation and affordable price makes it a good option to fulfil legal requirements for the owners of legacy or Do It Yourself (DIY) drones.

<table>
<tr><td>Owner</td><td colspan="4">Involi</td></tr>
<tr><td rowspan="3">Description</td><td colspan="4">LEMAN Remote ID tracker</td></tr>
<tr><td>Outcome type</td><td>Product</td><td>Outcome category</td><td>Compliance with legal requirement</td></tr>
<tr><td>Current TRL category</td><td colspan="3">TRL9 – Actual system proven in operational environment</td></tr>
<tr><td>End customer</td><td colspan="4">UAV owners.</td></tr>
<tr><td>Target markets</td><td colspan="4">UAS services for any target market, systems requiring additional safety by duplicated positioning.</td></tr>
<tr><td>Innovations</td><td colspan="4">Lightness, compatibility with all standards requirements, integration with https://involi.live web interface, possibility to integrate through APIs to any 3rd party software.</td></tr>
<tr><td>Product competition</td><td colspan="4">There are competitors providing similar products. Involi is competing with them through lightweight design, possibility to use https://involi.live platform or integrate the data with 3rd party software, and pricing.</td></tr>
<tr><td colspan="5">SWOT analysis</td></tr>
<tr><td colspan="2">Opportunities:
Use of tracker imposed by legal requirement.
The mandatory tracker can be enriched with additional functionalities that may create a product, which stands out on the market.</td><td colspan="3">Threats:
New drones will be equipped with embedded trackers.
Competitors providing similar devices.</td></tr>
</table>

Weaknesses: • Current version is 4G only. • Configuration through SMS messages.	Strengths: • Reconfiguration is possible. • Good operating time on one battery cycle, much longer than drone operating time. • Both networked and broadcast remote ID supported. • Good technical know-how about the solution inside the company. • Currently available data of tracker measurements can be used for creating cellular network coverage maps.

3.7.3 Plan of commercialization of the outcome

Current TRL9 means that the product is available commercially and tested in normal operation situations. It was certified and has Federal Communications Commission (FCC) and Conformité Européenne (CE) certificates. However, Involi is still looking for improvements of all its products and plan to release the new hardware version and use the cellular network data collected during tracker operation for creating the 3D coverage maps.

Product web page: **https://involi.com/leman-rid-drone-tracker**

Value Proposition canvas-based analysis of the LEMAN Remote ID tracker by Involi:

CUSTOMER	VALUE PROPOSITION
FUNCTIONS/JOBS: • Fly a drone BVLOS. • Fly over people. • Observe the situation around during the mission. • Fly multiple missions, with multiple batteries (3 × 30 min). • Observe the mission in preferred software.	PRODUCTS & SERVICES: • Compliant with ASTM F3411-19 standard – broadcast and network Remote ID. • Weight 49 g, attachable to the UAV. • Completely independent (own battery and communication). • Configuration through SMS. • Access to **https://involi.live** web portal included. • Interoperability through APIs.
PAINS: • Legacy drone not compliant with new legal requirements. • Software not compatible. • Need to buy a new drone. • Maximum Take-Off Weight (MTOW) is limited.	PAIN RELIEVERS: • Enabler for enhanced operations: BVLOS and over people. • Fulfilling e-conspicuity legal requirements. • Increased situational awareness in the operation area (**https://involi.live**). • Affordable price.

	• Lightweight solution.
GAINS: • Fast compliance with rules. • Possibility to use a well-known drone. • No big financial investment. • No increased power consumption. • Increased situational awareness.	GAIN CREATORS: • Solution for legacy UAV. • Easy to install on drone and use. • Long battery life, sufficient for at least 3 h of operation. • Possible to track UAV in any application through APIs.

3.8 Hepta and Flaperon – Post-storm inspection of power lines

3.8.1 High-level description of the outcome from the point of view of its commercial value

Power line infrastructure is built to withstand weather with a defined intensity – freezing rain, wind, temperature extremes. In some locations and on some occasions, these design limits will be exceeded by extreme weather and breakages in the grid can be expected. This can be exacerbated by the global warming which is expected to intensify the weather extremes. There are also many other factors that can lead to faults in the grid with bad weather that are hard to model precisely or even detect with periodic inspections – some examples would be trees falling onto the line due to weak soil or rotten trunks, wooden power line poles decaying quicker than expected due to worse than expected soil conditions or improper treatment. As a result, there can be as much as 30% of the repair budget on a distribution grid spent on repairing unexpected faults. Also, due to the large size of distribution grids, unexpected faults are not uncommon at all. These kinds of faults in transmission grids are much less common but carry a much larger risk due to the number of affected clients.

In many countries around the world customers may be entitled to receive liability payments from grid operators in case the power outages last longer than a defined time and were caused by their grid failing. This creates an incentive for the grid operators to find a good balance point between building stronger infrastructure and just finding and fixing the faults quicker. Building stronger infrastructure would, at some point, get prohibitively expensive. Finding the faults quickly is not a trivial task either, especially with medium voltage insulated wires, where the automatic fault locating systems may not even give an alarm if the line was not broken. Finding the faults on foot can be dangerous to the personnel due to the presence of a fault and the high voltages involved, but also due to the dangers posed by the terrain or wildlife. A common way to find the faults quickly is to dispatch a helicopter to check the faulty line. Using manned helicopters for this job is very expensive though and puts the flight crew at risk flying low with bad weather.

Possible clients for this service would be all transmission and distribution grid operators in countries where there is strong enough incentive for them to use quick reaction service to find faults. This would include most of the European continent, and large parts of the rest of the world.

Post-storm analysis of power lines is a service initially envisaged by Hepta to include 24/7 quick reaction drone flight service with payloads and software that would enable to scan the target power line in any lighting condition accompanied with a real-time data streaming service, a quick and capable data analysis setup, and an intuitive software for the clients to view and share the results. This set would enable the client to get the results the fastest and see the damage to the line in the shortest amount of time possible in any remote corner of its network.

Due to a business decision to focus only on drone flight service and data analysis service provision by Hepta, drone development was stopped. Flaperon acquired the drone development intellectual property from Hepta and is continuing with developing the drones and integrating payloads for power line

inspection. The post storm power line inspection service is currently envisaged to be provided by Hepta but the development of hardware and needed integrations would be finished by Flaperon.

The current service product has the capabilities of automatically capturing photos and live uploading them to Hepta's cloud-based infrastructure inspection software; there they can be automatically processed with ML models trained for this purpose to find the faults. Furthermore, the drone providing the service is equipped with a lidar which will send the captured point cloud to the drone operator in real time, which enables it to see what is going on below the drone even in darkness. The point clouds can be also quickly uploaded to the same inspection software where the client can have access to the data and analysis results. The system has been tested to work well on both 4G and 5G networks.

3.8.2 Perspectives of commercial exploitation of the outcome

The current vision of the owner:

<table>
<tr><td>Owner</td><td colspan="4">Hepta and Flaperon</td></tr>
<tr><td rowspan="3">Description</td><td colspan="4">Post-storm inspection of power lines</td></tr>
<tr><td>Outcome type</td><td>Prototype</td><td>Outcome category</td><td>Service</td></tr>
<tr><td>Current TRL category</td><td colspan="3">TRL5 – Technology validated in relevant environment</td></tr>
<tr><td>End customer</td><td colspan="4">Distribution and transmission grid operators, grid inspection service providers.</td></tr>
<tr><td>Target markets</td><td colspan="4">Power transmission and distribution markets – Mainly European market, but expansion is possible to other markets around the world.</td></tr>
<tr><td>Innovations</td><td colspan="4">Very fast and visualized digital results for the clients, low bandwidth requirement for the point cloud.</td></tr>
<tr><td>Product competition</td><td colspan="4">Manned helicopter quick reaction service, drone based quick reaction service.</td></tr>
<tr><td colspan="5">SWOT analysis</td></tr>
<tr><td colspan="2">Opportunities:
Regulative pressure on the grid operators to decrease their downtimes is increasing.
Ever growing interest in grid operators to replace manned helicopter services with services offered by unmanned systems.</td><td colspan="3">Threats:
Regulatory bottlenecks for ad hoc unmanned flights.
New direct competitor.
Running costs for quick reaction service could be too steep and incentives too low for the operators for widespread adoption in some markets.</td></tr>
</table>

Weaknesses: • Full capabilities only within 4G/5G covered areas. • Single flight range is lower than in case of manned helicopters. • Flight speed is lower than for manned helicopters.	Strengths: • Only system known to us with these capabilities in the market. • Night-time capabilities. • Visualized results to the client – more info than just a verbal report. • Easily expandable to the scheduled inspection domain and increase the speed and efficiency of service there. • Easily expandable to increase the speed and efficiency of any airborne scanning service.

3.8.3 Plan of commercialization of the outcome

Currently the service has been developed to TRL5. The plan is to finish the development of automatic uploading of point clouds to the cloud-based inspection software, refine the ML models to better detect faults, increase the robustness of point cloud mapping, finish the development of the hybrid drone platform, refine the user experience, and test out the service in an operational environment.

Bringing the service to the market in full capacity would require a significant additional development effort.

3.9 Alerion – 5G hybrid platform for inspection operations

3.9.1 High-level description of the outcome from the point of view of its commercial value

The 5G hybrid drone platform is a hybrid drone system which has the capability to fly as well as sail over bodies of water. This allows acquiring data to monitor bodies of water, or to be used as a search and research tool in this same environment. It is an interesting system to assess the quality of the natural or industrial environment, and to get data faster during emergencies. The 5G link allows the operations to have a higher scope and be more ambitious than without this technology, by having a greater range, or a better resource management. Companies and public organisations which are responsible for water bodies, for environmental purposes or security reasons, are the main end customers interested in this technology.

Currently at TRL6, Alerion will continue to work on this system to enhance the capacities of the end users using 5G with the hybrid drone.

3.9.2 Perspectives of commercial exploitation of the outcome

The current vision of the owner:

Owner	Alerion			
Description	5G hybrid drone platform			
	Outcome type	Prototype	**Outcome category**	Business Development
	Current TRL category	TRL6 – Technology demonstrated in relevant environment		

End customer	Environmental monitoring users and search and rescue users.
Target markets	Environment monitoring, industry, public safety.
Innovations	Increased range and real time analysis with this version.
Product competition	There are no direct competitors on this type of product. There are only companies that can offer parts of what this product can do.

SWOT analysis	
Opportunities: • Needs for a drone with hybrid capabilities (flying and sailing), and 5G are increasing. • Demonstrated need for customisation and specific missions expressed by clients. • Increase adoption of robotic solutions in these markets.	Threats: • New competitor. • Regulations may constraint some operations and require specific authorisations.
Weaknesses: • Full enhanced capabilities only within 5G covered areas. • Efforts are needed to bring the solution from prototype to market.	Strengths: • Only system with these capabilities in the market. • Easily customisable to specific needs.

3.9.3 Plan of commercialization of the outcome

Alerion has developed a 5G drone system up to TRL6 which does not provide a full vision for its business plan. In order to progress and move to the next steps, several developments, operational tests and validation are to be performed in the adequate environment and context, to fit the operational needs of end users. The 5G!Drones project has helped to understand the features drones can benefit from using 5G networks. Thanks to that, Alerion had discussions internally and with potential partners about the expectation of a hybrid drone mission using the 5G network. It has shown the benefits of using this technology to enhance the missions of Alerion hybrid drone. The environment monitoring users as well as the search and rescue users are the main sectors which may be interested in the system.

3.10 Unmanned Life – Autonomous drone swarm management

3.10.1 High-level description of the outcome from the point of view of its commercial value

Autonomous swarm management is a key capability on the Unmanned Life platform. Simply, it allows for the orchestration and coordination of multiple types of robots and IoT devices, to work together in real-time. The interoperability of the platform, across both networks and hardware, means that autonomous drone swarms are possible, even across UAVs from different vendors. The swarm management is included in the main platform module providing full solutions, meaning together with Data management, Mission Management, and Decision Management. It is able to offer autonomy in swarms of devices.

The key features are:

- Enabling admins to integrate various machines into a swarm;
- Coordinating tasks across third-party platforms;
- Managing the network layer on the hardware platforms;
- Feeding into Data management, Mission Management, and Decision Management to form end-to-end solutions

3.10.2 Perspectives of commercial exploitation of the outcome

The current vision of the owner:

<table>
<tr><td>Owner</td><td colspan="4">Unmanned Life</td></tr>
<tr><td rowspan="3">Description</td><td colspan="4">Autonomous Drone Swarm Management</td></tr>
<tr><td>Outcome type</td><td>Prototype</td><td>Outcome category</td><td>Service</td></tr>
<tr><td>Current TRL category</td><td colspan="3">TRL5 – Technology validated in relevant environment</td></tr>
<tr><td>End customer</td><td colspan="4">Platform operators in every deployment with multiple devices.</td></tr>
<tr><td>Target markets</td><td colspan="4">Ports, quarries & mining operations, enterprise security, critical infrastructure.</td></tr>
<tr><td>Innovations</td><td colspan="4">Scalability, Increased coverage with several devices, flexibility with the operator, ease of use.</td></tr>
<tr><td>Product competition</td><td colspan="4">Drone Fleet Management service companies, although they do not manage heterogeneous devices across vendors.</td></tr>
<tr><td colspan="5">SWOT analysis</td></tr>
<tr><td colspan="2">Opportunities:
Companies are scaling robotic operations, leading to demand for swarm management.</td><td colspan="3">Threats:
One/Two robotic fleet managers capturing majority market share and increasing integration capabilities.</td></tr>
<tr><td colspan="2">Weaknesses:
Consistent network coverage to maximise capabilities.</td><td colspan="3">Strengths:
Much more scalable than current solutions. Offers several benefits compared to fleet managers due to integrations and interoperability capacities provided even for heterogeneous fleets.</td></tr>
</table>

3.10.3 Plan of commercialization of the outcome

Current TRL5 means that features are still under development. Swarm management will be a key enabler of scalability in robotic operations, preventing fragmentation. It is also key for transparency amongst UTM systems.

3.11 Unmanned Life – Object detection through video analysis

3.11.1 High-level description of the outcome from the point of view of its commercial value

Analysis of real-time video is key to augment and enhance solutions to cater for client requirements, whether for person/object detection or otherwise. Drones especially do not have the onboard computational power to enable this, so video is analysed on the cloud or edge. There are two ways we can enable this:

- In-house analytics for person/object detection;
- Third-party artificial intelligence for product level analysis on a scalable level.

In this case, we can integrate to the platform, and display the results on our interface.

3.11.2 Perspectives of commercial exploitation of the outcome

The current vision of the owner:

<table>
<tr><td>Owner</td><td colspan="4">Unmanned Life</td></tr>
<tr><td rowspan="3">Description</td><td colspan="4">Object Detection through video analysis</td></tr>
<tr><td>Outcome type</td><td></td><td>Outcome category</td><td>Service</td></tr>
<tr><td>Current TRL category</td><td colspan="3">TRL5 – Technology validated in relevant environment</td></tr>
<tr><td>End customer</td><td colspan="4">Customers looking at the platform for end-to-end autonomous solutions.</td></tr>
<tr><td>Target markets</td><td colspan="4">Ports, quarries & mining operations, enterprise security, critical infrastructure, logistical operations.</td></tr>
<tr><td>Innovations</td><td colspan="4">There are no aims to innovate to the level of commercial AI platforms.</td></tr>
<tr><td>Product competition</td><td colspan="4">No considered competition, as this is not the aim of the in-house AI.</td></tr>
<tr><td colspan="5">SWOT analysis</td></tr>
<tr><td colspan="2">Opportunities:
Continued visualisation strategy to demonstrate AI person detection on the platform, over 5G and edge.</td><td colspan="3">Threats:
No threats, as not used at a product level.</td></tr>
<tr><td colspan="2">Weaknesses:
Not as powerful or consistent as commercial solutions.</td><td colspan="3">Strengths:
Can be deployed on-premises via a laptop.
Very visual way of showing the power of the platform as it was integrated to a third-party AI solution.</td></tr>
</table>

3.11.3 Plan of commercialization of the outcome

Unmanned Life continues to use its in-house analytics for demonstrations, pilots, and Proofs of Concept (PoCs), to demonstrate the power of the platform among our previous customers and stakeholders, its integration capabilities, and the visualisation on the interface. Meanwhile, there are ongoing discussions with trusted customers and stakeholders to assess the best strategy to develop an effective plan around AI.

3.12 Unmanned Life – Unmanned network extension service

3.12.1 High-level description of the outcome from the point of view of its commercial value

Networks are often at capacity during crowded events, resulting in slower transfer speeds.

One mitigation strategy is the placement of UAVs as aerial base stations to provide wireless coverage for users in a specific event that may be throttled by this network capacity. Not only are these flexible to deploy, but swarms of drones may be used as a method to scale this extension for larger crowds.

Unmanned Life has the platform to orchestrate swarms of autonomous drones, as well as the capabilities to integrate to several payloads. It is therefore the next step to offer additional applications such as connectivity extension, which uses a payload to do so.

3.12.2 Perspectives of commercial exploitation of the outcome

The demand continues to grow as 5G develops, and Unmanned Life's robotic orchestration platform means to support connectivity extension and can be offered in a more scalable and flexible manner.

<table>
<tr><td>Owner</td><td colspan="4">Unmanned Life</td></tr>
<tr><td rowspan="3">Description</td><td colspan="4">Unmanned network extension service</td></tr>
<tr><td>Outcome type</td><td>Prototype</td><td>Outcome category</td><td>Service</td></tr>
<tr><td>Current TRL category</td><td colspan="3">TRL4 – Technology validated in lab</td></tr>
<tr><td>End customer</td><td colspan="4">Hosts of crowded events.</td></tr>
<tr><td>Target markets</td><td colspan="4">Sports matches, concerts, large commercial events, large gatherings e.g. support marches/protests. disaster recovery situations.</td></tr>
<tr><td>Innovations</td><td colspan="4">Orchestration between several drones. Hardware agnostic technology means that different drones can be used depending on capabilities. Easy to deploy via the interface.</td></tr>
<tr><td>Product competition</td><td colspan="4">Tethered drone companies providing a similar solution without the orchestration element e.g. Elistair.</td></tr>
<tr><td colspan="5">SWOT analysis</td></tr>
<tr><td colspan="2">Opportunities:
Working together with network providers to offer package bundles to event hosts of government in order to sell at scale.</td><td colspan="3">Threats:
Competition in the space who can provide a simplified, yet effective solution.</td></tr>
</table>

Weaknesses: • Reliant on mobile network infrastructure as a base e.g. private 5G trailers.	Strengths: • Fast deployment. • Orchestration of several drones together for full connectivity.

3.12.3 Plan of commercialization of the outcome

Feature development will continue based on market's demands, in conjunction with key telco partners and enterprise customers.

3.13 Unmanned Life – UMS simulation testbed

3.13.1 High-level description of the outcome from the point of view of its commercial value

Unmanned Life uses a simulation testbed from two main perspectives:

- To test drone swarms on a scale that is not commercially viable in practice, due to price and feasibility. This could be for both internal purposes, or project wide Research & Development (R&D) with several stakeholders.
- To show the capabilities of the system to clients, specifically, the connection between drones, the user interface, and the flight path planning.

3.13.2 Perspectives of commercial exploitation of the outcome

From a commercial standpoint, the standard application is showing the solution to clients, who can then make a more informed decision on purchasing the product. There is an option to extend the hardware in order for clients to use the simulator, though this is not currently being commercialised.

Owner	Unmanned Life			
Description	UMS simulation testbed			
	Outcome type	Prototype	**Outcome category**	Service
	Current TRL category	TRL5 – Technology validated in relevant environment		
End customer	Commercial customers who wish to visualise the solution without deploying.			
Target markets	All relevant target markets as part of Unmanned Life product lines.			
Innovations	Easy to visualise custom interface shown on the testbed. No innovation needed directly relating to the testbed itself.			
Product competition	N/A.			
SWOT analysis				

Opportunities: • High demand for increasing the speed between technical validation and contract, as customers can visualise the solution before deploying at their premises.	Threats: • N/A.
Weaknesses: • There are stronger testbeds to be used, which are based at a much higher price. • Unmanned Life has not yet committed the resources into scaling the testbed so that customers can use it by themselves.	Strengths: • Easy to visualise the solution • Visualisation can be customised directly to the customer, down to which global coordinate the drones can (be simulated to) take-off.

3.13.3 Plan of commercialization of the outcome

Currently at an ongoing internal assessment about the potential commercialisation aspects, in addition to the pricing and business case around it, but still too immature to justify a concrete plan.

3.14 Thales – Mission Critical Services

3.14.1 High-level description of the outcome from the point of view of its commercial value

Thales mission critical systems and services exists in different areas: (i) armed forces that rely on robust communication systems to deliver information from multiple sources, securely and in all circumstances, (ii) tactical communication systems, used by armed forces when facing multiple types of challenges (terrorism, natural disasters, border tensions), and (iii) public safety forces, that play an essential role in protecting citizens, critical infrastructure and securing large events. For all these situations, to safely succeed in their day-to-day missions as well as in crisis situations, these teams need means to efficiently coordinate their actions. Thales offers secured and resilient PMR solutions matching their needs.

The outcomes of 5G!Drones prove that new capabilities that will make mission critical teams more efficient and rapid in deployment and execution are possible.

3.14.2 Perspectives of commercial exploitation of the outcome

The current vision of the owner:

Owner	Thales			
Description	Mission critical system			
	Outcome type	Prototype	**Outcome category**	Business Development
	Current TRL category	TRL5 – Prototype system tested in a relevant environment		
End customer	Public safety forces, or government organization (police, military, fire departments).			

Target markets	Public safety, mission critical organizations.
Innovations	Complete system for critical situations with need for rapid and precise execution, and network coverage extension.
Product competition	Other companies providing public safety communication systems and mission critical services. This will enhance the available services offered by Thales by providing additional features and more capabilities.

SWOT analysis	
Opportunities: • Needs for a drone with these features are increasing.	Threats: • New direct competitor.
Weaknesses: • Full enhanced capabilities only within 5G covered areas.	Strengths: • Only system with these capabilities in the market.

3.14.3 Plan of commercialization of the outcome

This prototype will help Thales show its capabilities of providing new features in the domain of public safety and mission critical systems and services. It will not be an actual product but more a demonstrator that shows new features.

3.15 Orange – Localization of a drone

3.15.1 High-level description of the outcome from the point of view of its commercial value

The 4 patents are related to UAV missions up to 120 m in the case where existing methods (GNSS, pressure-based altimetry, Simultaneous Localization And Mapping – SLAM, relative localization, etc.) for determining the x/y coordinates and the heights are:

- not available (for example, satellites signal may be hard to reach in a dense city, with high buildings);
- and/or not reliable enough, in particular (e.g. relative localization over a distance exceeding some tens meters, or GNSS for height measurement);
- and nor if a secondary localization source is required for flight authorization.

We propose an alternative solution based on signal quality of 5G connectivity onboard UAV.

The problem statement is covered by 4 patents. Two patents describe a method for determining the height/altitude of an equipment onboard a UAV. In the first case, the method is based on 2 base stations from which the equipment can receive signal power (Figure 5.d). In the second case, only one base station is needed by the method considering UAV able to receive signal from several antennas on this site (Figure 5.c). The two other patents describe a method to determine x/y coordinates of an equipment. Only one base station is needed in the case of a patent (Figure 5.a) and two base stations in the other (Figure 5.b), whilst the state of art requires 3 sites for applying triangulation methods for instance. An example of a situation is an UAV acting for maritime surveillance by the coast. 2 patents need to be combined for determining the x/y/z coordinates of a UAV, using either 1 base station or 2 base stations.

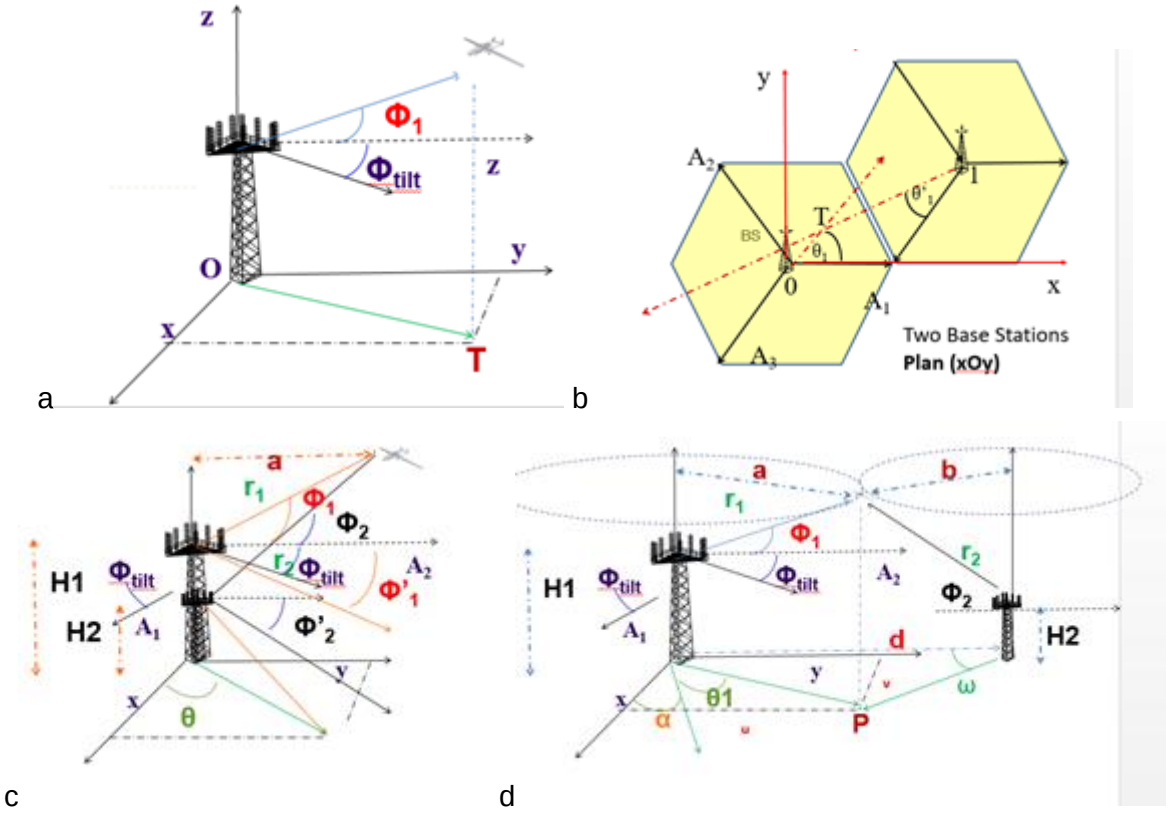

Figure 5 – UAV location hypothesis for the 4 patents

The method has been measured by theoretical works. It takes a few milliseconds for computing the algorithm. Localization accuracy may reach less than 1 m. The TRL level is 3.

Before using them in a commercial situation, there is a need to qualify the effective gain in real situations for taking into account how signal power values are accurate to be used as a hypothesis of the method. The accuracy of the UAV localization depends on the accuracy of signal power values measured by the chipset and used by the application computing the algorithm. Some tests have been carried out but are not enough for concluding.

Once this step will be validated, it will pave the way to implement the method in a software component that could be run in the equipment onboard the UAV or remote.

The four patents prepared and registered at French Institut National de la Propriété Industrielle (INPI) by ORA can be individually summarized as follows:

1. Patent FR2006741 (INPI): "*Procédé de détermination d'une altitude d'un équipement utilisateur, dispositif, station de base, système et programme d'ordinateur correspondants*". This patent describes a method for determining the height or altitude of a user equipment, in particular a drone. The method involves the powers received by the user equipment from a unique site of a terrestrial wireless network.

2. Patent FR2009246 (INPI): "*Procédé de détermination d'une altitude d'un équipement utilisateur, dispositif, équipement utilisateur, station de base, système et programme d'ordinateur correspondants*". This second patent describes a method for determining the height or altitude of a user equipment, in particular a drone. The method involves the powers received by the user equipment from 2 sites of a terrestrial wireless network

3. Patent FR2004322 (INPI): "*Procédé de géolocalisation d'un équipement utilisateur, dispositif, équipement utilisateur, station de base, système et programme d'ordinateur correspondants*". This third patent describes a method for determining the location of a user equipment (or a ship) on the sea,

which receives signal powers from 2 base stations of a terrestrial wireless network. Used together with patent FR2006741 or with patent FR2009246, it allows determining the location of a drone.

4. Patent FR1907193 (INPI): "*Procédé et dispositif de localisation d'un terminal connecté à un réseau*". This last patent describes a method for determining the ground location of a user equipment, in particular a drone. The method involves the powers received by the user equipment from 2 base stations of a terrestrial wireless network. Used together with patent FR2006741 or with patent FR2009246, it allows determining the location of a drone.

3.15.2 Perspectives of commercial exploitation of the outcome

The current vision of the owner:

<table>
<tr><td>Owner</td><td colspan="4">Orange</td></tr>
<tr><td rowspan="3">Description</td><td colspan="4">Localization of a drone based on 5G network</td></tr>
<tr><td>Outcome type</td><td>Theoretical simulation</td><td>Outcome category</td><td>Business Development</td></tr>
<tr><td>Current TRL category</td><td colspan="3">TRL3 – Experimental proof of concept</td></tr>
<tr><td>End customer</td><td colspan="4">UAV operators that require a high level of availability and security for localizing a drone.</td></tr>
<tr><td>Target markets</td><td colspan="4">Military, public safety, critical national infrastructures.
Drone scenarios in dense urban environments, where accuracy of less than a 1 m is needed, or where full autonomy is required (e.g. dangerous industrial sites).
Precision agriculture, where the satellite accuracy is not sufficient (ex: detection of poisonous plants in a field).
We consider only these targets by considering the difficulty to implement the patent for general purpose end-user devices. We expect to target dedicated UAV equipment only.</td></tr>
<tr><td>Innovations</td><td colspan="4">3GPP TR 22.872 in the 3GPP Release 15 is a study on positioning use cases for on-ground devices including UAV missions and operations. More recently, new 5G Positioning Reference Signal (PRS) has been defined in the Release 16 enabling techniques for positioning techniques such as Round Trip Time (RTT), Angle of Arrival/Departure (AoA/AoD), and Time Difference of Arrival (TDoA). These techniques are designed to meet initial 5G requirements of 3 m and 10 m for indoor and outdoor use cases, respectively, and apply only to horizontal localization.
Our patents also include the altitude, and therefore provide the coordinates with 3 dimensions. There are some similarities with these Release 16 techniques, but our requirements are closer to the parameters that are available in commercial networks.</td></tr>
<tr><td>Product competition</td><td colspan="4">Ericsson has initiated discussions for adding PRS signalling at 3GPP, but as far as is our knowledge, these are not used in commercial networks. Therefore, 5G-based localization requires cooperation between UAV operators and 5G network operators in order to share inputs for running the algorithm. The schema of such cooperation is not yet defined. It is related to the implementation.</td></tr>
</table>

SWOT analysis	
Opportunities: • Localization of a UAV based on 5G networks in situations where one cannot rely on GNSS and altimetry, for instance, in the case the GNSS system can be hacked or does work properly. Since these situations are exceptional, we may expect opportunities for highly critical use cases only.	Threats: • If altitude can be obtained without one of the patents, for instance by using altimetry, then the method for determining the x/y coordinates competes with techniques based on PRS. If these various use cases appear for network-based end-user devices localization, then more discussions are needed in standardization.
Weaknesses: • TRL level is very low at this stage and commercial exploitation will depend on the implementation of cooperation schemes between UAV operator and 5G network operators for embedding inputs related to confidential information of the network topology (such as precise location and tilt of antennas, aperture angle or radiation pattern).	Strengths: • High accuracy up to less than 1 m. • Can be executed in a few milliseconds, on UAV side or in the Cloud. • 5G provides appropriate inputs for localizing a UAV with accuracy, but the method can also be used with 4G.

3.15.3 Plan of commercialization of the outcome

Current maturity is TRL3. Orange is collaborating with a partner for implementing it and is looking for partnerships from defining an appropriate scheme for including inputs on network topology in a confidential way for paving the way to commercial exploitation.

4 Collaboration with international innovation communities in the area of 5G communication

From the point of view of collaboration with international innovation communities in the area of 5G communication, there are two involvements described below that can be reported.

4.1 5G PPP

The 5G Infrastructure Public Private Partnership (5G PPP) is a joint initiative of the European Commission and a circle of ICT industry in Europe, bringing together ICT manufacturers, telecommunications operators, service providers, SMEs and research institutions. The 5G!Drones project was an active participant of the 5G PPP bodies (see below). The full and detailed list of activities can be found in the Deliverable 6.6 [5].

- **5G PPP Steering Board**

The body is dedicated to the overall management of the 5G PPP and cross-project co-operation. The 5G!Drones project was represented by its coordinator (University of Oulu).

- **5G PPP Technology Board**

The body is dedicated to looking over the aspects related to the technology work of the projects and respective implementation of the initiative. The 5G!Drones project was represented by its technical coordinator (Thales).

- **5G PPP Work Groups**

The 5G PPP Work Groups are created as are cross-projects platforms of building a positive synergy between various 5G PPP projects where their activities can converge[33]. The 5G!Drones was represented in multiple groups. The full list is presented in Table 4 below.

Table 4 – List of 5G PPP Work Groups attended by the 5G!Drones project

Work Group name	Project representative
Small and Medium-sized Enterprises (SMEs)	Infolysis
Security	CAFA Tech, Thales (Work Group chairing)
5G/Beyond 5G Architecture	Thales
Pre-Standardization	Airbus
Software Networks	Frequentis
Vision and Societal Challenges	Thales
Trials	Robots Expert
5G for Connected and Automated Mobility (CAM)	CAFA Tech
IMT-2020 Evaluation Group[34]	National Centre of Scientific Research "*Demokritos*"
Test, Measurement and KPIs Validation	Robots Expert, Nokia

4.2 ACJA

Aerial Connectivity Joint Activity (ACJA)[35] is a joint activity of two industrial innovation alliances in the domain of mobile communication – Global System for Mobile Communications Association (GSMA)[36]

[33] https://5g-ppp.eu/5g-ppp-work-groups/
[34] https://5g-ppp.eu/5g-ppp-imt-2020-evaluation-group/
[35] https://www.gsma.com/iot/aerial-connectivity-joint-activity/
[36] https://www.gsma.com/

and unmanned aviation – Global Unmanned Traffic Management Association (GUTMA)[37], focused on promotion of interchange and understanding between both communities.

ACJA is organized in 4 Work Tasks:

- Work Task 1: Cellular Standard Coordination;
- Work Task 2: Interface for the Data Exchange between MNOs and the UTM ecosystem;
- Work Task 3: Standard Aerial Service Profile (finalized by the end of 2020);
- Work Task 4: Development of Minimum Operational Performance Specifications (MOPS) and Minimum Aviation System Performance Standards (MASPS).

The activities of ACJA were supported by the following 5G!Drones project partners:

- Orange, Work Task 1;
- Involi, Work Task 2;
- Nokia, Work Task 4.

More details about the activities of ACJA from the 5G!Drones project perspective as well as the input of the 5G!Drones project partners can be found in the section 2.5 of the Deliverable D5.4 “Report on contribution to standardisation and international fora – 2nd version” [1].

[37] https://gutma.org/

5 Conclusion

This deliverable presents in detail the multiple activities that have been performed during the 5G!Drones timeline. These activities are spanning across three domains, namely collaboration within the scientific communities, investigation of possibilities for the commercial exploitation of the project's outcomes, and collaboration with international innovation communities in the area of 5G communication.

Within the first domain, there were numerous activities proving that the 5G!Drones became a platform for establishing and developing cooperation, both bilateral and multilateral. 5G!Drones partners jointly initiated 6 research projects receiving grants. The "Smart City 2020-2030" strategy of the Municipality of Egaleo has received a development impulse from the project in the area of the applications of unmanned aviation supported by the 5G technology and will be continued through a follow-up partnership with the National Centre of Scientific Research "*Demokritos*". The project partners initiated 3 bilateral activities dedicated to specific research issues. Finally, thanks to the experiences and expertise gained during the 5G!Drones project, the National Centre of Scientific Research "*Demokritos*" has established 2 entrepreneurships with 3rd parties, aimed at coupling 5G technology and unmanned aviation.

In the domain of exploitable outcomes, 14 outcomes were qualified for further commercial exploitation. Their maturity varies between TRL3 and TRL9. For each of them, the high-level description from the point of view of its commercial value, perspectives of commercial exploitation including SWOT analysis, and plan of commercialization have been presented. In case of 3 outcomes with the highest maturity (TRL7-TRL9), the description is enriched with analysis based on Value Proposition canvas.

For the third domain, there were activities within 2 international innovation communities in the area of 5G communication: 2 boards and 10 work groups of 5G PPP – a joint initiative of the European Commission and European Information and Communication Technology (ICT) industry – attended by the 5G!Drones project team representatives, and ACJA, a joint activity of two industrial innovation alliances in the domain of telecommunication (GSMA) and unmanned aviation (GUTMA) where 3 project partners participated.

All in all, the outcome of this deliverable is showing that the 5G!Drones project has become a platform supporting the development of business and research partnership, both mutually between the partners as well as with the research and innovation ecosystem. Moreover, the work that has been performed during the lifecycle of the project has led to the development of commercial products for several partners. In this sense, the 5G!Drones project supported the involved partners in their technology transfer efforts paving the way for further interesting research and innovations projects and accelerating the process towards higher degree of technology maturity.

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[3] Deliverable D5.2 “Report on communication, showcasing, dissemination and exploitation achievements and plan for the second term of the project”, 5G!Drones project, April 2021.

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