Urban Air Mobility: A State of Art Analysis

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Abstract. Urban Air Mobility (UAM) is an aerial component of urban mobility system which integrates an emerging transport mode, Unmanned Aerial Vehicles (UAV), also known as drones, into multimodal urban mobility context. UAM has potential to bring new services related to both passengers and logistic/freight mobility (like passenger carrying air taxis or small package delivery drones) as well as enable better resilience in emergency situations resulting due to various causes (for example, traffic accidents, traffic congestion, catastrophic events and others). Such new services, accelerated thanks to the recent introduction of Vertical Take-Off Landing (VTOL) capable vehicles, able to need less air space to take-off or landing, have the possibility to transform the way people move within, around and between urban areas by shortening commute times, bypassing ground mobility congestion and enabling specific and oriented point-to-point flight across the cities. As currently the UAM integrations are still hindered by a number of constraints, in this paper we provide an overview of UAM legislative frameworks, with particular focus on European Union (EU), together with the overview of the most relevant UAM case studies and the potential new UAM services.

Keywords: Urban Air Mobility · Sustainable mobility · Passenger mobility · Logistic and freight delivery

1 Introduction

In recent years, Unmanned Aerial Vehicles (UAV), also known as drones, have gained much relevance. The initial applications of UAV technologies included a somewhat limited number of tasks, such as aerial photography or mapping, that were either costly or inconvenient to be performed using traditional aerial vehicles. However, with the advances concerning the payload of UAVs and relevant technologies, the number of possible applications have rapidly expanded paving the way for future UAV based services. This is even more highlighted in the context of a number of catastrophic and

© Springer Nature Switzerland AG 2021
O. Gervasi et al. (Eds.): ICCSA 2021, LNCS 12950, pp. 411–425, 2021.
https://doi.org/10.1007/978-3-030-86960-1_29

emergency events (due to climate change, to the recent pandemic and other causes). Hence, it has become evident that UAVs will make up an increasingly relevant component of the mobility system, when it comes to transportation of both fright and humans, in the years to come.

Nonetheless, the initial pilot studies and demonstrator use cases indicate that there are still a number of challenges associated with the wider adoption of UAV based services. For one, UAVs will need to fit into existing, both ground and aviation, systems to ensure ongoing safety and public acceptance. These systems have been established for a while and are underpinned by a number of regulations and standards, which are reflected in international conventions, national legislations, regulations, and practices. Integrating UAVs services and operations into these systems without compromising the safety or security will present a significant challenge for many years to come. This is especially pronounced in urban areas where UAVs represent Urban Air Mobility (UAM) component of urban mobility system, characterised by densely populated areas and highly interlinked mobility system networks and human and freight mobility patterns. Associated challenges as legal and regulatory, environmental, certification, public perception and infrastructure constraints become even more evident in such context, hindering the potential use and future development of UAM.

In order to support ongoing UAM development efforts, in this paper, we provide an overview of UAM legislative frameworks, with particular focus on European Union (EU). This section is followed by the overview of the most relevant case studies, starting from inter-governmental urban air transport collaborative programmes and continuing with the analysis of the individual national, regional or local applications, within the EU and wider. This is followed with the brief discussion on UAM and potential new UAM services.

2 Legal and Regulatory Assessment

As the EU agency responsible for regulating air operations and aircraft airworthiness certification, the European Union Aviation Safety Agency (EASA) has initiated a rule-making process which as a goal has regulated VTOL aircraft use in both production and operations, through development of regulatory building blocks to enable safe VTOL operation and new air mobility in Europe. The first building block is a complete set of dedicated technical specifications in the form of a special condition for VTOL aircraft. *This special condition addresses the unique characteristics of these products and prescribes airworthiness standards for the issuance of the type certificate, and changes to this type certificate, for a passenger-carrying VTOL aircraft in the small category. Certification with this small category Special Condition applies to an aircraft with a passenger seating configuration of 9 or less and a maximum certified take-off mass of 3 175 kg (7 000 lbs) or less.*

As a part of the work on the second building block, in 2020 the EASA has published the Proposed Means of Compliance with the Special Condition VTOL *to address the applicant´s requests for clarification of EASA's interpretation of these objectives and of possibilities how to demonstrate compliance with them.*

As a part of work on the third building block, also in 2020 the EASA has published proposed methods on how to certify hybrid or electric air taxis (VTOL) [Ref.]. *This*

Special Condition has been developed to support Applications received by the Agency for the certification of Electric and / or Hybrid Propulsion Systems. This Special Condition is articulated so as to provide objective based certification requirements which are independent of the propulsion system design or architecture. The type of technology used in the propulsion system will be addressed in the Acceptable Means of Compliance.

3 Actual UAM Application State of Art

In this section, we describe the application of UAM regarding both passenger mobility than logistic/freight mobility cases and relative to daily mobility or emergency services. The description is divided in two part: a first one describes the inter-governmental urban air transport collaborative programmes while the second part describe briefly some case studies dividing them for geographical area, starting from European Case Studies [3] and 'navigating' the rest of the world through Far East and Australasia, America and Middle East.

3.1 Inter-governmental Urban Air Collaborative Programmes

At european level, starting in May 2018, the European Union's Urban Air Mobility (UAM) Initiative, supported by the European Commission[1], brings together cities and regions, citizens, industries, SMEs, investors, researchers and other smart city actors to join a unique partnership. This initiative is part of the European Innovation Partnership in Smart Cities and Communities (EIP-SCC) and it is aligned with ongoing and future SESAR Joint Undertaking (SESAR JU) funded studies, including demonstrations, on drone traffic management in Europe moving one step closer towards the European Commission's U-space vision for ensuring safe and secure access to airspace for drones. With demonstrable benefits to citizens and their approval, developing a market for drones and drone services will create jobs and growth in Europe. Particularly in urban areas, civil drones could be a way to address mobility needs such as emergency needs and traffic congestion; the latter currently costs more than €100 billion a year in the EU alone.

In June 2018, the EU gave the European Aviation Safety Agency (EASA) new powers to set EU-wide rules for urban air mobility. Following EASA: "The so-called new Basic Regulation formalises EASA's role in the domain of drones and urban air mobility, enabling the Agency to prepare rules for all sizes of civil drones and harmonize standards for the commercial market across Europe", covering the full spectrum of aviation landscape with the possibility for EASA and European Member States to work closer together in a flexible way.

[1] Commissioner for Transport Violeta Bulc said: "Drones offer exciting opportunities for new services and business models, particularly in our cities. At the same time we need to ensure that drones operations taking place above our heads are safe, secure, quiet and clean. In that regard, the Urban Air mobility initiative is an important demonstration project involving several European cities to address these challenges and plan for the future. It will also contribute to the EU's U-Space, which is a flagship project of the European Union to manage air traffic at low level.".

In February 2018, the UK NESTA Challenge Prize Centre foundation, that designs and runs challenge prizes that help solve pressing problems that lack solutions, organizes a challenge involving five cities (Bradford, London, Preston, Southampton and the West Midlands) to design how drone technology can be used to support their local needs. In September 2018 NESTA published a research on the potential market of drones in the UK elaborated inside the Flying High project underlining the enormous prospects for future commercial development.

In October 2019, the European Commission and the European Investment Bank (EIB) announced the launch of a "European Drone Investment - Advisory Platform" to support innovation and investment in drones. The initiative aims to improve access to EU support in this field, and to develop a better understanding of the market to improve investment in this emerging field.

Going in the world far-east side, the Japan Prime Minister, in 2017, designs the "Road for the Aerial Industrial Revolution" with a japanese UTM consortium to create a new industrial drone innovation space with communication and collision avoidance technologies with the possibility to incorporate japanese systems into 'international standards" like the NASA's UTM.

In 2018 the Civil Aviation Authority of Singapore - CAAS, the EASA and Airbus have agreed to develop together safety standards and regulatory requirements for unmanned aircraft systems (UAS) in urban environments. The MoU established a framework for the expert knowledge exchange as well as operational and technological assessments for the deployment of UAS in urban environments, such as last-mile deliveries or safety information and learning outcomes from the applied trials.

Moreover, in February 2018, Singapore Government designs the One-North R&D hub to research about the application of drone in urban areas and for test-bedding innovative UAS technologies. Airbus, ST Aerospace and NTU's Air Traffic Management Research Institute have soon come on-board of the One-North drone research.

Finally, going in the American continent, in 2017 the U.S. Department of Transportation (USDOT) and the Federal Aviation Administration (FAA) have launched the Unmanned Aircraft System (UAS) Integration Pilot Program (IPP) to test and evaluate the integration of civil and public drone operations into national airspace system. The IPP Lead Participants evaluated operational concepts and possibility, including night operations, flights over people and beyond the pilot's line of sight, package delivery, detect-and-avoid technologies and the reliability and security of data links between pilot and aircraft. Fields that could see immediate opportunities from the program include commerce, photography, emergency management, agricultural support and infrastructure inspections.

The IPP program ended in October 2020 and, to continue work on the remaining challenges of UAS integration, the FAA launched a new program called BEYOND in the same month. The challenge areas to study in the program regard the Beyond Visual Line of Sight (BVLOS) operations that are repeatable, scalable and economically viable with specific emphasis on infrastructure inspection, public operations and small package delivery, the leveraging industry operations to better analyze and quantify the societal and economic benefits of UAS operations and Focusing on community engagement efforts to collect, analyze and address community concerns.

The DriveOhio Research Program is a partnership started in 2018 between Driveohio's UAS Center and the Ohio State University College of Engineering. The Program foresees the experimentation on 33 road corridors of traffic monitoring with drones, with an experimentation of communication between air and ground vehicles/ITS sensors. Unmanned aircraft will monitor traffic and accident response along the corridor in conjunction with the state's current fixed-location traffic camera system, so interacting with sensors and communication equipment along the corridor to feed data into the Traffic Management Center.

Nasa's Aeronautical Research Mission Directorate (ARMD) in 2018 has updated its strategic plan to also include research regarding Urban Air Mobility. It started with a consultant's research on Urban Air Mobility Market Study [1] describing legal and regulatory assessment, societal barriers, weather barriers, air-shuttle and air-taxi market analysis and air ambulance. In 2019 NASA has signed Space Act Agreements with 17 companies in the aviation industry to advance plans for the first in a series of technology demonstrations known as the Urban Air Mobility (UAM) Grand Challenge (see Challenge framework in Fig. 1). The final results are expected in 2022.

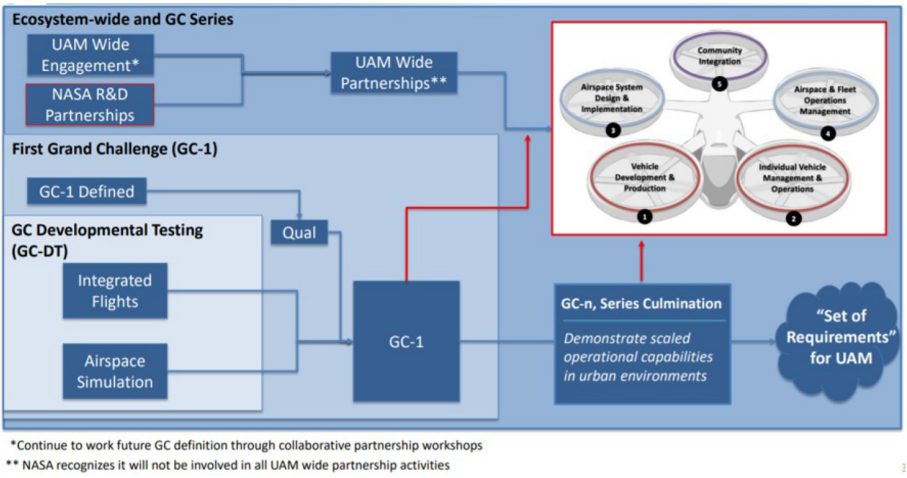

Fig. 1. Partnership and grand challenge series overview ([1]) source

3.2 Worldwide UAM Case Studies

Some recent UAM case studies are summarized in Tables 1 and 2 dividing european from extra-european applications (all cases relate to the period 2017–2021). In these tables, the general safety and flight infrastructure testing cases have not been included as well as cities that joined the UAM, the NESTA or other initiative but only cases regarding application of future UAM services [2, 4, 5, 8–11].

Moreover there are three cross-border area partnerships regarding respectively:

- France-Belgium cross-border region between Kortrijk (Belgium) and Tournai and Lille (France);
- Euregio project between Enschede-Netherlands and Munster-Germany, experiment the use of UAM in the field of emergency services for public safety;
- MAHHL (Maastricht and Heerlen-Netherlands, Aachen-Germany, Hasselt and Liege-Belgium).

Table 1. Some European UAM case studies (O = operative applications)

Country	Area	Field	Description
Austria	*Linz*	*Vehicle technology*	*Trail flights to evaluate the implementation in urban areas*
Belgium	*Antwerp*	*Security*	*Drones to monitor by the local police*
	Antwerp	*Health*	*Medical supplies transport by drone*
		Port	*Drone for surveillance flight (terminal container and oil spill inspection)*
		Civil	*Drone for high voltage line mapping and pylon inspection*
	Bruxelles	*Emergency*	*Drones for emergency services*
	Ghent	*Health*	*Ambulance drone application*
	St Truiden	*Many*	*The area is a 'drone port' to conduct tests in dedicated area*
Estonia	*Tallinn*	*Logistic*	*International drone flight between Tallinn and Helsinki*
Finland	*Helsinki*	*Emergency*	*Create a temporary flight restriction area around an accident scene*
		Logistic	*Wing Company start delivery goods with drone based on an App-O*
	Gulf of Finland	*Passenger/Security*	*Maritime traffic surveillance and drone taxi flight from airport to city*
France	*Nouvelle- Aquitaine*	*Many*	*Air goods delivery, tourist transport (based in Bordeaux city) or to cover needs of isolated people*
	Paris	*Vehicle technology*	*Test area at Pontoise-Cormeilles-en-Vexin airfield, starting in summer 2021. Focussing on 5 areas: vehicle development, ground infrastructure, airspace integration, operations and public acceptance*
	Toulouse	*Many*	*Drone and remote sensing for environm. Monitoring appl., urban services (traffic manag., air quality or infrastr. Monit.), emergency and logistic services*
Bulgaria	*Plovdiv*	*Many*	*Public transport, ambulance services, public safety and small rapid goods del*
Germany	*Bad Neustadt*	*Logistic*	*Drone delivery of pizza-O*
	Northern Hesse	*Logistic*	*Logistic across the airports chain of Kassel Calden and Frankfurt am Main*
	Frankfurt	*Passenger/Logistic*	*Airport Fraport AG start developing ground infrastructure and operations for air taxi service and drone for operational airport purpose*
	Hamburg	*Many*	*Emergency medical delivery, large infrastructure inspection (for ex. Bridges, turbines)*

(*continued*)

Table 1. (*continued*)

Country	Area	Field	Description
	Ingolstadt	*Health/ Passenger*	*Pilot programme for air taxi and organ transport*
		Logistic	*Drones on the national railway network to record storm damage or vegetation on the tracks-O*
	Munich	*Passenger*	*Air taxi from airport's labcampus to the city center (Lilium, 2020)*
Iceland	*Reykjavik*	*Logistic*	*Aha and Flytrex food delivery-O*
Italy	*Rieti*	*Many*	*Drone to parcel delivery, road traffic patrol, professional photography, railway and power lines monitoring, search and rescue, airport operations and firefighting*
Switzerland	*All Country*	*Passenger*	*Air taxi to develop last mile trips from railway stations to destination*
	Berne, Zurich, Lugano	*Health*	*Drone to bring goods and bloods from laboratory to hospital*
	Zurich	*Logistic*	*Drone delivery of e-commerce goods*
The Netherl	*Amsterdam*	*Logistic*	*Domino uses drone for pizza delivery*
	Leiden	*Passenger*	*Airbus forms Airbus Urban Mobility division with the ambition to offer passenger drone flights at a cost that is competitive with traditional ground taxi service (Downing, 2019; Airbus, 2020)*
United Kingdom	*London*	*Logistics*	*London residential complex implements rooftop "vertiports", encouraging drone delivery services (Stouhi, 2019)*
		Civic/ Safety	*Drone for safer infrastr. Inspections and for the capital's emergency services*
	Cambridge	*Logistics*	*Amazon carried out its first successful drone delivery operation (2016), unveiled the latest version of its Prime Air delivery drone and announced the intention to launch a delivery service using drones (Vincent and Gartenberg, 2019)*
	Bradford	*Safety/ Health*	*Drones To Help Disaster Response, Digital Health, Surveying And Community Safety*
	Oxford	*Many*	*Drone-based services to include roof and building surveying, land mapping, aerial photography and filming*
	Preston	*Civil*	*Drone for utilities and building inspection (O) and exploring its use for flood management and road networks upgrading*

Referring to the MAHHL cities (see Fig. 2), they consider better transport and logistical connections within the region as well as better connections to cross regional transport hubs with the use of drones and Air Taxis. A roadmap considering the inclusion of the mobility plans within the cross border region of the different aircrafts has been created at the official kick-off-event. The map focuses on the inclusion of UAS in rescue missions, transport of medical goods as well as transporting medical specialists. The Institute of Flight System Dynamics currently works on many projects according to the roadmap. One already finished project is GrenzFlug, where in cooperation with the

city of Aachen, the first fully automated cross border rescue mission has already been performed recently. Currently further projects for supporting rescue workers within the region are VISION and FALKE. The project SafirMed which started in December 2020 focusses on transporting medical goods.

Several European projects specifically focus on application of UAM for emergency applications. AiRMOUR project focuses on the use of UAM for doctors and medical supplies, in order to develop a UAM toolbox for aviation and urban authorities. The project includes the cities of Luxemburg (simulations), Stavanger, Helsinki and Nord-Hessen (demonstrations). The main objective of MOBNET project is to locate isolated victims during natural disasters and situations of emergency such as earthquakes, hurricanes or large snowstorms. MOBNET will also help first responder services to find lost people in general. AMBULAR has a different focus, with the goal of developing an eVTOL air ambulance. SAFIR-Med (Safe and Flexible Integration of Advanced U-Space Services for Medical Air Mobility) aims at real demonstrations in collaboration with hospitals, focusing on demonstrating the operational safety level.

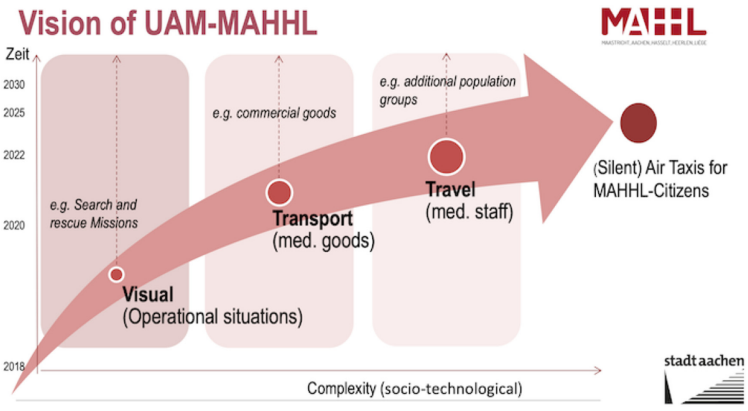

Fig. 2. Partnership and grand challenge series overview ([1]) source

Moreover, in the CASCADE project, started in 2018 and always ongoing, a partnership of five english universities (Bristol, Cranfield, London, Manchester, Southampton), are implementing some case studies, described in Fig. 3 (to which we need to add two recent ones related to the deliver NHS supplies to the Isle of Wight and to the ojin of machine-learning and drone technology to monitor populations of the Critically Endangered Kordofan giraffe at Bénoué National Park):

All the previous case studies show that there is a growing demand for urban services based on air mobility worldwide. In particular, the use of drones sees most of the current applications, with a more mature market, like for operative services regarding private distribution logistics. Applications relating to passenger transport are almost exclusively in the field of experimentation due to the greater complexity of both application and legislation (laws and regulations).

Significant legal and regulatory, weather, certification, public perception and infrastructure constraints exist to date. High service cost is a severe limitation, especially for

Table 2. Some extra-European UAM case studies (O = operative applications)

Country	Area	Field	Description
Australia	*Camberra Logan*	*Logistic*	*Wing Company start delivery goods with drone based on an App - O*
Brazil	*Sao Paulo*	*Passenger*	*Helicopter to bring people out from urban congestion*
Canada	*Calgary*	*Civic*	*Drone to collect mapping data for urban plan*
	Québec	*Vehicle technology*	*Trail flights*
China	*Muyang*	*Health*	*Drones equipped with speakers are being used to criticize people in public without a Covid19 mask*
	Hezhou	*Security /logistics*	*Transport of medical supplies and personnel*
	Shanghai	*Logistic*	*Drone to delivery food for 100 local restaurant on 17 different routes*
	Dongguan, Guandong	*Logistic*	*DHL uses a drone landing on an intelligent cabinet for delivery service*
Japan	*Changsha and Hohhot*	*Logistic*	*JD.com with Rakuten to use drones and UGVs in unmanned goods delivery service*
	Fukushima	*Security*	*After fukushima earthquake, unmanned flying vehicles were used to explore the disaster site, and specifically the nuclear plant*
Jordan	*Dead Sea*	*Security*	*Drone for the arab league summit to ensuring security of world leaders*
Mexico	*Ensenada*	*Security*	*Drone for daily police surveill. With a 10% decrease in crime and 30% reduction in home burglary after six-months pilot application-o*

(*continued*)

Table 2. (*continued*)

Country	Area	Field	Description
New Zealand	*Canterbury, Queenstown*	*Passenger*	*Air-taxi into the air-navigation service*
	Tararua	*Logistic*	*Drones to capture images of slips in the district's network of rural roads and where streams have scoured their banks to threatening roads*
Pakistan	*Karakoram Mountains (Himalayas)*	*Security*	*Application of a drone to locate and rescue a lost mountainier*
Singapore	*All Country*	*Many*	*UAS for solutionsas surveillance, inspection, package and marittime deliv*
South Korea	*Seoul*	*Logistic*	*Drone for disaster monitoring and logistic transport*
Turkey	*Zigana mountain region*	*Security*	*Experiment for use of drones in searching and location victims in a mountain area*
United Arab Emir	*Dubai*	*Many*	*Air-taxi service, drone delivery and traffic surveillance to incident detection*
USA	*Virginia*	*Logistic*	*Wing Company start delivery goods with drone based on an App - O*
	North Carolina	*Health*	*Drones to monitor residents' adherence to imposed protection measures (Covid-19)*
	Nevada	*Health*	*UAS to time-sensitive delivery of life-saving medical equipment (defibrillators for example)*

(*continued*)

Table 2. (*continued*)

Country	Area	Field	Description
	Florida	*Agricult*	*Low-altitude aerial applications to control/survey the mosquito population*
	Calif./NY	*Security*	*UAV for police search and rescue operations or access hard-to-reach crime scene*
	North Dakota	*Many*	*UAS to linear infrastr inspections, crop health monitoring and emergency response*
	Ohio	*Logistic*	*Drone commercial delivery services - O*
	California	*Passenger*	*Uber is trying to develop air-taxi with four-seats*

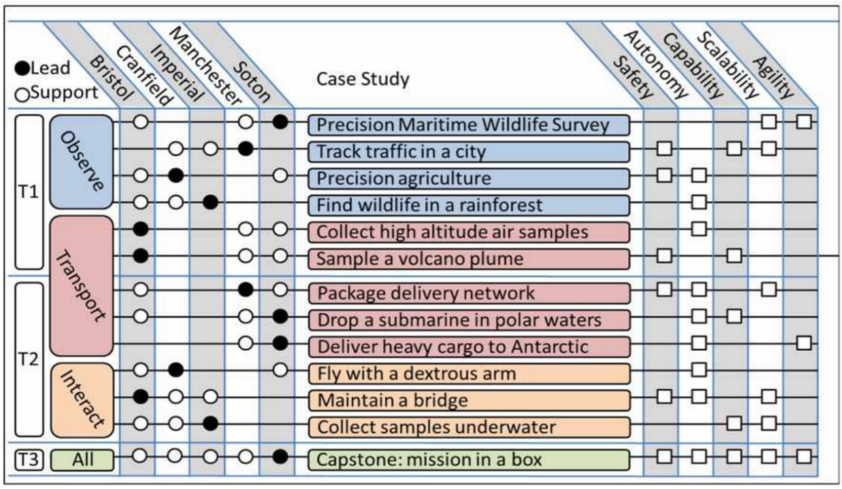

Fig. 3. Cascade project case studies ([6, 7]) source:

passenger transport where also problems due to weather events are bigger (both from damage than comfort side). Current battery technology creates a barrier like also battery weight and recharging times. Moreover noise introduces an environmental impact that could affect community acceptance. Other problems are lack of existing infrastructure, the habit of using traditional transport modes, the competitions of other innovative mobility (electric and autonomous cars for ex.).

4 Impacts of UAM on Sustainable Mobility

In general UAM case studies include application at different scales, depending on the support and services involved going from local areas, like port application, city center areas, to suburban/edge city areas and to inter-urban areas.

The following table presents **all potential UAM applications** coming from the case studies analysis (Table 3).

The case studies analyzed underline different UAM scopes:

- Decongestion of road traffic;
- Improve mobility level of services;
- Reduce transport time;
- Decrease pollution;
- Reduce strain on existing public transport networks;
- Reduce traffic accidents;
- Improve capacity of smart city management;
- Improve city security (decrease in crime and home burglary).

The use of drone has generally shown, in respect to classic mobility means, the following advantages:

- Cost reduction;
- Increase flexibility, e.g. to reach less accessible areas, more robust in case of infrastructure deficiency;
- Decrease of atmospheric mission;
- Highest planning reliability;
- More suitable for transport of small parts;
- About 5% of the maintenance costs of a car;
- 80–85% of energy-saving compared to electric cars;
- Decrease in transportation time (about 75%);

The exact evaluation and measurement of these impacts is however complicated by various considerations:

- The reduction of emissions is valid in the local context, but should also be considered on a more global level (e.g. include impact of energy production) and on a lifecycle basis (e.g. include battery production, replacement and recycling);
- Also the infrastructure required for a UAM system needs to be considered: hub stations, charging locations, maintenance, …
- Many aspects are largely depending on the local context and the exact design of the system (number and density of hubs), the vehicle properties (battery capacity, charging time, weight capacity) and regulations (e.g. which trajectories are available for flights, are trajectories combined with flows of motorized traffic, …)
- Large fleet sizes may be needed to obtain a system, which is economically viable. Similarly, large numbers of UAM flights (and thus fleet size) are needed to realize significant impact on e.g. urban congestion level. This also raises questions on the potential capacity of an urban UAM system.

Table 3. Potential UAM markets

Category	Potential UAM case study	Type
Air commute	*Airport Shuttle*	
	Air Taxi	*Passenger*
	Bus last-miles connection	
	Train last-miles connection	
First response	*Air ambulance*	
	Police/security event service	*Logistic +*
	Firefighter quick response	*Passenger*
	Humanitarian aid intervention	
Company level UAM	*Company shuttle*	
	Office-to-office travel	*Passenger*
	Inter-office/client delivery	
Events	*Pick-up and drop-off people*	*Passenger*
Entertainment/Media	*Extreme sport application* *Film/TV/Reporting* *Tourism Sightseeing*	*Logistic*
Logistic/Good del	*Air freight delivery service* *Air freight warehouses service*	*Logistic*
Construction/Real estate	*Aerial inspection and survey* *Replace external building operations (painting/window washing) in extreme environm* *Access to electrical wires and poles*	*Logistic*
Healthcare services	*Pick-up and drop-off patient for remote areas* *Delivery of urgent needed medical items*	*Passenger + Logistic*
Daily public services	*Replace winter snow plow and salt trucks* *Replace trash collection (hazardous waste disposal)* *School Busses service* *Smart City Monitoring (congestion, safety, etc..)*	*Passenger + Logistic*
Agriculture	*Reach remote flocks* *Reach remote farmland for harvesting goods* *Distribute seeds / other in the fields*	*Logistic*

- The effects may be compensated by rebound effects: the freed capacity on the road network may cause induced traffic; UAM as a last-mile solution may create a higher demand for deliveries; the resulting stimulation of e-commerce will increase the pressure on urban logistics.

Public acceptance is another major issue, because of negative or uncertain perception of safety, visual impact, noise hindrance, privacy issues, … This puts even more Importance in test projects to demonstrate and evaluate the effects of UAM.

For this reason, applications in emergency service (urgent interventions, deliveries of medical equipment and/or staff) seem most promising. On one hand, UAM offers clear benefits compared to classic motorized transport (speed, reliability), while the impact is limited because of the lower frequence of flights. The use for transport of passengers or goods suffers higher resistance, because of the large fleet size and number of flights needed to become profitable and to realize the expected impact on sustainability.

With the opening of EU drones services market in 2019, it is important to remember the "Drones Helsinki Declaration" that stressed the need to work on:

- Legal requirements for operations and airspace and U-Space services;
- An effective standard setting process;
- Further investment in demonstrators and the establishment of a European U-Space Demonstrator Network.

The Declaration also underlined a commitment to safe, secure, green drone operations that also respect privacy.

The future and the actual development of demonstration projects in close collaboration with local and/or regional authorities need to follow the aforementioned needs. Infact, one of the major needs to reach the objectives of UAM real application consists in the preparation of a permanent, definitive and clear regulation framework, overcoming the current condition of continuous updating and modification of UAM rules and legislation.

Acknowledgement. This paper is supported by European Union's Horizon 2020 research and innovation programme under grant agreement No. 101007134, project AURORA (Safe urban air mobility for European citizens).

References

1. Reiche, C., Goyal, R., Cohen, A., et al.: Urban Air Mobility Market Study. National Aeronautics and Space Administration – NASA. Permalink, 2018 November. https://escholarship.org/uc/item/0fz0x1s2
2. Urbanmobilitynew.com Document: Global Urban Air Mobility Report. Permalink (2019). https://www.urbanairmobilitynews.com/wp-content/uploads/2019/03/Global-Urban-Air-Mobility-Report-7-March-2019.pdf
3. Gianmarco, S., Walid, N., et al.: En-Route to Urban Air Mobility. On the fast track to viable and safe on demand air-services, Altran Company. Permalink (2020). https://www.altran.com/as-content/uploads/sites/27/2020/03/en-route-to-urban-air-mobility.pdf

4. European Commission: Mobility and Transport, Permalink (2020). lhttps://ec.europa.eu/transport/home_en
5. Canergie Endowment for International Peace: 2021 Mapped: Drone Privacy Law around the World, Electronic Frontier Foundation, AlgorithmWatch. For the full research behind the map, visit: bit.ly/DroneProvacyLaws (2021)
6. David, T., Hine, D., Schellenberg, B., et al.: S. CASCADE Open Aircraft Project: University of Bristol VTOL Drone Development AIAA Scitech 2021 Forum. AIAA 2021–1930, January 2021
7. Ferraro, M., et al.: CASCADE project, presentation at the Connected Places Catapult Drone Workshop (2019)
8. Lilium (2020): Website. https://lilium.com/about-us. Accessed 15 Apr 2021
9. Vincent, J., Gartenberg, C.: Here's Amazon's new transforming Prime Air delivery drone. The Verge (2019). https://www.theverge.com/2019/6/5/18654044/amazon-prime-air-delivery-drone-new-designsafety-transforming-flight-video. Accessed 15 Apr 2021
10. Stouhi, D.: London Development to Offer First Dedicated Drone Port in the UK, Arch Daily (2019). https://www.archdaily.com/911950/london-development-to-offer-first-dedicated-drone-port-in-the-uk/. Accessed 15 Apr 2021
11. Airbus (2020): Website. https://www.airbus.com/innovation/zero-emission/urban-air-mobility.html. Accessed 15 Apr 2021