Study on the Future of Helsinki’s Urban Air Mobility

Helsinki

Contents

Executive Summary

Urban Air Mobility (UAM) is not a new phenomenon in Helsinki. Approximately 30 000 drone flights took place in Helsinki in 2022. Whereas most of them served mainly recreational purposes, 3000-5000 professional flight operations also took place. The vast majority of these were executed within line of sight of the pilot using drones equipped with a camera serving UAM applications worth a few million euros.

While aerial operations may be the leading use case in Helsinki throughout the 2020's, new types of services will emerge, as described in *Table 1*. Total UAM service market in Helsinki by 2030 is 20–80 MEUR based on global and European estimates. In addition to new market potential in Helsinki, common regulation in EU will allow rapid scaling of UAM solutions to international markets. New UAM services can drive cost savings and improve delivery of services, both in private and public sector. The market estimate does not capture all the economic, social and sustainability impacts.

In addition to new market potential in Helsinki, common regulation in EU will allow rapid scaling of UAM solutions to international markets. Therefore, Helsinki-based UAM service companies that manage to scale up may over time, benefit the city.

From an operating standpoint, UAM growth is challenged by gaining access to the airspace, by minimising ground risk along flight routes and by weather, especially in winter. From a regulatory perspective, cities have a limited ability to influence urban aviation in current national and European legislation. In Nordic countries, airspace cannot be monetized or controlled by the city. The advent of U-space airspace[1] will give cities a formal role in airspace matters and solve several "access to airspace" challenges faced by UAM service providers.

Landowner permission is not needed for the landing of unmanned aircraft, only for manned operations. However, environmental permission will be required for frequent, commercial drone operation at a fixed location, if the operation causes noise or visual pollution to its neighbours. The city can influence the establishment and operation of vertiports for human passengers that require landowner and environmental permission.

As there are few legal possibilities for the city to manage urban aviation, soft policies, such as guidance, instructions, clear vision, cooperation, and early participation in the UAM development can be leveraged to impact the economic development and to mitigate potential drawbacks from urban aviation such as noise. City-wide urban development objectives should define the role of the city in UAM. There are several options for the level of involvement of the city. As long as air traffic volumes in the urban setting are moderate, the minimum level of involvement of the city is to ensure social sustainability and monitor public acceptance, in addition to building competence to engage in U-space airspace matters. The city can also assume a more active role and assume the role of an enabler and support the building of digital and/or physical infrastructure and proactively procure UAM services. The city will create a de facto large impact on UAM development by investments in open data to support and guide the development of UAM services.

[1] Automated traffic management solution for UAM and drones.

Users	Aerial operations	Cargo/deliveries	Passenger transport
Public sector	Several potential use cases within the city and its subsidiaries, especially in land use and maintenance sectors: Mapping, inspections of infrastructure projects, photo & video, surveillance & security, maintenance optimization. Fire & rescue and police are active users already today.	Medical deliveries, (laboratory samples, medicines, vaccines) replacing taxis/vans.	Transporting specialists between health care units Emergency medical services covering the gap between ambulances and HEMS[2] at a lower cost, faster starting time, smaller range compared to HEMS or ambulance.
Private sector	More mapping, inspections, photo & video, surveillance & security, maintenance service providers. Infrastructure and security industries lead use cases	B2B deliveries hub-and-spokes[3] – time critical components for industrial applications. B2C highly dependent on individual service providers and the future cost structure of deliveries.	Helsinki-Tallinn air shuttle (done before with helicopters). Tourism, i.e. cruise ships offering sightseeing over and to Suomenlinna.

Table 1. Summary of first use cases in public and private sector.

The study was commissioned by the Economic Development Department of the city of Helsinki, with Kalle Toivonen as the chair of the steering group, and Christina Suomi from Urban Environment Division of the city of Helsinki, Renske Martijnse-Hartikka and Minna Torppa from Forum Virium Helsinki, and Paavo Lehmonen from Stara as members of the steering group.

FLOU and Robots.Expert have conducted the study in the beginning of 2023. The project team included Taina Haapamäki and Tommi Kantala from FLOU and Tero Vuorenmaa, Jonas Stjernberg, and Benoît Larrouturou from Robots.Expert. Several aviation experts, city and region representatives and aviation authorities, both European and Finnish, were interviewed during the study. The artwork visualising the future of Urban Air Mobility in Helsinki (cover page and images in Section “Economic outlook of UAM use cases in Helsinki”) was created by Lakstein Fernandes of Studio Rævling.

[2] Helicopter emergency service
[3] From central warehouse to location of use

Glossary

Acronym	Translation	
AAM		Advanced Air Mobility
Aerial operations	Lentotyö	Use of drones equipped with sensors to generate data for use in mapping, surveillance, inspection, photography, video etc.
ATM	Ilmaliikenteen hallinta	Air Traffic Management
B2B	yritykseltä yritykselle	Business-to-Business
B2C	kuluttajakauppa	Business-to-Consumer
BVLOS		Beyond Visual Line of Sight
Drone	Drooni	Common name for Unmanned Aerial Vehicle
Droneport		We use droneport to denote landing infrastructure for cargo and other drones, what do not require a certified landing infrastructure.
EASA	Euroopan lentoturvallisuusvirasto	European Aviation Safety Agency (2002-2017)
EASA	Euroopan unionin lentoturvallisuusvirasto	European Union Aviation Safety Agency (2018 onwards)
EIB	Euroopan investointipankki	European Investment Bank
EIT		A European initiative for the future of urban mobility
ELTIS		The Urban Mobility Observatory financed by the European Commission’s Directorate General for Mobility and Transport
EMS		Emergency Medical Services
(e)VTOL		(electric) Vertical Take-Off and Landing
FVH		Forum Virium Helsinki
IAM		Innovative Air Mobility
IAS		Innovative Air Service
OEM		Original Equipment Manufacturer
SESAR		Single European Sky ATM Research
SUMP	Kestävän kaupunki-liikkumisen suunnitelma	Sustainable Urban Mobility Plan
UAM	Kaupunki-ilmailu	Urban Air Mobility. “New air transportation system for passengers and cargo in and around densely populated and built environments, made possible by vertical take-off, and landing electric aircraft (eVTOL) equipped with new technologies such as enhanced battery technologies and electric propulsion. These aircraft will have a pilot on board or be remotely piloted.” (Georgiev, Larrouturou, & Stjernberg, 2021)
UAM operator or service provider		Commercial stakeholder responsible for the operation of drones to deliver a service. Requires licenses/certifications depending on the equipment used and use case.
UAS		Unmanned Aerial System
UAV		Unmanned Aerial Vehicle

UIC2		Urban-Air-Mobility Initiative Cities Community
U-space		“A set of new services relying on a high level of digitalisation and automation of functions and specific procedures designed to support safe, efficient, and secure access to airspace for large numbers of air vehicles. Not synonymous to ‘U-space airspace’.” (Georgiev, Larrouturou, & Stjernberg, 2021)
U-space airspace	U-space-ilmatila	“A volume of airspace, in which the EU U-space regulation (EU) 2021/664 applies. Not synonymous to ‘U-space'.” (Georgiev, Larrouturou, & Stjernberg, 2021)
USSP	U-space-palvelutarjoaja	U-space Service Provider. “Private or public entity supporting the safe and efficient operation of drones and safe access to airspace. These organisations must be certified to provide U-space services in one or more European member states.” (Georgiev, Larrouturou, & Stjernberg, 2021)
UTM		Unmanned aerial systems Traffic Management
Vertiport	Ilmailuasema (VTOL kalustolle)	A possibly certified landing infrastructure intended for operations involving people onboard. Mobility hub with several take-off and landing pads, with support infrastructure (compare: bus terminal)
Vertistop	Ilmailupysäkki (VTOL kalustolle)	Single take-off and landing pad, with limited support infrastructure (compare: bus stop)
VLOS		Visual Line of Sight (of the operator)

Introduction to Urban Air Mobility

Briefly: Traditionally, air mobility has served international and regional transport needs between cities, both for cargo and passengers. Technological advancements in air vehicles, such as (electric) vertical take-off and landing (eVTOL, VTOL) and unmanned systems, have opened new possibilities for air mobility to move goods or passengers, which have not been feasible before due to high capital and operating expenses, regulation, space requirements for infrastructure, emissions, and noise.

With new VTOL capable small and large aircraft, the use cases for air mobility are diversifying. A concept called "*Innovative Air Services*" (IAS) as it is now defined by the European Union Aviation Safety Agency (EASA) encompasses these new types of services. IAS is further divided into two categories: "aerial operations" and "Innovative Air Mobility" (IAM). Aerial operations include use cases of today with both traditional air vehicles such as helicopters and drones. In aerial operations, the air vehicle is a platform for a payload, which can be used for surveillance, inspection, mapping, and imaging services among others, rather than the transport of goods or people from A to B. In the traditional definition of Urban Air Mobility (UAM), a subset of IAM, the focus is on moving goods or people.

UAM can be divided into three types of services based on the distance and area of operations: international, regional, or intra-urban mobility. In North America a third term "Advanced Air Mobility" is used to describe international or regional transport services with new types of mainly electrical aircraft. These services can resemble "traditional" air transport service between city pairs, whereas UAM services are provided in very low-level airspace below 150 m above ground level within or between the boundaries of a city or an urban area. All definitions of UAM do not include the "aerial operations" type of use cases and limit the definition to passenger and cargo transport in urban environments. While many hierarchies separate UAM and "Aerial Operations", this report includes "aerial operations" in an urban environment as a part of UAM. The "aerial operations" use cases utilize the very same regulation, hardware and support infrastructure as the cargo or passenger services.

IAM and UAM services are often provided with unmanned air vehicles (UAS/drones) of various types and sizes, such as drones equipped with sensors (cameras, gas sensors, etc.) or drones capable of transporting (light) cargo. Scenarios for passenger services include both manned (pilot onboard) and unmanned (remote pilot) aerial vehicles. Use case categories covered in this study are presented in Figure 1.

In this report, we will consequently use UAM as a synonym to IAS: the use of manned or unmanned aerial vehicles for the three different types of applications in the figure on the right, within the very low-level urban airspace below 150 m above ground level.

As an emerging and technology-driven phenomenon, new air mobility services often evolve faster than the terminology and there are no universally agreed definitions. The terms and abbreviations used in this report are collected in the Glossary at the beginning of the report.

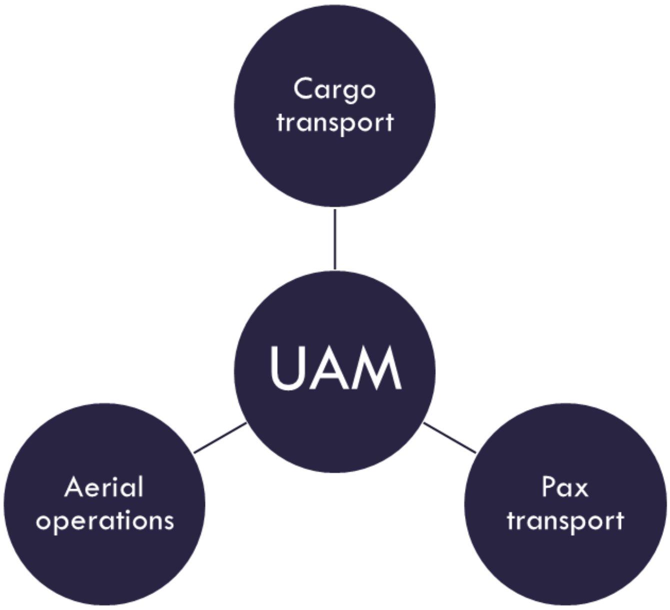

Figure 1. Use case categories of UAM (Pax = passenger)

Aviation and transportation in Helsinki today

In Helsinki, the city plan guides the long-term planning of land use and urban structure for decades to come. The latest legally binding and strategic City Plan 2016 came into force in 2018 and covers a majority of Helsinki. The plan guides Helsinki's urban structure by 2050 towards a rail network city. Transport planning aims to prioritize active mobility (walking and cycling), followed by public transport. Logistics and private car transport needs come only after the first three transportation modes. The aim is to grow the city in a sustainable manner by densifying the urban structure in the different city centres and use trunk lines in public transport to connect the urban nodes. While the liveable urban city and smooth transportation are goals for land use and mobility, sustainable economic growth and international attractiveness are corner stones of the city's wider vision. Helsinki aims to be carbon neutral by 2030 by reducing 80% of CO2-emissions and by compensating the rest of its emissions[4]. Further, Helsinki aims to be carbon zero by 2040 and carbon negative by 2050. Transport is the second largest source of CO2-emissions in Helsinki, after heating of buildings.

While the central business district of Helsinki is located on a peninsula and the city includes several islands, the street and road network are extensive and congestion is not perceived to be a major bottleneck. The road transport system consists of radial roads complemented with bypass roads that connect Helsinki with the nearby cities, such as Espoo, Vantaa, and Sipoo. The public transport network consists of an east-west metro line in the south complemented with radial commuter and long-distance trains. There is also an extensive tram network supported by bus lines. The city of Helsinki owns and hosts several active ports: Länsisatama, Eteläsatama and Katajanokka passenger and roro[5] terminals and Vuosaari container and roro harbour.

Aviation currently plays a limited role in Helsinki. The main airport in Finland is Helsinki–Vantaa international airport, located in the city of Vantaa, next to Helsinki. From an economic and transport planning perspective, access to the airport is important. The catchment area of the airport is large, extending even to the city of Jyväskylä in the Central Finland circa 3h away by train or car. The previously busy Helsinki-Malmi general aviation airport was closed in 2021 and the city plans to repurpose the area for urban development.

[4] Only counting emissions produced within Helsinki.
[5] Roll-on roll-off

While aviation has traditionally focused on regional and international travel, drones are extensively used in Helsinki already today. Drone operators (mainly professionals and serious hobbyists) can voluntarily make flight notifications through the Aviamaps[6] application. As the notifications are not mandatory, we estimate that less than 10% of drone operations are reported into the application. In 2022, 2500 operations were reported in the Helsinki area. Based on our estimate, we assume that there were more than 25 000 drone operations in Helsinki in 2022. In Aviamaps flight notifications, one of the leading use cases for UAM in Helsinki is infrastructure inspections and construction ground mapping, as a lot of the operations happen in the Kruunusillat bridge construction site, as indicated by Figure 2Figure 2.

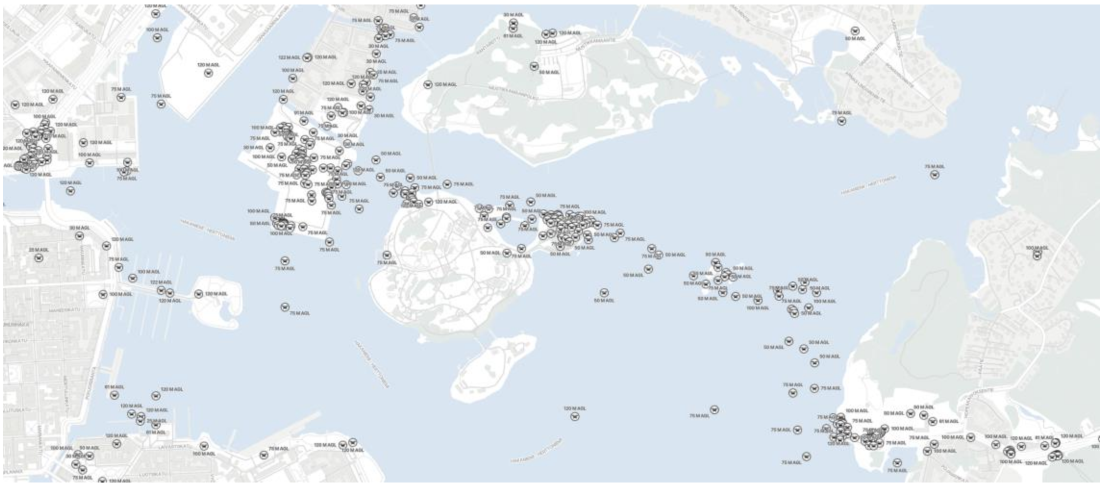

Figure 2. Drones are extensively used at Kruunusillat bridge construction site. (Aviamaps, 2023), timeline: 03/2022 – 02/2023.

[6] Finnish startup Aviamaps.com provides manned and unmanned aviation with a real-time aviation map platform and easy-to-use flight planning and airspace management tools.

Global outlook of Urban Air Mobility use cases and infrastructure reports

Briefly:
What distinguishes UAM from “traditional” aviation, is the use of smaller, often electric, and unmanned vehicles/systems to provide aerial operations services (such as mapping and infrastructure inspections), cargo services, or even passenger transport services. UAM services are delivered with various aerial vehicles ranging from small to medium size, with several types of requirements for ground infrastructure, whereas operational requirements and regulation are similar for all types of unmanned operations. If humans are onboard, the requirements are stricter.

UAM requires new types of traffic rules (airspace management) and restrictions, improved communications networks, and ground infrastructure enabling safe and efficient take-off and landing. Once the volumes increase from current number of drone flights, UAM creates new mode of transport to cities. Current volumes have not required major actions from the cities in Finland.

Today, delivery drones are already being tested in Helsinki by drone technology companies. Wing, an Alphabet company, has already delivered parcels commercially with drones in Vuosaari, Helsinki for several summers. Other research and innovation projects, such as the H2020 -funded project AiRMOUR have focused on time critical deliveries of medical supplies or healthcare professionals for Emergency Medical Services.

The global UAM use cases are based on the promise of electric and quiet unmanned aerial vehicles. Currently most civilian drones are operated within visual line of sight (VLOS), whereas future use cases are expected to be operated beyond visual line of sight (BVLOS) to allow the operators to scale their operations. Drones are used already today in several use cases. Some of the largest use cases for drones today are inspection, monitoring and follow up of infrastructure, building and construction sector projects. These operations are included in the “aerial operations” category. Different use case categories for UAM are more broadly covered in next three sections. This section describes the global outlook of UAM use cases – potential use cases for Helsinki are discussed in the Economic outlook of UAM use cases in Helsinki section below0.

The speed of market and technological development for UAM use cases is uncertain. So far, UAM tests in Helsinki have mostly focused on development of technology and use cases have focused on supporting public sector or common good. Specific cases include delivery of medicine or defibrillators, mapping of invasive species in the archipelago, traffic counting or monitoring and 3D modelling of the city. (Tapiovaara, 2020) (Forum Virium Helsinki, 2021)

Globally, the development paths are various. Several private sector companies are developing the technology to enable B2C or B2B cargo solutions or air taxis. Solutions in different cities can vary, but a common theme is that drone and UAM market is growing rapidly in the upcoming years. While technology companies and global hype focuses on B2C deliveries and air taxis, the B2B market and “aerial operations” category of use cases are likely much larger in the 2030s.

Market estimates for Urban Air Mobility are mixed. Estimates for drone markets are done mostly on global level or they focus on key markets, such as the United States and Asia, where regulation is more lenient, or in the megacities with existing demand for air taxi services using helicopters. Different market estimates were collected in the AiRMOUR project to reflect the range of global estimates for the economic or business impact of Urban Air mobility and are presented in Section "Economic outlook of UAM use cases in Helsinki". The estimates are a mix of different sub-sets of UAM and cover different parts of the value chain. The referenced study by robots.expert also lists outlier estimates that are uncorrelated with the scale of the **Error! Reference source not found.Error! Reference source not found.** below.

The deployment of U-space regulation (more in Section U-space regulation 0) and advancements in European regulation will enable the establishment of special volumes of U-space airspace, where UAM services can scale up in a predictable manner. Today, UAM services in Europe are limited due to very demanding drone regulation and to some technological obstacles (limited functionality of early U-space services, connectivity), but more advanced U-space services, expected after 2025, will allow for richer UAM services to emerge. Full U-space services allowing seamless mixing of manned and unmanned traffic in the same airspace are expected in 2030's, which should allow scaling the solutions rapidly in Europe thanks to the harmonised regulation (SESAR Joint Undertaking, 2022). EASA, along with research institutions and manufacturers, expect UAM to become highly visible in 2026–2028, when hundreds to thousands of daily flight operations could take place in the largest European metropolitan areas (EIT Urban Mobility, 2022).

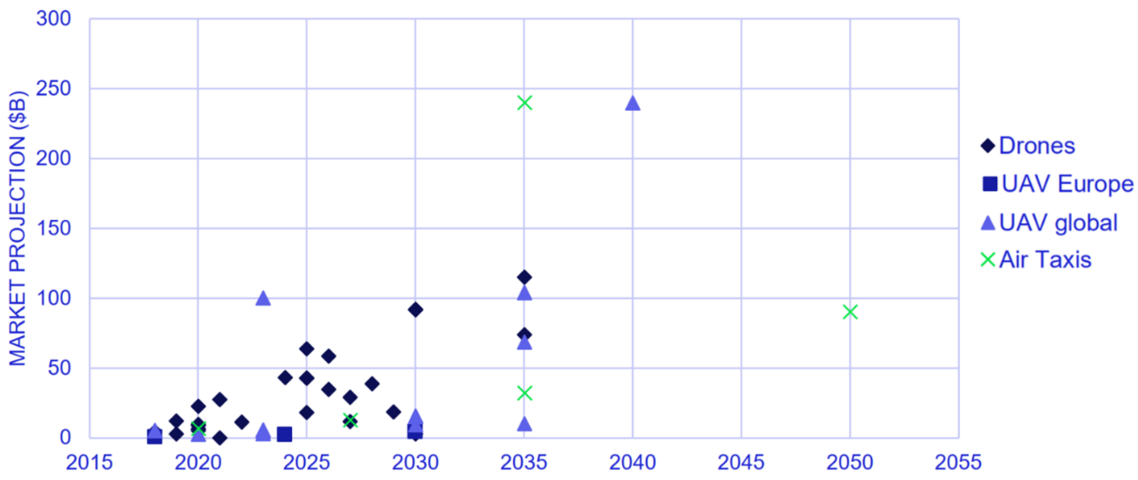

Figure 3. Global market estimates and timeline for different elements of UAM. (Georgiev, Larrouturou, & Stjernberg, 2021)

Aerial operations

While concepts such as innovative, advanced, and urban air mobility are rather new, the services similar to those defined by the term UAM already exist. Already, the use cases in the aerial operations category span a variety of fields: agriculture, infrastructure inspections, forest industry, weather, law enforcement, search and rescue, civilian and military surveillance, mapping and surveying, photography and filming, and entertainment. Aerial operations use cases utilize a variety of different sensors, such as visual and infrared cameras, radars, LIDARs, and radios to deliver data for the operators. What differentiates the current use of drones from ones seen as the future of UAM is the operating mode. Currently, a drone pilot needs to maintain visual contact (VLOS) with the drone at all times, whereas, in the future, the development of technology and regulation allows for operations BVLOS of the pilot. This will allow drone operators to both scale their operations and to offer new types of services. Currently, demanding regulatory requirements for BVLOS operations, access to airspace and reliable digital data links in the air are the three main factors slowing the development of BVLOS-enabled use cases. It is likely that the aerial operations category will grow in the shape of an S-curve once 1) the drone industry is able to meet the high regulatory requirements for BVLOS flights, 2) U-space airspace has been established to enable access to airspace, and 3) the use of mobile networks has been allowed in the air.

Cargo services

Several companies are developing cargo delivery drones globally. Different types of cargo delivery drones have been tested also in Helsinki, such as delivering medicines from Lauttasaari to Jätkäsaari in Forum Virium Helsinki's (FVH) Mobility Lab project and the Alphabet company Wing delivering bakery goods and groceries in Vuosaari since 2020. Delivery drones can be used for last mile deliveries between hubs for mainly B2B applications or directly to consumers in an urban or rural setting. Currently, the forecasts state that delivery drones will initially carry relatively light packages, up to a few kilograms. In the future, heavier loads such as pallet-sized items may become possible. While the main market in Finland for delivery drones is expected to focus on delivering time-critical and high-value items such as medical supplies and spare parts, many technology companies are testing business-to-consumer (B2C) drones to deliver eCommerce orders or fresh food.

Cargo drones come in various sizes and set ups. For example, last-mile express delivery drone can look very different from ones used in the forestry industry to spread fertilizers. The final delivery to the recipient can be done in several ways: landing on a roof of a building, at a drone stop with a human receiving it, at a parcel locker or other type of self-service terminal, either by landing the vehicle or by lowering the cargo via a winch or dropping it with a small parachute.

Emergency and medical sector can use delivery drones to transport different medical samples or equipment (such as defibrillators). Tests have shown that drones may be able to reach an accident site faster than traditional ambulances and deliver medical equipment to remote areas. While some laboratory samples are delivered in bulk, from time-to-time immediate transfer is needed, and drones may partly replace taxis or vans as a faster delivery method for these transfers. Emergency service use cases are studied extensively in Europe, as they are expected to enjoy better acceptance by the general public compared to many other drone use cases.

Changes in the road transport network, or land use policies or practices could speed up the market development of cargo drones. For example, car free zones or zero emission zones can improve the competitiveness of drones powered with electricity against Internal Combustion Engine (ICE)-vans and heavy goods vehicles used in the city logistics. Drones could also support the transition from diesel vehicles to more emission-free modes of propulsion by offering a certain delivery capacity with complementary service that can replace the least efficient van deliveries. Some estimates show that last-mile drone deliveries are sustainable from an energy consumption perspective, at least when the cargo is light and small and only single parcel needs to be delivered. The cost of operation quickly decreases with increasing transportation volumes and further when one pilot can control more than one vehicle at a time (Cornell, Kloss, Presser, & Riedel, 2023). However, this only applies to single parcel deliveries.

With heavier loads or more parcels, it is more energy efficient to use ground vehicles. Last-mile deliveries are always complex, especially in urban areas, whereas rural and suburban areas are better suited for drone deliveries.

According to a drone survey conducted by EIT in 12 European countries with 49 respondents from public sector, research & academia and private sector, medical deliveries are clearly seen as a priority within cargo use cases. Results are presented in Figure 4. (EIT Urban Mobility, 2022)

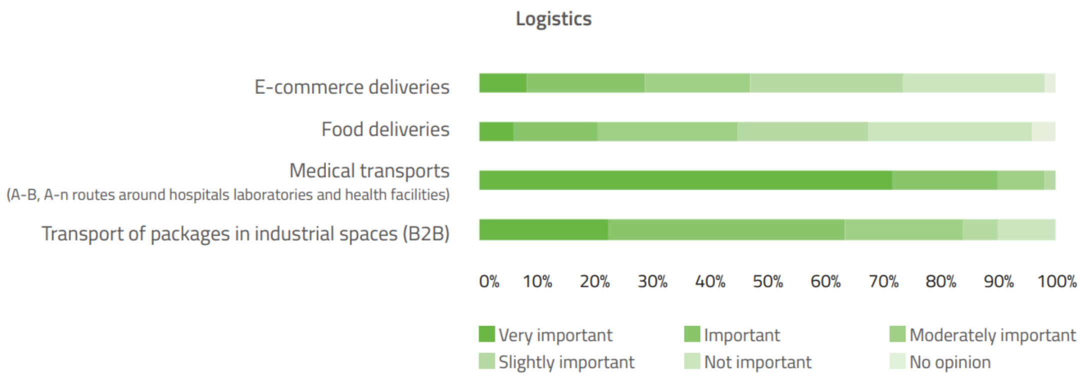

Figure 4. Across Europe, medical transport services are considered much more important than other use cases. B2B use cases are seen more important than B2C services (EIT Urban Mobility, 2022).

Passenger services

Passenger services, such as air taxis, are expected to emerge in the major cities around the world, mainly driven by ground traffic congestion and sufficiently large VIP customer segments. Air taxis are seen as a solution to relieve some of these issues in the short term as they create new capacity with relatively low infrastructure needs (traffic management and landing/take-off sites) compared to road transport. Air taxis are not seen as a separate transport system but as complementary to existing modes of transport as a first- or last-mile solution between destinations. Air taxis will compete mostly with traditional taxis and private cars on medium distance trips (10-40 km, depending on the first- and last-mile required to access a vertiport) in congested cities. Air taxis are often seen as a premium mode of transport between important nodes, such as between a city centre and an airport. Air taxis are planned to be tested for the first time in Europe during the Paris Olympics in 2024. While autonomous operation is a major driver in the cargo and aerial operations sector, passenger services are expected to rely on human pilots for the first few years.

Even globally, the scenario for a more wide-spread market for door-to-door air taxis is unlikely due to the high cost of landing infrastructure, required investments on vehicles infrastructure, noise and an expected lack of public acceptance. However, human carrying drone services are not limited to just air taxis and there might be profitable niches within the passenger market, such as leisure and tourism, similar to services currently provided with helicopters, and regular flights to otherwise difficult-to-access location.

At first, the prime use case for human carrying air vehicles is in emergency services, such as transporting specialist medical personnel between hospitals, first responders to accident sites or to evacuate casualties. Using drones for Emergency Medical Services (EMS) is currently studied in Helsinki in the H2020-funded AiRMOUR project. Across Europe, emergency services are seen as the priority use case in passenger mobility according to EIT's study (2022). Results are presented in Figure 5.

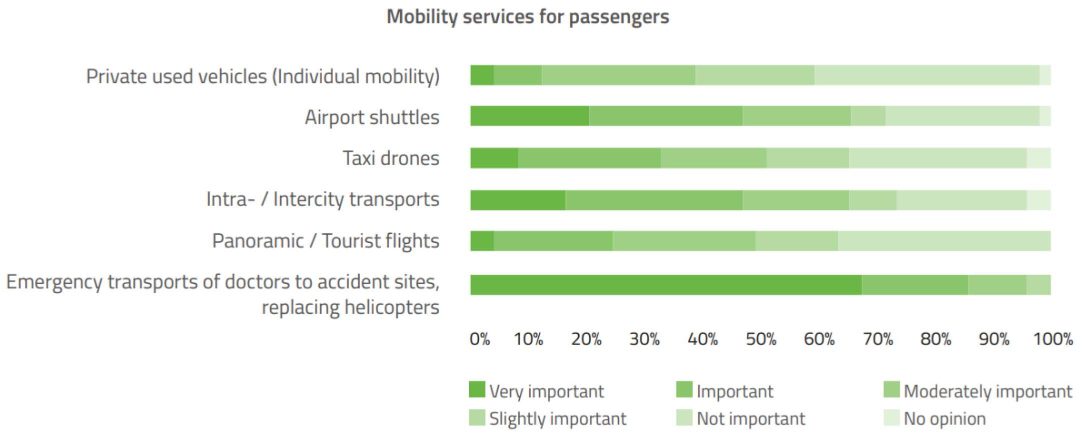

Figure 5. Emergency medical services have been ranked as the most important passenger service in Europe (EIT Urban Mobility, 2022).

Infrastructure requirements for UAM

Some requirements are shared between all types of drones and drone use case categories. This section covers the general requirements of UAM from an operational perspective. The regulation for UAM is covered in Section "Overview of regulation related to UAM". All UAM operations require arrangements to ensure that aircraft do not collide. U-space[7] airspace is heralded as one of the keyways to implement unmanned traffic management. Secondly, drones operating BVLOS over cities need to be more reliable than most of the drones currently flown with the drone in VLOS over our cities, and the organisations and pilots operating the drones need to meet higher requirements. Thirdly, reliable digital data links are needed to connect aircraft and drones operating at low-level. U-space is described in detail in Section "U-space regulation"0. Aircraft reliability and drone regulation is described in Section 0"Drone regulation" and frequency regulation in Section "Frequency regulation".

Landing, maintenance and charging infrastructure

The needs for and size of landing and take-off infrastructure vary with the size of drones that are being used and between different use cases. Some requirements for the take-off and landing infrastructure, such as the need for charging and maintenance, concern all types of operations to a varying degree. Infrastructure needs also depend on whether the drones are multirotor, fixed wing or a hybrid between the two. In many use cases, at least in the aerial operations category, the landing infrastructure requirements are low. It is sufficient to have safe areas for the drones to take off, execute the mission and land. Some drones could use mobile landing sites on top of vehicles or simply land on ground or water, without a need for prepared landing sites.

Delivery services and passenger services have higher infrastructure requirements. Both the exact location and the equipment at the landing site need to integrate as seamlessly as possible into the logistics operation or passenger travel chain. Delivery drones require some degree of cargo handling at least in one end of the delivery. Loading is likely to happen at logistics hubs, and delivery either at a prepared site or at an ad hoc location. There are several last-meter solutions available. If delivery drones are to land on top of a typical building, either a human needs to receive the goods, or the cargo must be delivered from the roof automatically. Logistics hubs and industrial sites can often with little modification be converted to be suitable for different types of cargo operations. Typical needs include support for charging, cargo loading/unloading, and maintenance.

[7] "*U-space is a set of new services relying on a high level of digitalisation and automation of functions and specific procedures designed to support safe, efficient and secure access to airspace for large numbers of drones."* (SESAR Joint Undertaking, 2023)

The requirements for vertiport infrastructure are currently being developed in Europe. It is likely that for heavier operations also air cargo security aspects will need to be addressed akin to the procedures already in place for commercial air transport at airports.

Both for logistics and passenger operations, the need for adjacent infrastructure is likely to be very significant. Hangars or warehouses will be required to a varying extent to support the scaling up of cargo operations. Boarding facilities will be required for human transport. Drone passenger transport in Helsinki is likely to be a combination of transportation for medical professionals and of premium experiences mainly for tourists. This will require heated buildings, possible lounges, security controls and charging as well as parking for the vehicles away from the landing pads. Most importantly, this supporting infrastructure needs to be in the immediate vicinity of the demand including full interconnectivity with other modes of associated transportation.

In general, the more drone operations, the more infrastructure will be required, but only up to a limit. The coverage of the network quickly expands when the number of nodes grow (vertiports[8], vertistops, drop-off points, parcel delivery stops, etc.). With five nodes, ten different routes can be established. With ten nodes, 45 different routes can be established. When the number of nodes grows to 20, the number of route-pairs already grows to 190. While the number of nodes in the network grows linearly, the coverage grows nonlinearly.

In a study carried out for EASA by McKinsey & Company, it was estimated that medium sized cities (such as Helsinki) will have three to five vertipads[9] (at major suburban commuting stations or wealthy suburbs), three to seven vertibases[10] (at major corporate HQs, retail districts or commuting stations) and one or two larger vertihubs[11] (for example at the airport and in the city centre) (EASA, 2021). In Helsinki, the city centre has good accessibility to the airport. Therefore, an air taxi service between it and Helsinki-Vantaa airport has low potential. In total, EASA estimates 20 to 45 landing pads to be feasible in medium size cities. On the other hand, Porsche Consulting (2018) estimates that even the largest megacities with five to ten million inhabitants will not have more than 1000 passenger air vehicles by 2035. With direct scaling, there could be at most 60 air vehicles capable of transferring passengers in Helsinki in 2035.

To simplify the text, we use consistently **vertiport** to denote possibly certified landing infrastructure intended for operations involving people onboard. We use **droneport** to denote landing infrastructure for cargo and other drones, what do not require a certified landing infrastructure.

Traffic rules and restrictions

As is explained in more detail in the regulatory overview (Section “Overview of regulation related to UAM”0), air traffic rules are currently exclusively managed by authorities in the aviation domain, primarily the European Commission through the so called “basic regulation” (EU) 2018/1139, by EASA (European Union Aviation Safety Agency), by the Finnish Ministry of Transport and Communications (LVM), and by Finnish Transport and Communications Agency Traficom.

All manned aircraft must comply with the Standardised European Rules of the Air (SERA). With a few very special exceptions, SERA does not concern UAM traffic. Instead, the Implementing Act on Drones (EU) 2019/947 spells out the rules and restrictions for UAM traffic. These rules allow for the establishment of different types of airspace conditions, such as flight restriction or prohibitive volumes of airspace. The rules also define which type of ground area can be

[8] Vertiport = take-off and landing sites for air taxis (EASA, 2021).
[9] Vertipad = one or two landing pads, limited infrastructure, located in commuting stations or private areas (EASA, 2021). Synonymous to vertistop.
[10] Vertibase = sized between vertipads and vertihubs, located in major corporate HQs, retail districts or commuting stations (EASA, 2021).
[11] Vertihub = major UAM node with around 10 landing pads located in airports, downtown and major work districts (EASA, 2021).

overflown. Population density plays a key role in defining how UAM vehicles are allowed to fly. The denser the population, the stricter the rules become.

Currently cities are only consulted in aviation matters related to the establishment of U-space airspace. However, there is an expectation on EU-level that cities will both want to and need to engage with UAM much more actively in the future.

Communications networks

Whereas manned aviation has traditionally relied on collision avoidance based on looking out of the cockpit, and on communicating over voice radio, drones cannot “see-and-avoid” other aircraft and are not capable of understanding human speech. Therefore, digital communication links between drones, ground control units and eventually also manned aircraft is sorely needed to ensure that the high aviation safety levels can be maintained as drones start to fly BVLOS in the same airspace as manned aircraft, such as helicopters. Few use cases are possible without additional communications networks.

The mobile network is seen as the strongest candidate for digital communication links at low-level aviation. Contrary to other European countries, it’s use in aircraft is restricted in Finland. Work is ongoing in Europe to open its free use, whilst also improving the reliability of the data links for safety critical drone operations.

Overview of national and international strategies and guidelines related to UAM

Briefly:
The European Commission's Drone Strategy 2.0 is the main UAM strategy in Europe. The emphasis of the strategy is twofold: aerial operations, health care logistics and emergency service solutions serving a common good but also air taxi services should be part of everyday life in Europe by 2030.

When cities create mobility plans, urban air mobility should be part of the plan. A vision and strategy are needed to emphasize sustainable and integrated transport development, where different modes of transport fulfil the local objectives and promote the needs of the citizens.

National and regional strategies have identified UAM as a new mode of transport, but the regulation is lagging technological development. Cities and regional authorities must have an active role in the UAM ecosystem through land use planning, by taking the ground infrastructure requirements into account. The development of regulation is driven by European and national authorities.

Strategies emphasize the role of the city as a representative of its citizens. The cities should pay attention to public acceptance and enable citizen participation in the urban air mobility deployment.

While there is hype around Innovative Air Services and Urban Air Mobility, few strategies or guidelines have been published, internationally or nationally. Lack of standardization and common regulation combined with uncertainties related to the technological development and the ambiguity of use cases cause a "chicken and egg" problem between technology and infrastructure providers, land use, regulators, transport authorities, cities, service providers and end-users. This section focuses on highlighting the key aspects of European and national strategies and guidelines related to Urban Air Mobility. Regulation is covered in Section "Overview of regulation related to UAM"0.

International strategies and guidelines

European Commission's Drone Strategy 2.0

The European Commission's Drone Strategy 2.0 aims to "Build the Union drone services market" and "Strengthen European civil, security and defence industry capabilities and synergies" for a smart and sustainable unmanned aircraft ecosystem in Europe to support the transition defined in European Green Deal. The European Commission envisions that by 2030 drones will be part of the life of EU citizens. The vision highlights several use cases which should benefit both citizens and industry: aerial emergency services, surveillance and inspections and delivery of goods. Further, the Commission sees Innovative Air Mobility (IAM) services (i.e., passenger transport using new types of aircraft) as part of the urban mobility ecosystem by 2030. While the IAM services are likely to be executed with a pilot on board, the Commission sees full automation as a goal.

The European Commission highlights that drone sector must be mindful of its environmental impact, not only energy consumption but also of noise and visual pollution. Local, regional, and national levels of coordination are required for a fair and sustainable deployment of unmanned aviation in urban and rural settings.

The strategy highlights the role of cities and local authorities in the alignment of new air services. Cities should have a pivotal role in regional planning of air mobility infrastructure. The planning for location of new infrastructure, such as vertiports, charging infrastructure and routes should be systematically analysed, balancing between the requirements, affordability, and societal aspects. Equal access is a major concern, as the air navigation services are expensive and may limit the affordability of drone operations. The strategy sees cities' role as a decision-maker in the regulation of innovative air services, such as placing restrictions on night-time operations in their territory, but also as transport innovators, who integrate urban air mobility solutions to address mobility challenges in urban areas. Emphasis should be placed on noise mitigation in route design, procedures and other practices by both local authorities and drone operators.

The strategy recommends conducting studies on societal acceptance of UAM, as previous studies have shown noise and safety rank as main concerns, followed by privacy, security, and environmental issues. Citizens should be encouraged to have their say in the decisions regarding innovative air mobility deployment, for example through living labs, regulatory sandboxes, or demonstrations. Cities should be transparent of the air mobility plans, by clearly communicating where, when, how, and what innovative air mobility services will be deployed.

While the Commission intends to support drone technologies through EU instruments and European Investment Bank loans, it notes that cities' efforts to deploy drone services should also be supported with other means through cooperation ecosystems such as ELTIS[12] and UIC2 to share information, knowledge, and experiences. The Commission intends to fund an online platform developed by EASA. This online service will support cities, authorities, and drone industry to implement sustainable IAM services.

The Commission and EASA have a major role in the governance of UAM and IAM in EU. For example, the commission intends to adopt rules to enable a "certified" category (for example human carrying drones or dangerous goods transport) of drone operations, standardise rules, adopt rules for the design and operations of vertiports and develop guidebooks on counter-drone operations and infrastructure protection. National level authorities such as Traficom and Fintraffic also have a major role in the regulation of new types of air mobility, especially in U-space regulatory package. The Commission will monitor how drone regulatory frameworks are implemented in member states to ensure harmonised implementation across EU.

The strategic goals are supported by 19 planned action items, with actions related to the role of the city bolded shown in *Table 2*:

In order to build the European drone services market, the European Commission intends to:	In order to strengthen the European drone civil, security and defence capabilities and synergies, the European Commission intends to:
Adopt amendments to the Standardised European Rules of the Air and the Air Traffic Management/Air Navigation Services Regulation to safely integrate drone and piloted eVTOL operations;	Continue to provide funding for R&I on drones and their integration into the airspace under the Horizon Europe programme and the European Defence Fund;
Promote coordinated research on integrated Communication, Navigation and Surveillance technologies;	**Set up a coordinated series of calls under the existing EU instruments and EIB loans to support a new flagship project on 'drone technologies';**
Adopt new European standard scenarios for low to medium risk aerial operations;	Consider possible amendments to the existing financing/funding framework to ensure a consistent approach in support of dual-use research and innovation to improve synergies between civil and defence instruments;

[12] ELTIS = The Urban Mobility Observatory. Eltis facilitates the exchange of information, knowledge, and experience in the field of sustainable urban mobility in Europe.

Adopt rules for the 'certified' category of drone operations, addressing the initial and continued airworthiness of drones subject to certification; and the operational requirements applicable to manned VTOL-capable aircraft;	Develop a Strategic Drone Technology Roadmap to identify priority areas to boost research and innovation, reduce existing strategic dependencies and avoid the emergence of new ones;
Adopt rules for the design and operations of vertiports under the scope of EASA Basic Regulation (prototype technical specifications have been published);	Coordinate with other relevant EU actors a common approach with the aim of providing sufficient radio frequencies spectrum for drone operations;
Develop balanced economic and financial requirements for licensing of drone operators.	Set up an EU network on civil-defence drone testing centres to facilitate exchanges between civilian and defence sectors;
Fund the creation of an online platform to support a sustainable IAM implementation by authorities, cities, industry, and stakeholders;	Encourage all relevant actors to further align certification requirements for civil and military applications towards those set by EASA while considering military specificities and existing military certification standards;
Adopt training and competences requirements for remote pilots and pilots of VTOL aircraft.	Adopt new standard scenarios for civil operations that could facilitate corresponding military use cases;
	Adopt a counter-drone package;
	Adopt an amendment to the aviation security rules aiming to ensure that aviation authorities and airports increase their resilience when faced with the risks posed by drones;
	Define criteria for a voluntary "European Trusted Drone" label.

Table 2. Actions proposed by European Commission to build European drone services and strengthen security & defence capabilities. Actions related to the role of the city bolded. (European Commission, 2022)

UAM Initiative Cities Community's (UIC2) Urban Air Mobility and Sustainable Urban Mobility Planning guideline

To comply with European Green Deal emission reduction objectives, to promote more accessible and sustainable cities and to deal with the complexity of urban transport, many European cities and regions use Sustainable Urban Mobility Planning (SUMP) to tackle these issues. A SUMP is a long-term, strategic, and integrated approach to plan urban mobility in functional urban areas.

With the advent of urban and innovative air mobility, a key question for cities concerning UAM is how to integrate it to other aspects of urban spatial planning, especially other modes of transport and land use. UAM should not be a separate mode of transport but integrate with other modes of transport complementing them. The integration of UAM requires incorporating ground infrastructure into the land use process and UAM as a new mode of mobility to SUMP process.

According to UIC2, cities can take different strategic positions regarding UAM. All of these positions may be justified and prove to be beneficial. The main difference is timeline of integrating UAM within a city's transport system. The cities can either be:

1. Frontrunners, which engage early into UAM development, innovate with private sector, and become integral part of the UAM ecosystem,
2. Followers, which wait for UAM services and regulation to mature and then adopt best practices from frontrunner cities, or
3. Value-seekers, which wait for full maturity of UAM services, technologies and regulations and only then integrate established applications which are proven to have great benefit-to-cost ratio. Even in the value-seeker case, cities should develop and acquire UAM competency and participate in policy making.

No matter what the role is, cities should have a clear vision, plan, and strategy on how to integrate UAM with rest of the mobility. The UIC2 identifies three different types of approaches:

- top-down,
- bottom-up, and
- greenfield.

In the top-down approach, a city adapts higher-level mobility plans set by state or regional authority or the plans can be based on an existing SUMP-concept. In the bottom-up approach, no overarching masterplan exists, but single actors or coalitions build the UAM ecosystem and structures in the city. In the greenfield approach, the city has no existing UAM structures, and it adopts a comprehensive mobility planning approach, covering also UAM, combining the top-down and bottom-up approaches.

The guide recommends cities to create an inter-departmental team to cover different issues and aspects of planning related to integrating UAM into wider mobility and land use planning. To ensure the coverage, cities should scan and analyse their organizational and institutional landscape with broad view, to identify all relevant stakeholders. Further, cities should start involving and familiarizing citizens to UAM, to understand the social acceptance of air mobility and to ensure that plans for UAM align with the needs of the citizens. After all, the main aspect of SUMP is the focus on people and quality of life instead of on traffic and infrastructure. In short-term, cities should initiate public discourse of the benefits and challenges of UAM and co-create use cases with stakeholders to serve the public good. Mid-term, the cities should expand the UAM from technology demonstrations to UAM services in living labs and test environments to understand the feasibility of different UAM implementations. Long-term, continuous cooperations and alignment is needed between different authorities on different levels of planning to harmonise UAM and urban environment.

EU TEN-T revision

The EU TEN-T revision proposal (COM/2021/812 final) does not directly address drones or UAM. The focus of the TEN-T network is on road, rail and air corridors and nodes between major cities, regions, and nations of European Union. In air mobility, the focus in on the air space management, improving infrastructure in airports and supporting the multimodal connectivity of main airports. No requirements for Urban Air Mobility, Advanced Air Mobility or Innovative Air Mobility have been set.

The revision proposal also emphasises urban nodes, such as Helsinki. The urban nodes should have a Sustainable Urban Mobility Plan (SUMP) by 2025. Further, urban nodes should have multimodal passenger terminals by 2030 and cargo terminals by 2040. While this does not directly address UAM, it can be part of the integrated transport solution.

National strategies and guidelines

Liikenteen automaation lainsäädäntö- ja avaintoimenpidesuunnitelma (Action plan on legislation and key measures of transport automation, LVM, 2021)

The vision for transport automation focuses on three principles: improving traffic safety, efficiency, and sustainability, which enable Finland to benefit from transport automation. The guiding principles in transport automation are human-centric development, improving information exchange and holistic development of transport automation regulatory framework. In unmanned aviation, the objective for Finland is to be attractive location for pilots and tests to ensure a frontrunner role. The public sector should act as an enabler. Widescale aerial operation will require dynamic air space management and air traffic control to ensure safety and efficiency.

The plan identifies the need for cooperation between cities and authorities on all levels of planning. Cooperation is needed not only in UAM, but in transport automation in general. According to the action plan, the focus of the public sector should be in enabling technological development, especially in unmanned aviation. This can be done through active participation in drone (UAS/UAM) tests.

The plan identifies the lack of regulation for UAM landing sites and the need for national regulation. No timeline is given for the development of national regulations or guidelines. Despite the lack of regulation, the plan recommends cities to take UAM infrastructure requirements into account in land use planning. Further, real-time data of flight obstacles in urban environment and low altitudes are needed, which requires actions from the cities. According to the plan, the current information of flight obstacles is limited. Cities are also listed as minor stakeholders in the study of mobile network coverage for unmanned aviation and in the development of regulation. Real-time and dynamic data of the transport system supports all modes of automated transport and supports the needs for transport system integration.

Liikenteen automaation tiekartta Helsingin seudulla (Roadmap for Transport Automation in Helsinki regions, Traficom & HSL, 2021)

The emphasis of the roadmap for transport automation in Helsinki region was on the road transport automation, but drone services, both logistics and passenger services were identified as potential use cases. Use cases not directly related to moving cargo or people from A to B were not covered. The roadmap recommends cities and other regional planning authorities to follow the U-space development and be involved in the coordination process through dialogue with Traficom. Other recommendations include collecting and sharing information of permanent and temporary flight obstacles, weather, and airspace use. Digital twin of the city was seen as a later action, which can support drone operations. The cities and regional planning authorities are advised to include take-off, landing and loading sites in land use planning and zoning and ensuring necessary coverage of mobile networks and alternative positioning methods.

As shared actions between all modes of transportation, cities and regional planning authorities are advised to provide standardized and open-source data of transport system and creating a situational picture of transport system. Further, the cities and regional authorities should ensure accessibility of related automated transport systems and infrastructure and improve their transport automation related capabilities through tests.

Logistiikan digitalisaatiostrategia (Logistics digitalization strategy, LVM, 2020)

The vision for logistics in 2032 is defined as follows: “Infrastructure, logistics and data form a functional package in the transport corridors. Digital transformation has moved Finland towards efficient and sustainable logistics”. The strategy does not directly name drones or UAM, but it includes themes overlapping the general questions related to the integration of UAM with other modes of transport. The strategy states that the logistics data environment is to be developed such that situational picture data is improved and different actors (data providers, utilizers, users) of all sizes have access to data. Enterprises should have an equal playing field in providing services. Digital transport data should be real time and of high quality. Climate impact should be reduced through efficiency, optimization and streamlining.

Further, the strategy states urban logistics should be improved with optimized fleet, capacity, and multimodality. Greater flexibility is needed using smaller delivery vehicles for the last-mile deliveries. The strategy identifies noise from loading and unloading as a major hurdle for flexible use of fleet, which is an important consideration for drone operations in logistics.

Overview of regulation related to UAM

Briefly:
Aviation authorities ensure the safety of UAM flight missions, considering both the airspace and the ground overflown. The higher the population density overflown, the stricter the requirements.

The municipal planning monopoly does not extend to the airspace. Outside U-space airspace, the city has no formal influence on what goes on in the air. Landowner permission is not needed for unmanned aircraft landing sites, only for manned operations. However, environmental permission will be required for frequent, commercial drone operation at a fixed location, if the operation causes noise or visual pollution to its neighbors. The city can influence the establishment and operation of vertiports for human passengers that require landowner and environmental permission.

U-space airspaces with drone operations must be coordinated since January 26, 2023. The new U-space regulation and the updated Finnish aviation law recognize for the first time that cities should be involved in the hearing and oversight process of a piece of airspace.

By making relevant geospatial city data available, the city can have a substantial de facto impact on where and when drones fly:

- Digital maps of areas to “prefer” or “avoid” flying over, including hours of applicability. For example “avoid these daycare centers 07-18 on weekdays”
- Information of planned gatherings of people, such as sports events, concerts, marathons, demonstrations, etc., so that drone operators can avoid them easily.

As highlighted by national and international strategies and guidelines, UAM is at a crossroads of aviation and urban regulation. Also, radio frequency and environmental regulations apply to UAM. This section provides an overview of the applicable regulation, and how it is applied in four example use cases.

Three enablers are needed before UAM can scale up and prosper:

1. Drones, which are safe (“airworthy”) to fly over cities,
2. Access to airspace for BVLOS operations, and
3. Reliable digital communication links to drones flying BVLOS at low-level.

The first two enablers are regulated by aviation regulation while the third enabler is regulated by the radio frequency authority. A fourth enabler, public acceptance, is not regulated but heavily influenced by the actions and engagement of cities and regions. Therefore, it is only natural that the new EU Drone Strategy 2.0 recognises that *“Local communities, cities, regions have a deciding role for ensuring the alignment of Innovative Aerial Services with the needs and preferences of their citizens.”.* However, currently urban, and environmental regulation have only very limited, if any, influence on UAM operations.

Aviation regulation

History

Until October 2015 drone operations were not regulated in Finland. The rapid growth of drone use had started only a few years earlier and until the early 2010's drones had been a very marginal phenomenon. However, the advent of affordable and capable "ready-to-fly" drones, combined with the precision of the Global Navigation Satellite System (GNSS) led to more people starting to fly drones for both work and hobby. In 2015, the first Finnish regulation on drones, OPS M1-32, was published by Traficom, the Civil Aviation Agency (CAA) in Finland, regulating the use of drones heavier than 250 grams.

A new European Basic Regulation (EU) 2018/1139 on Common rules in the field of civil aviation and establishing a European Union Aviation Safety Agency (ASA) was adopted in 2018. According to the Basic Regulation all drones, irrespective of their weight, became subject to the Union harmonised safety rules. Based on the Basic Regulation, the Commission adopted in 2019 a series of rules regulating operations with drones. Commission Delegated Regulation (EU) 2019/945 of 12 March 2019 on unmanned aircraft systems and on third-country operators of unmanned aircraft systems and Commission Implementing Regulation (EU) 2019/947 of 24 May 2019 on the rules and procedures for the operation of unmanned aircraft has divided drone regulation into three categories, Open, Specific and Certified categories. The open category's operations are low-risk operations, the Specific category operations are medium-risk operations and the certified category's operations are high-risk operations.

The EU regulation on drones 2019/947 came into force in Finland on 1.1.2021 with a one-year transition period for professional drone users, meaning that existing national permits were recognised until 31.12.2021. It is only from 1.1.2022 onwards that the EU drone rules have been the only regulatory framework for private and professional drone operations in Finland[13]. Many Finnish drone operators struggle to cope with the new, much higher level of complexity of the regulation, compared to the previous national drone rules. The high complexity of the EU rules for operations BVLOS has slowed down progress and innovation in the European and Finnish drone sectors. However, the slow-down is only temporary, as the end goal – safer drone operations – is rapidly maturing and builds the foundation for scalable and trustworthy drone operations in cities.

Finally, to ensure the safety of drone operations in airspace, the Commission adopted in 2020 three Implementing Regulations on U-space, which provide the air traffic management system for drones.

Drone regulation

Unmanned Air Systems (UAS) operations are divided into three categories based on the type of mission being performed. A summary of the categories is presented in Figure 6. The three categories in regulation (EU) 2019/947 on Drone Operations are:

1. UAS operations in the **'open' category** do not require any prior operational authorisation or declaration by the drone pilot. Operations in the open category are subject to a number of limitations. The most important limitation is that all operations need to be in direct line of slight of the pilot (VLOS), for example inspecting a construction site within line-of-sight of the pilot. Another restriction is the distance to uninvolved people, where only drones less than 900 grams can occasionally fly close to uninvolved people. Drones up to 4 kg must keep a minimum safety distance of 30 meters to uninvolved people, and heavier drones cannot be operated in the open category in areas where there are uninvolved people, including most places in a typical city.

2. UAS operations in the **'specific' category** require a permit (operational authorisation) most of the time from the CAA. The nature and risk of specific category operations vary

[13] State aviators, mainly the Police, Border Guard, Fire & Rescue, and the Finnish Defence Forces continue to operate under national rules.

dramatically from low-risk operations very close to the open category all the way to high-risk operations almost qualifying into the certified category. Except for human-carrying flight operations, transportation of dangerous goods or flights over assemblies of people with large drones, all flight operations without the pilot maintaining eye contact with the vehicle belong to the specific category.

3. UAS operations in the **'certified' category** require the certification of the UAS and the certification of the operator and, where applicable, the licensing of the remote pilot. All Electrical Vertical Take-Off and Landing eVTOL "air taxi" operations with people onboard fall into the certified category. The same eVTOL with only cargo onboard is likely to fall into the specific category. An eVTOL vehicle is the epitome of Innovative Air Mobility[14] promising vertical take-off and landing with a significantly lower noise profile and requiring only a fraction of the energy compared to traditional helicopters.

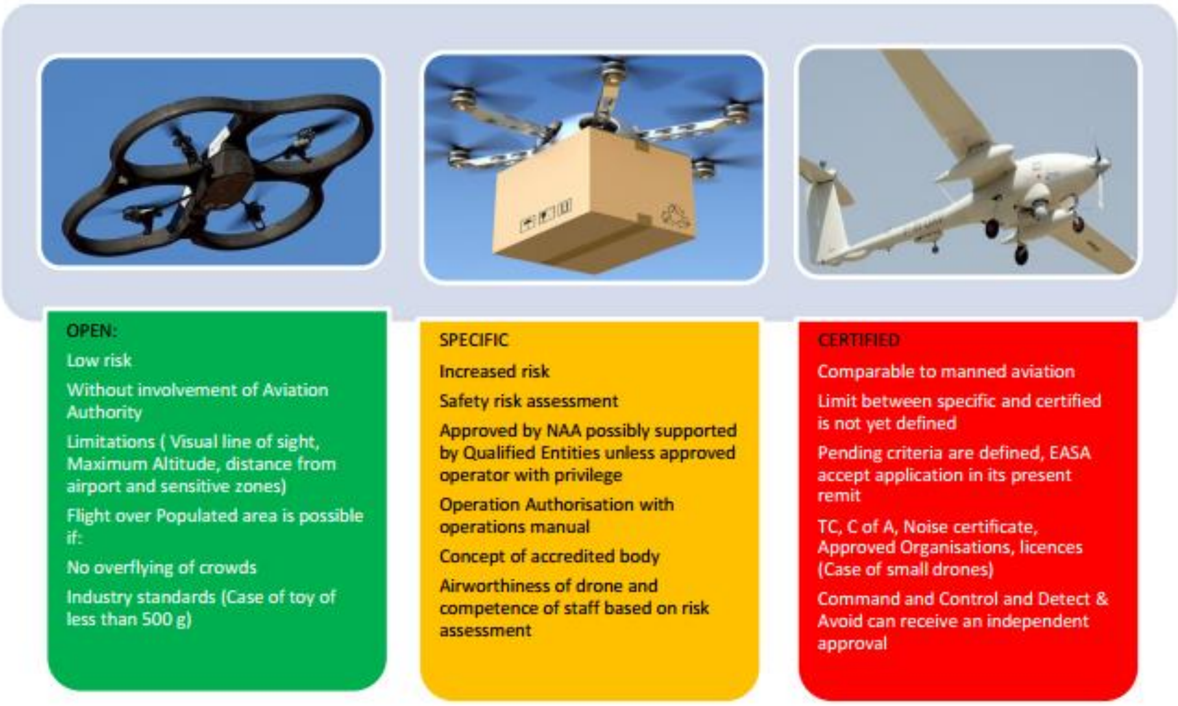

Figure 6. Summary listing the respective characteristics of the open, specific, and certified categories. (European Aviation Safety Agency, 2015)

The cost of regulatory compliance in the **Open** category is negligible, but the scope of possible operations is limited to the smallest of drones.

The procedures and equipment related costs immediately increase when moving to operations in the **Specific** category. Anywhere from 40 to 100 working hours can be expected to be required of a budding drone operator to establish a new drone operation in the **Specific** category in addition to training. In addition, flight approval processing times and fees from Traficom need to be considered. While a drone system suitable for the open category typically

[14] The concept of Innovative Air Mobility ('IAM') is to accommodate operations with novel aircraft designs (that do not automatically fall under one of the known categories, but which have vertical take-off and landing (VTOL) capabilities for take-off and landing, specific (distributed) propulsion features, can be operated in unmanned configuration, etc.), that are conceived to offer a new air mobility of people and cargo, in particular in congested (urban) areas, based on an integrated air and ground-based infrastructure. IAM describes a diverse array of aircraft types (such as manned and unmanned), whose designs are enabled by ongoing innovations particularly in the areas of hybrid and electrification of propulsion systems, energy storage, lightweight materials, digitalisation and automation. These innovations have made possible an array of novel designs spanning multi-rotor, tilt wing, tilt-rotor, powered wing, offering short take-off and landing (STOL) through to VTOL capabilities. (European Commission, 2022)

costs hundreds or at most a few thousand of euros, a drone system for the specific category suitable for BVLOS operation over cities typically costs tens or hundreds of thousands of euros per drone. Eventually this cost is expected to come down significantly.

While the vast majority of UAM operations today are in the Open category with some in the Specific category, no operation in the **Certified** category has yet been approved in Europe. The certification instructions are still being developed by EASA, and the type certification process for an eVTOL is both lengthy (likely spanning years) and very costly. Yet, as billions of euros have been invested by private equity companies into startup companies building eVTOL's such as Volocopter and Lilium, these companies experience high pressure from their financers to be able to deliver commercially capable eVTOLs. Given that Volocopter successfully flew a prototype eVTOL at Helsinki Airport already in 2019 with a pilot onboard, it is not the technological readiness but regulatory compliance that has slowed down the development of eVTOLs and the **Certified** category.

BVLOS operations and Danger areas

Unless operating in U-space airspace (see Figure 7), BVLOS operations in Finland are only allowed in parts of the airspace with a very low probability of encountering manned aircraft. To achieve this, BVLOS drone operators apply for and operate in so called Tempo-D areas (temporary danger areas), which are managed by Traficom. The cost to apply for a danger area for up to a year at a time is 320 EUR and is used for example by Wing, who delivers parcels with drones in Vuosaari (EFD728 in the Figure 7).

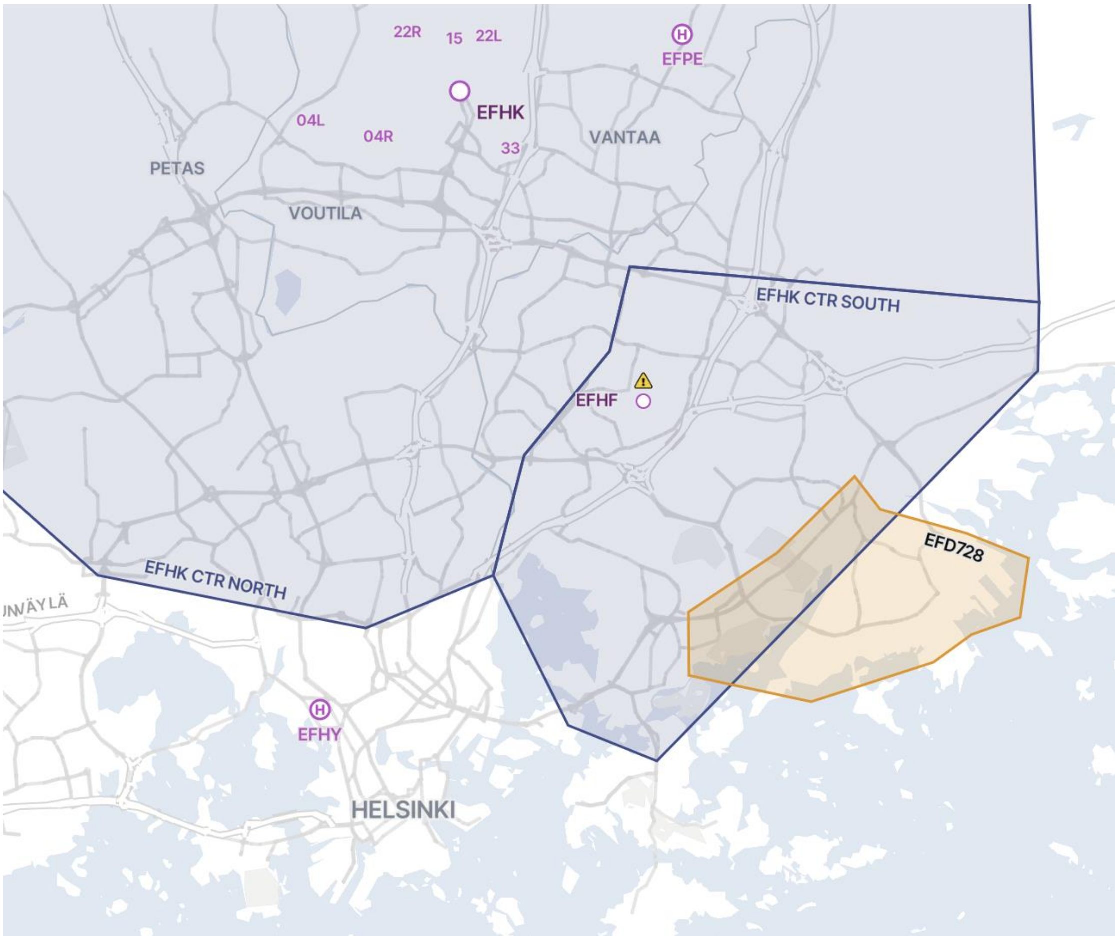

Figure 7. Simplified map of the airspace in Helsinki. EFD728 (orange area) is a Danger area where Wing operates BVLOS drone deliveries. The grey areas are CTR (controlled airspace), relevant to the section on U-space airspace (Section 5.2). (Aviamaps, 2023)

The increasing number of Danger area applications in Finland is a growing challenge in that manned aircraft and drones should avoid flying in danger areas when active. Danger areas are used by the Finnish Defence Forces (FDF), by hobby pilots and beyond line-of-sight drone operators and are typically activated for a day at a time, and not for an individual flight. It is a quite a static tool, and not well suited to support the growth of the digitally enabled, dynamic UAM industry.

When a Danger area or a similar airspace structure is proposed, Traficom sends, based on the aviation law, the proposal to a regular group of aviation stakeholders including state aviators (Finnish Defence Forces, Police, Border Guard, FinnHEMS) as well as aviation industry organisations (Finnair, Suomen Ilmailuliitto, RPAS Finland, etc.). Cities or environmental authorities are not included in the list, as they are currently not recognised as stakeholders in the management of the Finnish airspace. The situation is the same as in for example Estonia and Sweden.

Liability insurance for drone (UAS) operations

According to (EC) 785/2004 all aircraft and drones with a maximum take-off weight exceeding 20 kg must be insured for third party liability. The need for a liability insurance up to 20 kg is regulated nationally. The Finnish aviation law does not require liability insurance coverage from operations in the Open or Specific categories for drones up to 20 kg.

However, the Finnish law on liability compensation 31.5.1974/412 states that an entity causing damage is liable to compensate for its caused damages. Therefore, most commercial on authority drone operators have a third-party liability insurance coverage, even if the aviation regulation does not necessarily require it.

U-space regulation

Commercial manned aviation relies on humans in the plane cockpits communicating with humans in air traffic control towers (air traffic control; ATC). Drones are basically machines in the air that need to communicate with machines on the ground handling drone traffic control. In Europe, the concept of drone traffic management is called U-space. The concept of U-space was established in 2017, where *“U-space is a set of new services relying on a high level of digitalisation and automation of functions and specific procedures designed to support safe, efficient and secure access to airspace for large numbers of drones.”* (SESAR Joint Undertaking, 2023)

On January 26, 2023, the first new European regulation EU) 2021/664, 665 and 666 on U-space airspace enabling establishing certain parts of the airspace into U-space airspace, where a subset of the complete U-space vision can be implemented as a first step towards enabling missions BVLOS without overly restricting traditional aviation and enabling several BVLOS missions from different drone operators to coexist in the same airspace.

In U-space airspace:

- Drones have to keep sending their position and identity to the U-space system while they fly.
- Drones need to have an approved and activated flight authorisation (“flight plan”) before they can take off. This flight authorisation ensures that there are no other conflicting drone flights planned, and the authorisation can be withdrawn to avoid risk of collision with manned aircraft.
- Drones must report any contingency or emergency condition, that may lead to them violating the conditions in their flight authorisation and become a risk to others.
- In controlled airspace, such as in northern Helsinki, air traffic control must temporarily close U-space airspace if manned aircraft needs to fly through (for example a rescue helicopter). In uncontrolled airspace, such as in southern Helsinki, manned aircraft must

make themselves electronically visible to the U-space service before entering U-space airspace. This can mean extra costs for the manned aircraft operator.

Initially, U-space airspace is expected to be limited to below 150 m (500 ft) and established in airspace where the risk of encountering manned aircraft is low. This limitation is considered necessary to ensure safety of operations in the U-space airspace across the EU as the present status and maturity of the technical U-space solutions are still evolving rapidly.

The role of cities in U-space airspace

The Finnish airspace is national property. Interviews with LVM and Traficom underline that the free access to airspace is a basic right in Finland. However, there may be commercial services associated with ensuring flight safety such as air traffic services for commercial aviation and U-space service subscriptions for drone operators. LVM underlined in an interview, that the establishment of U-space airspace requires drone operators to make a service contract with a U-space service provider, which might come at a fee. This restricts free access to airspace and therefore is not unproblematic.

However, when aviation "lands" in cities, it is only natural that cities become active stakeholders in the management of the low-level airspace and the supporting ground infrastructure. Drone Strategy 2.0 outlines: *"52. Local communities, cities, regions have a deciding role for ensuring the alignment of Innovative Aerial Services with the needs and preferences of their citizens. They have a key role in deciding to what extent drone operations can be conducted in their territories. For example, they are in a good position to assess which critical infrastructure should be protected, whether operations should be allowed in day or night-time, what should the measures in place be in terms of noise and visual abatements. […]"*

The U-space regulation and its Article 18 (f) is the first regulatory artifact supporting a broader role of cities in the management of the low level airspace. Article 18 (f) says: *"The designated competent authorities shall (f) establish a mechanism to coordinate with other authorities and entities, including at local level, the designation of U-space airspace, the establishment of airspace restrictions for unmanned air systems (UAS) within that U-space airspace and the determination of the U-space services to be provided in the U-space airspace;".*

The Guidance Material to the regulation provides more detail on the establishment and management of U-space airspace and the role of cities. An in-depth discussion of the U-space regulation is beyond the scope of this study. Only key points are highlighted here to facilitate a general understanding of the expected role of a city in U-space airspace.

Central to U-space airspace is a coordination mechanism. In Finland, Traficom is responsible for establishing the coordination mechanism and in particular for nominating a U-space coordinator responsible for preparing, performing, and completing the coordination process by providing recommendations to the competent authority throughout the life cycle phases of the U-space airspace (planning, execution, review). The process is illustrated in Figure 8.

"*GM1 Article 18(f):*

> *c) The U-space coordinator should identify, involve, and consult with all these relevant 'other authorities and entities, including at local level'. These authorities or entities may be affected by, or interested in, the deployment of a U-space airspace in some way and therefore should be considered accordingly. The term 'local' refers to public and administrative authorities, and to entities of various types at local and regional level, such as **municipalities, metropoles, prefectures, regions**, airports, and ports in accordance with the multilevel governance models of a given Member State. In addition, relevant local civil society organisations, associations, and private entities should be involved and consulted."*

"*GM3 Article 18(f): The coordination mechanism is considered a high-level framework (see Figure below) for managing the coordination and alignment activities throughout the life cycle phases of the U-space deployment. The following topics may be considered during its definition and establishment:*

b) The coordination mechanism could deal with topics beyond the safety, security and performance of aviation-related activities, which are typically managed at national level, by encompassing and addressing the relevant requirements and constraints (e.g. with regard to the environment and the society) imposed by regional and local authorities at different time horizons of the U-space deployment.

In other words, ***the aim of the coordination mechanism is that the designated and deployed U-space airspace fits the regional and local well-being needs, local traffic infrastructure and complements it (e.g. without hindering other traffic users such as pedestrians, cyclists, and means of public transport).***"

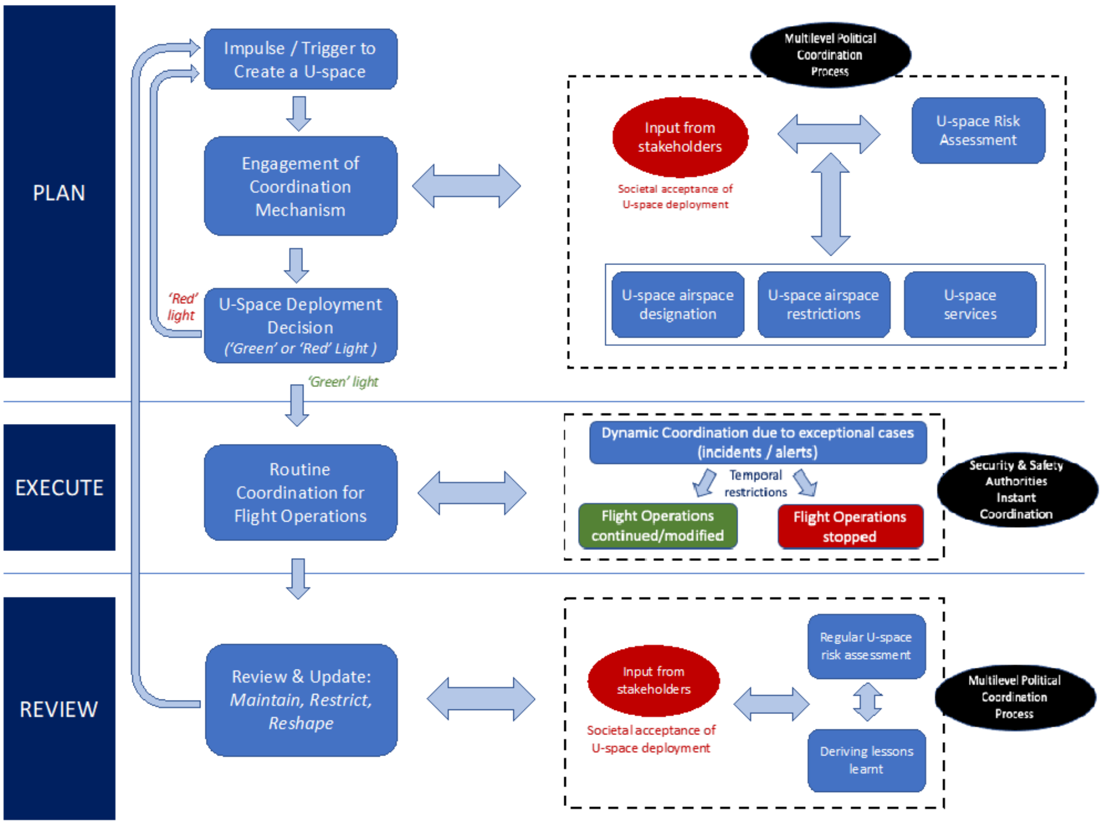

Figure 8. Block diagram providing an overview of the main tasks that require coordination among stakeholders across the different levels of governance, and of the activities for the planning, execution, and review phase of the U-space deployment. (European Union Aviation Safety Agency, 2022)

Noise and environmental permits

When establishing aerodromes, Traficom requires an environmental permit or at least an environmental impact assessment. As there are no regulations or permits required for establishing droneports for non-human carrying operations as of yet there is no explicit process to require an environmental permit. However, the Law on Protecting the Environment 527/2014[15] states, that an environmental permit may be required if the activity, among others:

- jeopardizes the general comfort in a public area or areas of particular cultural value; or
- reduces the value of an area intended for general recreation.

In addition, the law on particular neighbourhood relations *26/1920*[16] paragraph 17 dictates that regular, commercial, or industrial activities cannot significantly encumber neighbours due to among other reasons noise or vibration. The need for an environmental permit from the

[15] https://www.finlex.fi/fi/laki/ajantasa/2014/20140527
[16] https://www.finlex.fi/fi/laki/ajantasa/1920/19200026#

municipal environmental department may therefore be required if a vertiport or a droneport has a significant impact on the environment.

Landing infrastructure and land use

Permits related to use of land for air operations

Regulation on land use is beyond the scope of the study.

The Finnish aviation law 76[17] § outlines that aircraft should operate only from airfields or temporarily from land- or sea areas with the permit of the landowner. However, this restriction does not apply to unmanned aviation. Therefore, the selection of take-off and landing sites for any non-human carrying aircraft is not restricted by aviation law and does not need a permit from the landowner, unless Traficom has explicitly restricted access.

Having said that, interviewees indicated that permit of a real estate / building owner will be needed to access any property, although the aviation law does not mention it.

Therefore,

- Any eVTOL operation with humans onboard will need the landowner's permission to operate, unless they operate from established airfields, such as the planned Kivikko helipad.

- Any other UAM operation can be planned freely without involvement of landowners.

However, interviewees clearly expect cities to engage in the planning of at least high-traffic landing sites to ensure, that they remain socially acceptable to citizens in addition to being well integrated with overall urban mobility plans.

Vertiport and droneport regulations

Currently only heliports and registered airfields / airports are regulated.

EASA has in March 2022 published a Prototype Technical Design Specifications for Vertiports (PTS-VPT-DSN) to enable the safe design of vertiports that will serve eVTOLs. It includes the concept of a funnel-shaped area above the vertiport, designated as an "obstacle free volume". This concept is tailored to the operational capabilities of the new eVTOL aircraft, which can perform landing and take-off with a significant vertical segment compared to traditional helicopters. Depending on the urban environment and on the performance of certain eVTOL aircraft, omnidirectional trajectories to vertiports will be also possible. Such approaches can more easily consider environmental and noise restrictions and are more suitable for an urban environment than conventional heliport operations, which are constrained in the approaches that can be safely applied.

The scope of the PTS-VPT-DSN is limited to human-carrying enhanced category (similar to performance class (PC) 1 of helicopters), allows proportionality in safety objectives, and enables the highest level of safety in protecting third parties when flying over congested areas and when conducting commercial air transport (CAT) operations with passengers. Therefore,

[17] *"Ilma-aluksen lentoonlähtöön ja laskeutumiseen saa käyttää vain lentopaikkaa tai 2 momentissa tarkoitettua aluetta. Kielto muiden alueiden käyttämiseen ei koske hätätilannetta, pakkolaskua tai muita niihin rinnastettavia tapauksia, ei myöskään lentoonlähtöä ja laskeutumista miehittämättömällä ilma-aluksella tai sotilashelikopterilla, muulla valtion helikopterilla eikä etsintä- ja pelastustoimintaan käytettävällä helikopterilla pelastus-, virka-apu- ja operatiivisilla lennoilla. […]*
Ilma-aluksen lentoonlähtöön ja laskeutumiseen saa tilapäisesti käyttää avointa vesialuetta sekä alueen omistajan tai haltijan suostumuksella muuta maa- tai vesialuetta, vaikka aluetta ei ole sellaiseen tarkoitukseen erityisesti järjestetty. […]"

the prototype specification is not directly appliable to cargo-carrying eVTOLs or to smaller droneports.

In short, currently there are no regulations or authority specifications for droneports. Instead, the requirements for these are driven by the operational and technical requirements of respective UAM system manufacturer.

Privacy and cybersecurity

There is currently no explicit regulation for privacy or security for UAM. Normal privacy regulations, such as GDPR, apply. During a flight operation, sensors collect data to complete the task or to support safe flying. Privacy in UAM operations is not part of the approval process of flights. The GDPR imposes obligations onto organizations anywhere, so long as they target or collect data related to people in the EU. In particular, they address:

- **Lawfulness, fairness, and transparency**. The GDPR requires that the processing must be lawful, fair, and transparent to the data subject.
- **Purpose limitation** — You must process data for the legitimate purposes specified explicitly to the data subject when you collected it.
- **Data minimization** — You should collect and process only as much data as absolutely necessary for the purposes specified.
- **Storage limitation** — You may only store personally identifying data for as long as necessary for the specified purpose.
- **Integrity and confidentiality** — Processing must be done in such a way as to ensure appropriate security, integrity, and confidentiality (e.g., by using encryption).

The Regulation does not require that one complies but that one is able to demonstrate that they comply. As drones are equipped with cameras and sensors, any operator should be able to demonstrate that the information picked up by cameras and sensors cannot be used to identify a person (anonymization at source and geofencing of any private compound or that they obtained consent from the subjects).

Whilst flight approval processes focus on airworthiness (limitation or control of ground and air risk) the respect of privacy is neither monitored nor controlled. As the rules are either missing (for noise and visual violations) or those responsible for enforcing them are unclear about their relevance (for GDPR), cities should engage with their experts to clarify their exposure.

Regarding cybersecurity, there is consensus that the UAM sector has not sufficiently addressed the relevant questions. According to Drone Strategy 2.0, drones with a higher level of cybersecurity could be required for operations in some airspace, helping to separate legally operated drones from the illegal ones. Drones manufactured to comply with specific requirements could be eligible for a voluntary “European Trusted Drone” label. Such label would provide assurance to users that the corresponding drones have been vetted and found to be sufficiently secure to be used for more critical or sensitive operations.

Security and counter-drone/UAS

Security and counter-UAS were highlighted in the Drone Strategy 2.0 and were highlighted in the interviews as an often-forgotten topic in the UAM discussion. The cities have an obligation to protect citizens and ensure safety, which includes planning and coordinating UAM security.

In 2020, the Commission adopted two Communications, which both introduced new policy actions to counter possible threats that drones could pose. The EU Security Union Strategy and Counter-Terrorism Agenda stated that the threat of non-cooperative drones is a serious concern in Europe that needs to be addressed (European Commission, 2020), (European Commission, 2020). Moreover, the proposed Directive on the resilience of critical entities (CER Directive) will introduce obligations on Member States and critical entities to conduct risk assessments, and on critical entities to take technical, security and organisational measures to ensure their resilience against identified risks (European Commission, 2022). This initiative has expanded and will now include “Protection against Unmanned Aircraft Systems – Handbook on Counter-UAS for Critical Infrastructure and Public Spaces” and “Protection against Unmanned Aircraft Systems – Handbook on Principles for Physical Hardening of Buildings and Sites”. It is not clear when these publications will be available. The publication “A guide to key information on the protection of Public Spaces” from 2021 compiles a list of useful studies on the subject, such as “Berlin Memorandum on Good Practices for Countering Terrorist Use of Unmanned Aerial Systems“ and “Protecting Against the Threat of Unmanned Aircraft Systems (UAS)” published in the USA. (Karlos & Larcher, 2021)

Central to counter-UAS is the ability to intercept and disturb radio signals used to control rogue drones. In Finland, both the Police, and the Defence Forces are allowed to intercept and terminate the flight of unauthorized drones, both using kinetic force and radio interference. In practice, counter-UAS systems are very expensive and have a limited range. Therefore, it is not expected that counter-UAS systems cover the whole area of a city.

Frequency regulation

UAM should be seen as a digitally connected environment, where operators on the ground and in the air are constantly able to produce or consume digital information and services. One of the current bottlenecks is the lack of reliable digital connectivity for both manned and unmanned low-level flying aircraft.

The standard go-to solution for ubiquitous, affordable digital connectivity is cellular mobile phone networks. However, these are not configured to support connections to the air. In fact, in Finland, in contrast to most other European countries, the use of mobile networks in the air needs a special permission from both the network operator and Traficom, unless it is being used by authorities or for certain authorised tasks. (Traficom, 2023)

The Aerial Connectivity Joint Activity (ACJA) is a collaboration by Unmanned Traffic Management and mobile communication entities aimed to promote interchange and understanding between the aviation and cellular communities, the purpose being to enhance information sharing and avoid incompatibilities between those groups. Also, the U-space regulation has triggered a need for allowing cellular networks in the air. Based on interviews and the views of the authors of this study, a city is in general not expected to have a significant role in enabling digital connectivity.

Environmental regulation and protection

Environmental protection, for example protecting wildlife during their breeding period, is in Finland seen as a more important regulation than aviation regulation. Indeed, the Finnish aviation law recognises in Article 11 environmental protection as an acceptable reason to restrict aviation, including unmanned aviation.

Aviation studies show that over 95% of bird strike events occur in the volume of airspace that will be hosting urban air mobility, either during take-off and landing or during the lower phases of flight (climb/descent). It is possible, that general rules will be developed in Finland on, for example, minimum flight height over nesting birds or other bird protection measures. Until then, environmental protection rules on what can be regarded as disturbing must be applied also to UAM.

Ongoing and future aviation regulation activities

In December 2022, EASA updated the Terms and Conditions for its rulemaking task RMT.0230 “Introduction of a regulatory framework for the operation of unmanned aircraft systems and for urban air mobility in the European Union aviation system”. This RMT has already produced the new EU drone regulations and the U-space regulation, but a significant number of new regulations are needed and planned to be released for commenting and later decided between 2023 and 2027. Regarding air taxis, only type certified aircraft can carry people. Given the rather slow pace that the regulation task is progressing it is reasonable to expect the first air taxis with pilot onboard to be operating earliest in 2025. Air taxis without a pilot onboard can be expected earliest in 2028. (European Union Aviation Safety Agency, 2022) The timeline is presented in Figure 9.

Central to drone logistics, high-risk Specific category operations and cargo drones in the Certified category can be expected to emerge only after 2025 after the necessary regulations have been decided.

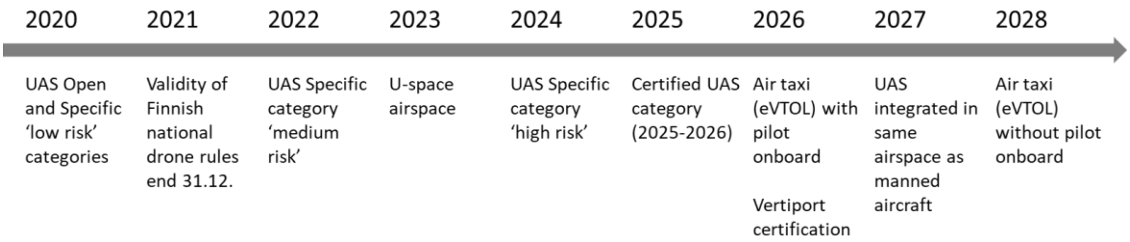

Figure 9. Timeline describing the emergence of UAM-related aviation regulation and requirements 2020-2028.

It is expected that vertiports approved for human-carrying operations will be available earliest in 2027. Until then, air taxis will have to operate from existing aerodromes – either airports or heliports. However, planning can already start, as EASA released Prototype Vertiport Design specifications in 2022.

Roles and responsibilities of authorities and the city in an example drone logistics case

To exemplify the contents of this section, let us study a fictive case, where a drone operator seeks permission to commence regular drone deliveries between Huslab Meilahti and Huslab Pihlajisto.

At 16:00 on a Friday afternoon, the route is predicted to take 24 minutes with a car as indicated by a route search in Figure 10. With a drone, the distance is 7.6 km as there are no flight limiting restriction areas[18] in the path of the drone. Allowing 1.5 minutes for take-off and landing, the drone flies at around 70 km/h and conducts the total mission in 8 minutes, or a third of the time it takes for a taxi to drive the parcel on the ground or a quarter of the time it would take to deliver the parcel by bicycle. The flight path is presented in Figure 11. During non-rush hours, a taxi could take a much shorter 10.1 km route and drive the distance in circa 15 minutes or only two times slower than the drone.

To be allowed to perform the mission, the drone operator would need an authorization from Traficom and likely a permit from a mobile network operator.

[18] Assuming permission to operate inside the Meilahti helipad restriction area.

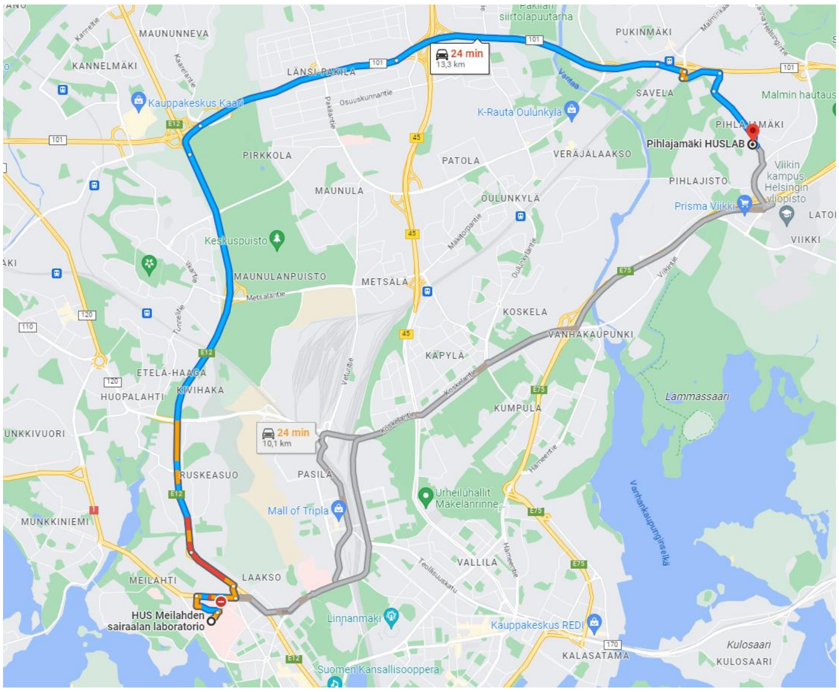

Figure 10. Map of 13.3 km driving route between Huslab Pihlajamäki and Huslab Meilahti during rush hour. (Google, 2023)

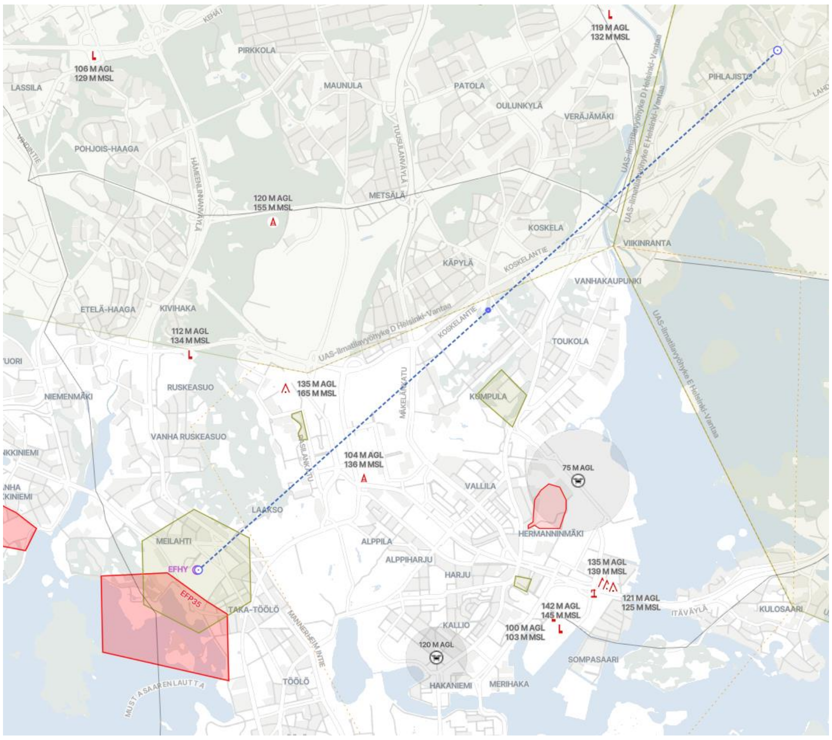

Figure 11. Map of the airspace and the 7.6 km direct flight route between Huslab Pihlajisto and Huslab Meilahti. (Aviamaps, 2023)

Aviation authority involvement

Applying for a permit from Traficom for this beyond visual line of sight mission would require the operator to complete a so-called SORA assessment, where the applicant analyses in detail the air risk but most of all the ground risk. What is the population density of the overflown area, are there any aggregations of people along the flight path (the mission likely needs to avoid Käpylänpuisto sports fields), what areas should be avoided in case of an emergency landing (avoid flying along high-speed roads), etc. Ground risk increases tenfold when the average population density exceeds 25, 250, 2,500, 25,000 and 250,000 people per square kilometre[19].

[19] These limits are part of SORA v2.5, which is expected to be approved in Europe during 2024.

Regarding air risk, the applicant would need to prove that they are not at risk of colliding with manned aircraft (foremost helicopters, as the applicant intends to fly fairly low, about 60-80 m above the ground). This can be done with a special airspace arrangement called danger area (Tempo-D). However, it would be better if the airspace could be established as U-space airspace.

The aviation authority will also expect the applicant to identify and address other risks, such as privacy, cybersecurity, and noise concerns, although there are no prescribed ways to do it. It is very much up to the applicant to argue their point of view. Regarding privacy, the applicant needs to demonstrate that if a camera or other sensor is used for navigation, the data collected is processed in compliance with GDPR. Regarding cybersecurity, the command-and-control link as well as any other radio communications need to be secure. Also, patient information inside the drone must be obscured sufficiently that sensitive patient data is not disclosed even in an emergency landing. Regarding noise, Traficom may inquire as to the expected noise pollution at the take-off and landing sites.

Once Traficom is satisfied that the risk of the operation has been successfully mitigated including using a sufficiently airworthy drone system, the personnel is sufficiently trained and the operating organization is qualified enough, the applicant will receive an Operational Authorisation in the Specific category for the mission.

Frequency authority involvement

If the applicant is planning to use radio communication that requires a permit, such as a mobile network connection to the drone, Traficom's radio licensing department must evaluate the application. The applicant needs to demonstrate that the use of mobile network in the air is acceptable, and one part of this is to obtain a permit from the mobile network operator that they support the application. Once Traficom's radio licensing department is satisfied, the applicant will receive a radio license. Currently, the use of mobile networks in the air is supported for authority and security of supply use (in Finnish: "huoltovarmuus"), and for testing campaigns. It is not clear, whether the applicant would meet the criteria for using the mobile network in the air and may have to look for other alternatives.

Insurance coverage

Third-party liability insurance coverage is required in the EU for any drones above 20 kg total take off mass. Below 20 kg, drone operators in the Specific and Certified categories are required to have third party liability insurance. Open category drone operators are exempt from the requirement to have a liability insurance. However, any professional drone operator need to recognize that they still are generally liable for causing damages according to the liability act (Vahingonkorvauslaki 412/1974).

City involvement

As the flight route does not cross any sensitive areas, and as take-off and landing sites for unmanned aviation does not need the landowner's permission, the city is not consulted nor involved in the flight permit application process itself. However, if U-space airspace is requested to be established to support the operation, the city would be involved in the establishment and ongoing evaluation of the U-space operations.

If the drone operator is smart, they may expect that citizens may start to complain on noise if the drone always flies the same route several times a day. Therefore, the drone operator could proactively decide to approach the city's Urban Environment Division to inform about the intended mission and provides the city representatives with sufficient background information to tackle any immediate complaints and refer citizens to the drone operator's website for more information and for contact information.

Economic outlook of UAM use cases in Helsinki

Briefly:
The current VLOS-based drone service market in Helsinki is estimated to a few million euros of which the flight operation part is estimated to be less than 500 kEUR. In the near future the UAM service market will evolve significantly by both allowing existing use cases to benefit from beyond visual line of sight capabilities and by creating completely new services. In Helsinki, Port of Helsinki and Stara are likely to benefit early on, as well as many private-sector mapping, surveying, and inspection applications. The healthcare sector will be first to embrace drone logistics solutions such as express delivery of samples and medicines between healthcare units. As service prices drop, B2B drone cargo services are expected to grow rapidly. Towards the end of the 2020’s medical experts can be transported by eVTOL drones between care units or reach accident sites faster. Later, in the 2030’s tourism and flights to Tallinn may become feasible.

The city cannot monetize the airspace, as it is controlled by national authorities and Finnish aviation legislation grants few rights for the cities to affect the airspace management. If the city aims to directly monetize UAM, it could provide and monetize supporting services such as ground infrastructure, U-space services, or supplementary data.

The UAM service market potential in Helsinki is estimated to be 20–80 MEUR annually. The economic impacts are still unclear as the UAM market as of today has low maturity. There is a significant indirect market potential from UAM service, when employed by the city and its affiliates directly, starting with healthcare. The added mobility provided by UAM may offer, e.g., significant savings in stockkeeping and personnel on duty costs. Also, due to the high scalability potential of UAM services thanks to the uniform EU drone regulation, the city may benefit in the long run from supporting Helsinki-based companies to grow and expand, even if the local drone service market potential in Helsinki is limited.

Costs, benefits, and the overall economic outlook of UAM in Helsinki

UAM has both direct and indirect costs and benefits related to it. The transportation system could benefit from UAM by reducing logistics and transport costs and by providing new services. Some of the benefits are financial (revenue from new markets, better services, increased efficiency of different processes) while others are economic benefits (travel time savings, tax revenues, emission reductions, better health care services).

There are several costs related to UAM, majority of them being related to operational aspects. U-space service providers are likely to charge the drone operators for the services to cover the costs of operating the service. Building the integrations to other modes of transport (both cargo and passengers) and building the ground infrastructure is costly. Obviously, there are costs directly related to the operation of the drones, such as capital expenditures, maintenance, energy, and personnel costs, with different cost structures depending on the type of operation and equipment used. For drone operators and users, integration and operational costs dominate over the investment costs.

It is possible for the city to have a passive role in UAM. In such case, most of the costs are related to resources (personnel costs) in the administration needed to engage with UAM planning and regulation together with national authorities or direct costs related to procuring UAM services to support core activities of the city or its subsidiaries. If the city has a more active role, the costs may be higher, for example if the city plans for landing sites and supports the drone operators in the construction of such sites.

Benefits of UAM are also both direct and indirect. UAM has the potential to directly improve the transport systems characteristics. UAM may improve logistics in Helsinki by reducing costs or creating new services adding value for businesses or consumers. Reduced emergency response or delivery times in health care sector may reduce costs and save lives. Globally, passenger services come with the promise of travel time savings. Many businesses or subsidiaries of the city can be supported with aerial operations to improve efficiency or reduce costs. The benefits are discussed in more detail in Sections “Aerial operations in Helsinki”0, “Cargo services in Helsinki”0, and “Passenger transport in Helsinki”0.

The UAM or drone market itself is an emerging market that has potential to generate jobs and thus indirectly benefit the city in many ways. Many market studies try to estimate the market size of UAM in general. Due to major uncertainties related to UAM, making an exact estimate of the economic impact of UAM in Helsinki is difficult. Direct scaling of international potential using gross domestic product of Helsinki and Finland can be used to derive some market estimates.[20] Forecasts derived for Helsinki based on both global and European[21] market estimates are presented in Table 3. Most of the estimates presented try to predict the drone market size based on very little evidence (covering the whole ecosystem, to varying extents) and different definitions of the “market”. Some of the estimates may focus only on the passenger services, which complement or replace existing helicopter or taxi service, but mainly in megacities. In the Finnish context, air passenger services are likely a niche market, as there is very limited demand for helicopter transport. Further, the weather conditions limit the usability of unmanned Air Systems during the winter.

Market	Aerial operations	Original market and forecast year	Source
Use case specific estimates	39 M€ (aerial operations) 5 M€ (cargo) 31 M€ (cargo) 21 M€ (passenger)	Global, 2035 Global, 2035 Europe, 2030 Global 2035	(Porsche Consulting, 2018) (Porsche Consulting, 2018) (Statista, 2023) (Porsche Consulting, 2018)
Drone/ UAM Market	21 M€ 24 M€ 93 M€ 285 M€	Europe, 2030 Global, 2030 Europe, 2030 Europe, 2030	(EIT Urban Mobility, 2022) (Drone Industry Insights, 2023) (European Commission, 2022) (Morgan Stanley, 2019)

Table 3. Market estimates for UAM in Helsinki derived from various international estimates. The estimates only include total addressable market (revenue), not the wider impacts (economic, social or sustainability benefits received by end-users),

Most of the value of UAM is related to improving operations in different value chains. In many cases, the value chain is rather long, and the impacts are hard to measure without a deep dive into each one separately (for example construction industry and improved situational awareness). It is impossible to cover all the different potential use cases.

Sustainability goals of Helsinki and UAM

The city of Helsinki constantly shows leadership towards achieving carbon neutrality. The “Carbon Neutral Helsinki” objective is to reduce CO_2 emissions by 80% compared to 2030. Further, the city aims to be carbon negative by 2040. The action plan focuses on direct

[20] Helsinki contributes ~37% of GDP in Finland, and Finland’s share of global GDP is ~0,31 %. Helsinki’s share of global GDP is ~0.12 % and ~0.51 % of European GDP. (World Bank, 2023)
[21] In the estimates, “Europe” is not defined. In this analysis, Europe is defined to include EU27 + UK + Norway + Switzerland, as this captures majority of GDP in Europe.

emissions of the city, such as heating of buildings, electricity, and transport. (City of Helsinki, 2022)

Drones may offer some strategic advantages over other means of transportation. The recent development of technologies and miniaturization of sensors and cameras allow for equipping light drones with equipment that would previously be fitted only on larger helicopters. Moreover, the cost of drones may allow the dispatch of several of those for a cost significantly lower than the one of a helicopter. Finally, it can also be expected that BVLOS drones and air taxis will be faster, cheaper, and easier to dispatch than conventional helicopters. However, it is unlikely that drones will provide a significant contribution to the plans of the city to reach carbon neutrality (Pukhova, et al., 2021). Applications where drones replace significantly heavier vehicles or are used to improve the city’s resilience to climate change will nonetheless have a positive impact.

Examples of when UAM is expected to contribute towards sustainability relate to the increasing centralisation of health care services and other specialist services that threatens to force citizens to travel more leading to increased emissions. Also, businesses are looking for ways to reduce inventory levels and improve efficiency of operations. The time-savings offered by drones for logistics has the potential to maintain or improve service levels for citizens as well as allow businesses to improve their efficiency. Benefits from the use of drones are not limited to transport sector. Heating of buildings is the largest direct source of CO_2 emission in Helsinki. As an example, drones can be used by the infrastructure sector to find heat leaks in buildings or optimise construction site logistics with better situational awareness.

While sustainability in Helsinki focuses mainly on the carbon neutrality, other aspects of environmental sustainability and emissions elsewhere have become more paramount. Non-CO_2 aspects of sustainability such as the biodiversity loss and material limitations would need to be considered separately and do not fall in the scope of this study. Instead of sub-optimizing different areas of urban planning, the urban system should be optimized as a whole. Consequently, the city must adapt for the effects planned but also expect that unplanned events will come to create disruptions and mitigate those. (Eräranta, 2023) Drones should not be considered solely a part of the transport system, but as a tool in the urban planning toolbox that can be used to achieve the sustainability goals.

To conclude, drones are not expected to cannibalize other modes of transports, at least not significantly, but to add transportation capacity. Drones are less energy efficient than ground transport of similar size, unless there is a very significant difference in travel distance on the ground compared to the air. As there are no comparable transportation means of the same size as smaller drones, a one-for-one comparison is not meaningful. Nonetheless, applications where drones replace significantly heavier vehicles or are used to improve the city’s resilience to climate change will nonetheless have a positive impact. Drones can play some part in many of the action items listed by the city to achieve carbon neutrality. **Drones will not be a plug-in part-solution to the “urgent need to reduce climate emissions”. They may, however, by creating new services, reduce the need to add emissions elsewhere.**

Aerial operations in Helsinki

Based on the results of this report, it is clear that not all globally discussed use cases are equally important for Helsinki. The public sector (the city itself, its subsidiaries such as Stara or Kaupunkiliikenne, and regional stakeholders, such as HSY, HSL, HUS) and private sector mostly benefit from very similar use cases.

Aerial operations are likely to represent the main volume of UAM operations for the rest of the 2020’s, as this is already a mature market relying on drone operations within line of sight. These operations do not require involvement from the city as they are well spread out and mainly involve very small, and therefore unobtrusive drones. This category includes the use of drones by the police and fire & rescue. Conducting aerial operations is not limited to the public sector; the private sector is using drones today and the volumes will increase in future, especially once operation beyond operators’ visual line of sight is possible. The enabling of BVLOS operations will see new types of use cases such as road condition inspections, industrial area perimeter control, event security management, traffic monitoring as well as large-area mapping for a variety of users ranging from heat leak mapping to observation of the environment.

The city is expected to directly benefit from these services. Indeed, Stara is already active in the area and interested in efficient data collection related to everything from tactical, near real-time planning of snow ploughing (mapping parked cars, finding space to dump extra snow) to detecting invasive plant species and park waste management. The city building inspection department is interested in ensuring that temporary traffic arrangements are complied with, that construction sites sprawling into streets stay within agreed limits and that real estate is used as per the respective permit. An artistic illustration of future aerial operations is presented in Figure 12.

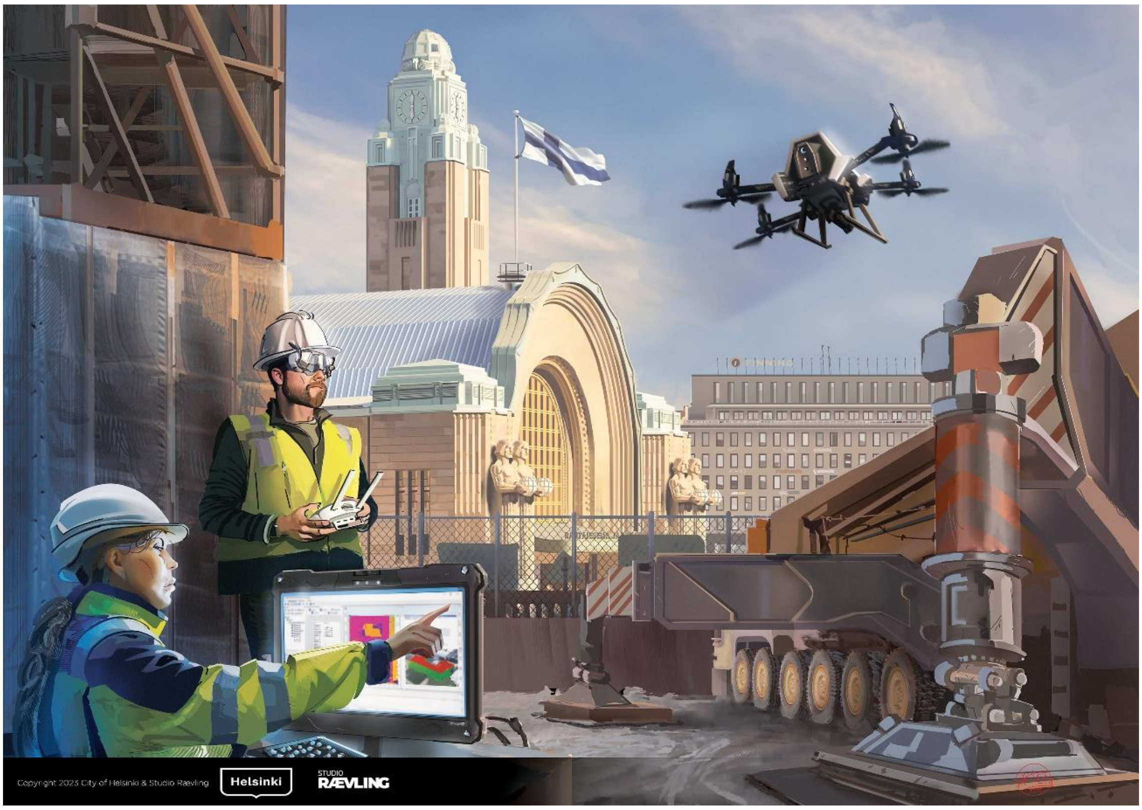

Figure 12. An artistic illustration of future aerial operations in Helsinki.

Aerial operations impact potential in Helsinki

While aerial operations will be the leading category near-term, estimating the financial or economic impacts is challenging due to the diverse portfolio of use cases in both public and private sectors. The impacts are highly linked with the adaptation rates.

Cargo services in Helsinki

In the cargo services category, healthcare applications are likely leading the development in near future. Consolidation of laboratory services and warehousing in healthcare sector increases the demand for express deliveries, which are currently done with taxis and vans. Landing and take-off locations would be static and few in Helsinki, which makes the use cases more feasible, as the infrastructure investments are limited to few locations. In European studies, emergency service and health care applications for UAM have had the highest public acceptance. Such development is heavily driven by public sector stakeholders, such as HUS, with support required from the city to grant construction and environmental permits.

It is possible similar time-critical applications will emerge in the private B2B sector, where express deliveries of critical equipment could be possible using drones. Missing materials or equipment often delay construction or maintenance work at a high opportunity cost when workers have to spend valuable time driving between warehouses or suppliers.

B2C cargo use cases are more challenging to scale up due to the low opportunity cost of choosing another mode of delivery. Companies Zipline, Manna and Wing have demonstrated, that cargo delivery with a winch is effective and safe since it removes the need to have to land at an unknown destination to make a delivery. Some business models have the drone pick up the parcel from the seller before flying to the destination, while other models utilize central warehouses with integrate drone ground infrastructure, delivering goods directly to customers.

The winch approach allows delivery to backyards, parks, and designated pick-up points, but last-meter delivery is harder for customers living in densely populated areas of Helsinki. While parcel lockers with drone integration have been presented and tested, wide scale examples are lacking. Thus, the potential for these services is not equal in all areas of Helsinki. Further, the winter weather conditions limit the availability of flight-based services. Finland differs from many other European countries regarding B2C deliveries. In other countries, delivery to workplace is the preferred option, whereas in Finland delivery to a parcel locker is the preferred option. (Posti, 2019) This may slow down the development of B2C services, as the current level of service in B2C logistics is good in most parts of Helsinki. An artistic illustration of cargo services is presented in Figure 13.

Figure 13. An artistic illustration of future cargo service in Helsinki.

B2B drone delivery impact potential in Helsinki

The B2B sector market potential for deliveries is approximately four times the size of the B2C sector (Posti, 2020). This is also reflected in the drone delivery business potential. The clear early B2B business potential comes from the healthcare sector. In discussions with HUS and FinnHEMS there seems to be a clear demand for urgent blood and special medical product deliveries using drones: *"It's expensive to maintain blood logistics in many locations! More cost effective to centralise processing and use drones for fast deliveries. Same with expensive medications used in rare cases: e.g. antidotes for snake poison, which are extremely costly but only needed a couple of times per year."*

During 2021 the City of Helsinki spent around 40 MEUR on logistics directly plus 10-15 MEUR via health & social care sector and 5-10 MEUR via Stara on subcontracted transportation. Most of the transportation costs cannot be replaced with UAM solutions. Of the health & social care logistics spend ~20% (~5 MEUR) was related to goods and ~80% (~20 MEUR) to moving patients and personnel. Assuming that ~10% of medical goods deliveries could and would be meaningful to be replaced with drones, ~500 kEUR worth of transportation costs could be diverted to drone logistics as a starting point. Discussions with medical experts indicate, that the use of drone logistics would expand quickly between medical service units, as it could provide significant cost savings in other part of the value chain. We estimate that the potential for medical drone logistics in Helsinki is in the order of one million euro per year. A more accurate estimate of the economic potential requires a deep understanding of the care value chains, as drones would not be a one-to-one replacement for ground transportation means.

Industrial customers are spending significant resources on intra-company logistics, for example when a maintenance procedure requires an unplanned spare part. Several interviewed CEOs stated a clear interest in site-to-site deliveries. The economic potential is tied to high price elasticity regarding transportation costs. As advanced drone systems are costly, we expect that the economic growth for non-medical B2B logistics will start slowly with time-critical shipments only, only to accelerate quickly once the cost of an individual drone shipment drops from the initial hundreds of euros, to between 10-20 euros as the industry matures.

B2C drone delivery impact potential in Helsinki

The estimates for B2C delivery potential in Helsinki come from a Gaia Consulting report for the drone cargo service provider Wing. The benefits are estimated to be a mix of business and economic benefits. According to their estimate, six percent of household deliveries could be done with a drone (with a different share of cargo deliveries in different product categories). The main benefit for drone deliveries is the faster delivery time, direct delivery to customers from local businesses and lower delivery costs due to efficiency. The benefits estimated in the report are presented in *Table 4*. It should be noted that the estimates presented assume a certain percentage of deliveries can be delivered with drones and that the logistics system is efficient. (Gaia Consulting Oy, 2021) A summary of the benefits is presented in *Table 4*.

Category	Benefit	Reasoning
Local businesses	13 M€ more sales 4 M€ cost reduction potential	Better reach to customers due to drone delivery extending the range of express delivery. Cheaper express deliveries.
Consumers	4 M€ reduction in delivery costs 40 M€ in travel time savings	Cheaper express deliveries costs (note: already counted as benefit for local businesses). Instant delivery to home replaces pick-up journeys.
Society	11 million vehicle kilometres reduced 38 road accidents avoided 2000 tCO_2e reduction	Express deliveries with drones replace road vehicle kilometres travelled. Drones replace both pick-up trips by consumers and use of delivery vehicles. Note: Benefit partially included in the travel time savings.

Table 4. Potential benefits of B2C drone deliveries in Helsinki. (Gaia Consulting Oy, 2021)

Passenger transport in Helsinki

In Helsinki, the transport system is well developed and works well. As there are no regular passenger helicopter services in Helsinki, passenger transport has very limited potential. Tourism has some potential in future, but it requires advances in technology and regulation. Also, healthcare sector could identify potential for new types of aerial vehicles to offer new types of emergency services between traditional helicopter and ambulance services. The feasibility of such services heavily depends on the technological development and cost structure. Concerning international travel, UAM and new types of air vehicles combined with economic growth of Helsinki and Tallin could re-establish the air taxi service between the two cities, especially if the number of ferry departures between the cities are reduced. These services could be integrated with existing ferry terminals and share the ground infrastructure, which would promote multimodality and reduce the need for additional infrastructure.

The transport system and its congestion issues in Helsinki region are insubstantial when compared to megacities. Helsinki has less wealth and more equal income distribution, and spatial planning is transit oriented and there is less existing infrastructure to support widespread use of air taxis. Based on the global estimates and realities of the land use and transport system in Helsinki, it is likely that there will be less than 20 vertiports in Helsinki at the end of the late 2020's. The potential for air mobility is larger, when Helsinki metropolitan area is considered, as the distances between urban nodes grow. An artistic illustration of passenger transport is presented in Figure 14.

Figure 14. An artistic illustration of future passenger transport in Helsinki.

Passenger transport impact potential in Helsinki

The most obvious early potential for passenger transport is to transport medical specialists between hospitals. Malmi Uusi Sairaala hospital in Helsinki now has a 24/7 anaesthetist available in case of emergencies which costs around one million euro per year to maintain. Such a specialist could be there with an eVTOL in a few minutes, flown in from another hospital. There are other specialists, such as neonatology which are seldom called upon, but who need to be available on a short notice. With air taxis, the number of medical specialists on duty could be reduced, at least for the part of the year, when the weather generally is flyable. Currently FinnHEMS is not performing these types of transports, but a less costly eVTOL could make the business case attractive. It is easy to see, that even a few eVTOLs could make an economic impact on the health care cost structure and medical specialist mobility in Helsinki.

Before Covid-19 Helsinki was the second largest cruise passenger harbour in the world. The pandemic brought cruise ship visits to a full stop. 2022 has seen the start of a recovery, but still only 162,000 international cruise passengers visited Helsinki during 2022 compared to 520,000 in 2018 (Port of Helsinki, 2023). Russia's invasion of Ukraine has also deterred Asian tourists from flying to Helsinki. The obvious use for air taxis would be to provide "Helsinki and Suomenlinna from the air" tours for the tourists. However, its advent is highly dependent on the tourist flows. The potential for air taxi rides to cover for slow public or car transportation in Helsinki is marginal, as Helsinki has little traffic congestion and well-functioning public transport connections to the harbours and to the airport.

Given the environmental challenges and the growing prices for energy, the economic potential is not obvious, despite the previous helicopter flights being the closest "predecessor" of urban air mobility. All combined, we expect the economic potential for UAM passenger transport to be concentrated to the medical domain and be valued at most a few million euros in the next few years.

Direct value of the airspace for the city

As described in section 0, the city cannot "own" the urban air space same way it owns land, as the Finnish airspace is regulated on a national level by LVM and Traficom. While direct monetization of the airspace is not possible, the city is expected to participate in the establishment and monitoring of U-space airspace. There could be monetization potential related to role of the city in the establishment and monitoring of the U-space airspace. It is more likely that the guidance and support the city can provide to UAM actors can provide indirect economic benefits.

City as a ground infrastructure provider

The main argument why the city should provide and operate UAM ground infrastructure is to ensure equal access to the city and an open market for all UAM service providers. Privately owned landing sites are unlikely to be open for competing air operators. If the city identifies internal UAM use cases that support its core activities and the use cases require landing infrastructure, the city could consider sharing the infrastructure with the private sector. Although this is contrary to current policy where the property owner is primarily responsible for providing sufficient infrastructure for parking, charging and maintenance services, providing landing infrastructure may provide revenue for the city if demand soars or international regulation mandates public participation. On the other hand, as the UAM sector is still developing, the city may want to see how the demand develops and let the private sector carry the risk associated with providing landing infrastructure early on.

As there are yet no established standards for landing infrastructure, the requirements for the infrastructure are driven by drone manufacturers. The infrastructure needs are concentrated on the areas where businesses and people reside. Furthermore, different business cases require different types of infrastructure. Considering that the need of infrastructure is in already built areas, the development of ground infrastructure is likely to be driven by vertical use cases. For air taxis, investment estimates have been presented by McKinsey (2022):

- Vertiports (for passenger drones, one to multiple landing pads) from 200 kEUR to 7 MEUR

- Charging infrastructure in tens to hundreds of thousands of euros

For **unmanned air operations**, while the city of Helsinki owns most of the land in the city, take-offs and landings do not require permission from the landowner. Instead, as most landing infrastructure is foreseen to be placed on buildings, the owners of the buildings will have negotiating power to allow or restrict operations at their facilities. This aligns with the current views of the city on how certain parts of the transport infrastructure costs and responsibilities should be split between the city and the real estate owners. This is also in line with how real estate owners are expected to plan for parking and service areas, instead of solely relying on public areas (roads, sidewalks etc.). However, it also means that real estate owners, and not the city, are in a key role for determining where and how landing infrastructure is established.

The city may still influence the decision making in two ways:

1. Frequent, commercial flight operations at a fixed location may disturb neighbours. In such a case, an environmental permit may be required for the activity.
2. The city owns a majority of the land in the city. The city may add conditions in land lease contracts for real estate owners regarding UAM operations.

For **manned air operations**, while vertiport certification regulation is yet to be written, a permit to build and to operate a vertiport is likely to be required by Traficom, who in turn will require that a vertiport is not in conflict with land use plans and does not cause harm to the environment.

There are global examples of helipad infrastructure operations but the business models and cost structures for UAM are different. The business case for eVTOL infrastructure operators has not been acid-tested, and industry development is still driven by private equity investments. The city could aim to channel revenues from landing infrastructure. The city (or a subsidiary) can lease or sell land, and require the owner to construct UAM infrastructure, such as a droneport or a vertiport.

City as a U-space service provider

U-space regulation for the first time includes the city in the decision-making process related to the airspace. The establishment and monitoring of U-space airspace gives the city more influence over the airspace and what type of requirements are set for UAM operation over parts of the city. The first version of the U-space airspace regulation does not include all of the foreseen functionalities of a fully automated traffic management solution, where drones are safely, smoothly, and quickly routed around each other. U-space technology is not yet fully mature. There are many different systems and services that need to developed and integrated. The first few years of U-space airspace will be suited only for low flight densities. Therefore, the advent of U-space airspace should not be understood to mean a step-change in the number of flights over a city. The growth of UAM will be limited until more advanced U-space services are available, and the EU U-space regulation is updated to include advanced U-space services in the second half of the 2020’s.

There exists no real benchmark for U-space airspace business cases. U-space system software licenses cost five to six-digit numbers of euros annually, whereas annual revenues from U-space early on are likely to be much smaller. International benchmarks (Norway, Poland, Switzerland, USA) indicate that it may take five or more years until service fees can be levied on occasional/hobby users, whereas professional drone operators can be expected to pay early on.

Thus, it is possible that U-space airspace will not be established without support from the public sector. In a forerunner role, the city could invest and become a U-space service provider and thus enable for example for medical drone deliveries, even if it is likely that the direct income from U-space service provision does not have a positive return on investment. However, the savings in the healthcare system might justify the investment.

City as a supplementary data service provider

UAM, as all of transport automation and new services, rely heavily on good-quality and real-time data. While there is a lot of open data available for Helsinki and the city is developing its digital twin, air transportation and U-space services require data that is not easily accessible today. The digital twin of the city could provide information on flight obstacles to U-space service providers and UAM operators, including temporary obstacles such as cranes. Other types of data can be used to ensure the safety of flight operations with regard to ground risk, such as dynamic information on planned gatherings of people, based on data from telcos or from public event notifications. Further, static information about areas suitable/not suitable for flight operations could be useful. For example, school yards and day-care centers can be “avoid” areas during the day but “allowed” areas by night. Other areas, such as suitable flight corridors could be marked as “preferred” areas. Even if such guidelines would not be mandatory for UAM service providers, the mere existence and availability of such guidance would most likely have an impact on UAM traffic in the city.

Some of the data envisioned may incur costs for the city, while some information is already collected and would only need to be consolidated and shared with UAM service providers. Different types of models for sharing data can be supported. Currently, the city provides most if not all its data free of charge based on the openness principle. A similar approach could be used for data needed for UAM. Free and open data is a policy choice and there could be other licensing approaches. Some of the data could be restricted (such as safety data) or licensed for a fee (for example real-time data, while history data is open and free).

Three scenarios for the involvement of the city

In this section, we describe three alternative scenarios for the level of involvement of the city. The scenarios are incremental and not mutually exclusive – the role of the city can be a mix of the roles introduced. The scenarios presented in Figure 15 are not biased or prioritized – they should be approached as scenario tools for strategic work by the city.

It should be highlighted that **doing nothing is not an option**. The cities will be part of the U-space coordination if and when such airspace is established within the the city. The city needs to have the competence to participate and understand the implications of UAM for city planning, safety, businesses, land use and the transport system to engage in a meaningful way. Further, the city representatives need to understand public acceptance aspects and have an overall working knowledge of UAM (such as noise considerations, visual pollution, ground safety, data needs, sustainability, environmental permissions and building permits for ground infrastructure).

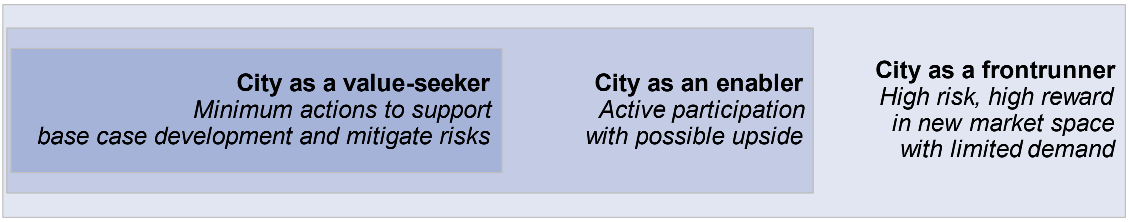

Figure 15. The three roles describe three different levels of involvement and describe the role of the city in UAM. Each scenario builds on the previous one and the scenarios are not mutually exclusive.

City as a value-seeker

If the city assumes the role of a value-seeker, the city or its subsidiaries will continue the use of drones as they do currently, following an organic growth path. New use cases are introduced based on verified positive cost-benefit impacts elsewhere. Private sector use cases are purely market driven and developed in cooperation between private sector entities. Main market growth is expected from aerial operations and cargo categories, in both B2B and B2C use cases. Examples of possible use cases for the city or its subsidiaries are:

- Digital twin development and real time situation awareness in Vuosaari harbour, less waiting time for trucks,
- Traffic monitoring and traffic counting,
- Delivery of blood and laboratory samples to aid consolidation of laboratory and blood bank services,
- Inspection of road infrastructure for maintenance optimisation,
- Inspection of buildings for elimination of heating insulation leaks.

As most of the use cases are related to aerial operations, the ground infrastructure needs are limited. In cargo operations, the land infrastructure is handled by the cargo drone operators or by privately owned logistics hubs. Property owners are responsible for accommodating and maintaining the required landing/parcel handling infrastructure. Any integration of UAM with other modes of transport should happen within the properties and use of public spaces should be avoided.

In order to participate in the UAM and U-space coordination, the city establishes a multi-disciplinary team as a contact point for UAM-related issues and builds core UAM skills and capabilities such as:

- Business development/economics,
- Noise regulation, environmental permits,
- Land use and transport planning,
- Transport data for UAM, such as flight obstacles (static and dynamic).

The city participates in the U-space airspace coordination mechanism to ensure that its prime interests are looked after. To ensure this, the city needs competence on the UAM issues listed above. As noted by the European strategies and guidelines, the role of the city is to act as a representative for its citizens and to ensure safety, accessibility, and fair use of public space. The city collects feedback from citizens and businesses to be shared with aviation authorities:

- Noise and visual pollution complaints,
- Public acceptance,
- Construction that may impact aviation, such as planned high-rise buildings.

As the city does not actively promote use cases in the private sector and it lacks the regulatory authority to restrict the use of the airspace, most of the UAM development happens within the private sector, which may cause complaints from the citizens. Noise permissions and building permits can impose some limits on the operations. Further, the city can list areas for safe/unsafe operation and areas to avoid as a soft policy and present the results to Traficom during the U-space coordination process. As several U-space airspaces can be established and they are regularly updated, the processes need to be continuous.

The unmanned air modules (UAM) market is driven by individual use cases both within the private and public sector without the city taking any role in market development or in providing ground infrastructure. The city benefits directly from the use of UAS in its own departments either through lower operating expenses or through improved services. Direct benefits of UAM can be quantified if the city maps their internal use cases and tracks the financial impact.

The city also benefits indirectly from UAM, through increased efficiency in the private sector (for example, better situational awareness in the construction industry leads to better efficiency in building activities and less traffic disturbances due to leaner operations) and the UAM ecosystem grows when new companies enter the market to provide infrastructure, vehicles or services and the economic growth yields more tax revenues for the city.

City as an enabler

If the city takes a more active role in the UAM ecosystem, the city follows the example of other cities, how the market and regulation develop and adopts best practices from frontrunner cities even if the use cases are not thoroughly acid-tested and there are some financial risks related to them.

The city or its subsidiaries and stakeholders use drones for many aerial operations, such as building inspections and street monitoring. Current users explore the possibilities of operations with a range past the operator’s line of sight, healthcare services being a top priority. Test projects together with private stakeholders help understand costs and benefits.

The city creates clear guidelines for public and private sector use of UAM vehicles. The city makes dynamic digital data freely available to help operators plan missions for minimum negative effects and maximum benefits in the city. The city creates a publicly available UAM advocacy priority list and actively engages in the establishment and development of U-space airspaces. Early involvement in the UAM ecosystem allows the city for more negotiating power and soft policies to steer the development of UAM in Helsinki.

While the city does not actively invest in the market, the city guides and enables development of UAM in both private and public sectors. The city considers UAM in the city plans for new industrial, business, and residential areas, which are suitable for UAM based on a combination of demand, noise, and safety perspectives.

The market is mainly driven by private sector companies. The establishment of and service provision in U-space airspaces is handled by the private sector, with full support from the city. U-space airspaces will be applied for in Helsinki. By reaching out to the ecosystem early on, the city has the opportunity to guide the development in line with the rest of the development of the city.

The city can support UAM and U-space services by providing or procuring data, such as:

- Crowd data from telcos and on live events (concerts, marathons, demonstrations, …) to ensure drone operators can avoid large gatherings of people,
- 3D digital twin for obstacle avoidance (already in development),
- Geospatial data on areas sensitive to noise, schools, day-care centres, nature reserves and other areas which should be avoided,
- Geospatial data on areas particularly suitable for UAM operations “corridors”,
- GNSS/GPS (positioning) accuracy maps.

Support from the city lowers the barrier for entry for any sector to deploy drones socially and environmentally sustainably at scale. Supporting UAM operators with data lowers the barrier for market entry. The city benefits only indirectly through taxes or directly if it can utilize drones to improve the quality of city’s service or cut costs. Lowering the barrier for entry could give the city a first-mover advantage, which attracts investments in the short-term with the expectation that later the ecosystem would be self-sustained. For direct benefits, the city must analyse its value chains and identify which aspects could be improved with UAM solutions.

In order to enable a diverse use case portfolio, the city should manage public acceptance and ensure that the use cases serve the common good and support sustainability goals.

City as a frontrunner

In the last scenario, the city seeks to become an active investor in and promotor of UAM services. The city stimulates demand by publishing public, multi-year procurements for UAM enabled service production as well as encouraging its own departments and subsidiaries to embrace UAM services.

The city takes the initiative to establish U-space airspace and produces or procures U-space service provision for its U-space airspaces. Access to U-space airspace is initially free for users, with the understanding that the city will expect payback on a 5–10-year horizon either through direct fees or indirectly, based on lessons learned from the deployment of U-space airspaces and UAM services elsewhere. The revenues and costs related to U-space services are unclear, which creates a financial risk if the city acts as the U-space service provider. Other actions could include operating landing infrastructure or providing valuable data for the U-space service provider or UAM ecosystem stakeholders, as described in Section 0.

As a frontrunner, the city is likely to encounter issues with emerging drone service providers without solid experience from UAM operations. Cooperation with national authorities is necessary, but the city has its own and ambitious advocacy agenda. The city seeks to influence the development of European and national guidelines and regulations to align with its ambition. With investments in know-how, advocacy, and strategic enablers such as U-space airspace and participation in national and European development projects, the city has a large influence on what type of operations will emerge and where. Close and early cooperation with the private sector allows the city to push market development in the desired direction as the city can use "soft" policies instead of "hard regulatory" restrictions. If the city procures UAM services, it can accelerate the market development and grow the UAM ecosystem in Helsinki and in Finland.

While the frontrunner role may grow the UAM ecosystem, there is still limited demand for UAM in Helsinki. Largest benefits occur if services can be exported by the ecosystem. Risks can be minimised by actively collaborating with partner cities and proactively importing lessons learned.

From a sustainability perspective, it is important to identify use cases that promote sustainability. While new and innovative air vehicles are built on the zero-emission principle, they increase energy consumption and raw material use. A clear strategy and cooperation between different stakeholders are needed to ensure efficient use of the fleet across different modes of transport.

Being a frontrunner and actively promoting diverse UAM use cases increases the need for managing public acceptance and monitoring the effects of UAM. There can be more clashes between authorities, private organizations, and citizens. Public acceptance might limit viability of some use cases, or some services may be cancelled, for example due to complaints about noise, which leads to revoking the environmental permit.

Integration of UAM into existing transport system and the role of Kivikko in UAM

The city of Helsinki is currently planning a heliport in the Kivikko industrial area, ten kilometres north-east from the central business district to allow helicopter operations in Helsinki after the closure of Helsinki-Malmi airport. Currently, the Urban Environment Division has the authority to include it in the zoning plan. There is currently no dedicated area for commercial helicopter operations in Helsinki.

In the current regulatory landscape, there are no regulatory limitations to allow using Kivikko also for UAM traffic. While the regulation and requirements of UAM are still evolving, it is clear that new eVTOL air vehicles require less obstacle free space around the take-off and landing platform compared to helicopters, especially when it comes to smaller vehicles. Also, UAM vehicles have a significantly lower noise profile than traditional helicopters, reducing the need to place landing sites in remote areas. Current legislation requires human carrying air vehicles to use designated take-off and landing areas; in most use cases non-human carrying air vehicles are used and using designated sites like Kivikko is not needed. Especially aerial operations will likely use a variety of take-off and landing sites and cargo operations need to be integrated with warehouses to ensure efficient operation.

When asked about the planned Kivikko helipad, interviewees could not mention any particular benefit from it and highlighted some operational challenges. The heliport would reside on the final to runway 15/33 of Helsinki Airport. While 15/33 is seldom used for noise abatement reasons, it is sometimes the only available runway in windy conditions. The heliport would potentially interfere with the safety procedures, and if active, making operations from runway 15/33 difficult.

While there are no technical obstacles for UAM vehicles to share the heliport, Kivikko as a location is seen as being detached from other transportation infrastructure and service demand. Regarding passenger traffic, it would be more natural to locate UAM vertiports at Helsinki Airport, or near the sea and harbours in Helsinki, allowing passengers to arrive directly at traffic nodes instead of a somewhat remote location. However, given that certification rules for human-carrying vertiports may emerge only in 2027, Kivikko may play a role in air taxi trials or early operations until certified vertiports can be established on a walking distance from mobility hubs, for example on rooftops.

One of the main challenges and requirements for beneficial UAM use cases is tight integration with existing transport system. In Kivikko, this can be achieved only to a limited extent. While

Kivikko is an industrial area, there is little demand for UAM services nearby or possibilities to efficiently integrate UAM cargo service with warehouse operations. Indeed, one of the base assumptions for UAM is that landing sites are located at or on top of locations of service demand.

If UAM traffic volumes grow moderately and there are no issues with public acceptance, strong actions from the city might not be needed in terms of transport integration. The current policy of the city is to push real estate developers and property owners to ensure sufficient space is reserved for serving the properties. This policy should steer the UAM market towards integration of the services, instead of relying on using the public space for ground infrastructure. Space is a rare commodity in the city and there is already demand for public spaces in the most populated areas. If drone cargo deliveries grow rapidly there may be challenges related to the integration of ground infrastructure if landing areas are placed in public areas. In less populated areas of Helsinki, it could be possible to plan for future needs by considering the spatial needs of the ground infrastructure in city planning and zoning. All in all, the overall mobility plans and strategies should include guidelines for UAM to ensure equal treatment between modes of transport. If passenger services emerge (outside of health care sector use cases, which can utilize infrastructure existing already), the ground infrastructure should be integrated with existing transport nodes, such as utilizing ferry passenger terminals or other mobility hubs.

Conclusions

Drones are already commonly used in today's Helsinki. An estimated 30 000 flights were completed last year within the limits of the cities. Most of these were conducted within visual line of sight of the pilot.

Urban Air Mobility applications are starting to emerge. UAM has the potential to create a new 20–80 MEUR service market in Helsinki, mostly from increased use of aerial operations category of use cases, but with a significant part in the healthcare sector. Flights beyond the line of sight of the pilot operations will improve work efficiency for aerial services, whilst transportation capacity is expected to emerge in the near future for medical applications including emergency medical services and shortly after also for B2B and B2C logistics. Human-carrying flights are expected to become a reality in limited volumes towards the end of the 2020's.

BVLOS operations and air taxi flights always require a flight permit from the aviation authorities. Apart from permissions related to the establishment of human-carrying vertiport landing sites, the city is not formally part of the flight permit and safety assessment process. Airspace is managed on a national level with the city being heard only in matters related to the establishment of U-space airspace. Nonetheless, the city has several ways to influence the advent and growth of UAM:

Possibilities for the city:

Roles and responsibilities

- Build internal competence in UAM and U-space to be able to engage with both aviation authorities and with the UAM community.
- Assign a clear contact point(s) where citizens and UAM stakeholders can engage with the city. The role of the city is crucial in citizen communication and a catalyst for public acceptance and adoption of UAM services.
- Create a UAM advocacy agenda to be promoted both in Finland and towards EU.

Investments

- Stimulate the market by encouraging city concern units to procure UAM services.
- Promote or drive the establishment of U-space airspace in Helsinki.
- Invest in shared vertiports for people-carrying operations within at most a few minutes walking distance from main traffic and mobility nodes.

Clear guidelines for public and private sector use of UAM vehicles

- Make data on areas to avoid and prefer openly available, ideally with applicability times, similar to parking zones, which have validity times separately for weekdays, Saturdays and Sundays.
- Make data on ground risk elements available, be they static (e.g., schools, daycare centres, sports fields) or dynamic (gatherings of people that require a permit).
- Ensure UAM plans are and remain aligned with the city's sustainability objectives.
- Include UAM space and access reservations in new real estate permits.

The study found no obvious synergies between the planned Kivikko heliport and future UAM traffic, as UAM landing infrastructure is expected to be placed on top of or at locations where the mobility demand originates. Kivikko is not located close to any clear UAM demand.

Further studies are recommended on:

- Public acceptance of UAM
- Potential for the use of drones supporting the delivery of services provided by the city of Helsinki or its subsidiaries, including healthcare / HUS, urban planning and transport planning divisions, Stara, and Port of Helsinki.
- Qualifying the market size of UAM drone services in Helsinki
- Sustainability of UAM and IAM, including electrical and other low-emission aviation.
- The development of urban policy in Europe and experience exchange with other cities.

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