

SLOVENIA ON THE WAY TO DRONE DELIVERY - WHAT MORE NEEDS TO BE DONE

KRISTIJAN PERČIČ & BRANKA LESKOVŠEK

Post of Slovenia, Maribor, Slovenia.

E-mail: kristian.percic@posta.si, branka.leskovsek@posta.si

Abstract Nowadays, it is impossible to bypass the fact that digitization, robotics and automation of work are becoming an increasingly important part of our living and business. It becomes crucial, especially in urban areas, to identify new operational models that could be applied for last mile deliveries, where increasing of city logistics sustainability is being the main goal. Drones have been widely acknowledged as a promising technology in many fields and industries, especially for the delivery of medical and aid packages in humanitarian and healthcare logistics. In this study, we present the project of Post of Slovenia, which aimed to implement first delivery drone to the fleet to access hard-to-access locations. Slovenian Post aims to create innovative, cost-efficient and market-led business environment for the development and take-up of new drone services and technologies within the Slovenian's internal market. As the national legislation in this area is still relatively unregulated, Post of Slovenia has actively contacted with the national authorities, which are the drafters of the relevant legislation, in order to accelerate the introduction of delivery drones into Slovenian airspace.

Keywords:

drone
delivery,
U-space,
sustainability,
delivery
solutions,
logistics

1 Introduction

Over the last few years, drones have become less of a fantasy and more of a reality. They already contribute positively to wildlife conservation, emergency rescue and military operation efforts. Drones are prime candidate for solving a complex and expensive last-mile delivery. They are able to deliver where no person can. The UPS is using drones for delivery routes around water, hilly terrain and unpaved streets. La Poste has been using them to make deliveries to remote Alpine villages. The Swiss Post is testing drones for delivery since 2015. They have transported mail, parcels, emergency relief supplies and high priority lab samples.

When talking about the delivery of medical items, time and efficiency are of highest priority. Delivering of urgently needed medications to remote areas by Traditional Last-Mile Delivery Modes (TLMDMs), like delivery vans and trucks, represents quite a large challenge for delivery companies. Is not only the problem of hard access of some locations. There are also issues as traffic congestion, traffic accidents, road closures, poor transportation infrastructure etc. All these impose a huge time pressure on the delivery system. Unmanned Aerial Vehicles (UAVs), also known as drones, offer a sensible solution to overcome the challenges associated with last-mile delivery by TLMDMs. Interest in the use of drones for the delivery of small parcels, not only for medications, has arisen dramatically during the last few years. Their competitive advantage is multifaceted. They are not restricted to established road networks; they do not need a delegated driver (pilot); they do not require launching infrastructures. The coronavirus pandemic also proved that UAVs are able to reduce the physical interactions between senders, delivery service and recipients. Drones can save time and cost but what is more important, they can also save people's lives. All of the above have induced many companies to begin drone delivery of medical items to hard-to-access locations. Several studies (Haidari, 2016) revealed that employing drones, compared to TLMDMs, in vaccine delivery can reduce annual logistics costs by \$0.08 per dose and improve vaccine availability by 2 %. They concluded that the cost savings of the drone vaccine delivery, compared to the delivery by TLMDMs, outweigh the capital cost of installment and maintenance of the drone system. Despite the fact that employing delivery drones can improve healthcare logistics, the challenges associated with delivery of times-sensitive medical items to hard-to-access locations require efficient logistics planning solutions.

UAVs are expected to become a crucial part of everyday operations in many industries. Several applications are already in place, such as in agricultural field analysis, crop spraying and monitoring, recreational video-taking, property and infrastructure inspections, and warehouse inventory checking (Anderson, 2017). Such applications are expected to play an important role in delivery services for e-commerce companies. The Federal Aviation Administration (FAA) is developing rules and regulations for drones to fly over populated areas, which should pave the way for drone-based commercial delivery services (Pasztor, 2019). UPS received the first authorization from the FAA to operate drones in populated area, which represents a huge step towards commercial usage of drone deliveries (Black T, 2019). Amazon has been investing significantly in its Prime Air program with drone deliveries within a 30-minute time window to customers within 15-mile radius from prospective areas where drones operations are possible (Palmer, 2020). Google has been investing in a drone-delivery program named Project Wing (Kanellos, 2014), e-commerce businesses Alibaba and DJ.com in China have been utilizing drones to fulfill demand in certain areas since 2016 (Harashima, 2017). SF Express, the largest Chinese logistics firm, has received the first official permit to legally offer drone-based delivery services nationwide in China in March 2018 (Huang, 2018). DHL invested in its Parcelcopter program (Bryan, 2014).

Specific details on drone-based delivery operations are mostly dependent on future government regulations. Delivery trucks usually transport on longer distances with a larger quantity of items while drones for e-commerce deliveries may deliver small number of items per trip in a short distance, given payload weight limitations and battery capacity requirements. Drones can also travel at a constant high speed while trucks depend to road traffic conditions. Furthermore, drones can provide more customized delivery options, where orders can potentially be delivered to wherever the customer is located at a given time, e.g., at home, work, or on a boat. Given these facts, it is clear that there is a need for new operational approaches for the management of drone-based delivery systems (Chen, Improved delivery policies for future drone-based delivery systems, 2021).

Our objective is to contribute to this emerging area by exploring research problems, relevant for delivery sector in Slovenia. Besides accessing remote places safely, using drones also brings other benefits. One of them is fast delivery. Drones can deliver far more per day at a far faster rate. They don't have to circumvent traffic

congestions or accidents since they have pre-programmed and perfectly optimized routes. German company called Wingcopter created a special drone that can combine multiple trips, what is making deliveries much more efficient. Depending on the size of drones and the weight of packages they carry, drones can be a much more sustainable form of delivery. Generally, drones consume far less energy per kilometer than the average delivery van. They are powered by electricity, meaning drones have little to no CO2 emissions. Plus, drones have the potential to perform other activities for the greater good while they are delivering mail parcels, like collecting air quality data, keeping tabs on illegal loggers, or checking in on alternative power plants. Another great benefit, as a byproduct of using drones for delivery, is also data gathering. For example, current drone flight plans can assist regulatory agencies in planning and monitoring drone flight patterns and routes to avoid costly crashes into other drones or even buildings and power lines. USPS also plans to utilize unmanned aircraft systems (UAS) to gather sensor and geospatial data for autonomous vehicles. Other companies are exploring drones as methods of distributing groceries, prescriptions, hot meals, and other lightweight goods. (Escher Group, 2021)

The remainder of the paper is structured as follows: Section 2 discusses history of drones and some pilot implementations of delivery drones and related research. Section 3 introduces first steps towards unmanned aircraft package delivery at Post of Slovenia. Section 4 describes how we see the future of drone delivery. Finally, Section 5 summarizes the observations and outcomes of this study and outlines some avenues for future research.

2 Related literature

2.1 A brief look at the history of drones

Drones have been in use for more than two decades, but their roots go back to World War I, when both the US and France worked on the development of unmanned automatic aircraft. As is often the case with modern technologies, regulation usually follows technological development itself, which often dictates the pace. While drones and related technologies are evolving to unimaginable heights, the regulation of the area is following at a slower pace, which is becoming faster. Due to the deserved opportunities for development, the regulation also began to

slowly direct development and set certain frameworks for it. These are needed because unmanned aerial vehicles were considered toys until a few years ago, but today they are capable of many activities, from inspecting infrastructure, searching for casualties, filming, to delivering medical and postal items to the front door. They are capable of automatic take-off, flight and landing - this is also an important difference between drones and aircraft models - aircraft models and modelers belong to a special category of drones. Aircraft models require in-depth flight knowledge, which has contributed to good practices to date.

Unmanned aerial vehicles have evolved into real tools (sometimes even weapons), without which many industries can no longer imagine everyday life. They offer fast, safe and greener solutions to problems that were considered complex, financially demanding, environmentally unfriendly and dangerous for workers yesterday. The production, sales and use of drones are growing exponentially. They are already used today in various fields, from postal services (delivery of items), energy (infrastructure inspection), agriculture (crop control, livestock, use of sprays), media space (photography and aerial photography) to security (police and army and borders control).

In the initial stages of development and use, however, drones also caused some complications. Innovation and development need a certain amount of time for people and the environment to get used to them and to some extent to adapt to them. All innovations inevitably bring with them regulation. It is necessary to establish clear rules of the game for (safe) use and to anticipate the consequences in the event of unforeseen events (eg traffic accidents and insurance). In the field of drones, one of the first visible incidents was certainly the crash of a recording drone behind the famous skier Marcel Hirscher in 2015. At the same time, various questions arose about situations such as e.g. unmanned aerial vehicle and manned aircraft accident. It has happened several times that civilian airports in Europe have had to close due to the presence of drones in their airspace. The first such incident occurred on December 19, 2018, when two drones were spotted at Gatwick Airport in the morning. For security reasons, the airport was closed, which remained closed for 33 hours, resulting in more than a thousand flights being canceled and more than 140,000 passengers affected. The airport suffered damage of € 1.7 million and airlines that had to cancel flights suffered damage of € 64.5 million. In response to such events, countries have begun to enforce their own rules in the field of drones.

2.2 Regulatory framework

In Slovenia, the first regulation in the field of unmanned aerial vehicles was obtained on 29 June 2016 and was in force until 31 December 2020¹ or is still valid in the transitional period until 31 December 2021, when the legislation delegated by EASAc² comes into force. The latter represents the legal framework for the establishment of U-space. U-space is a set of new services based on a high level of digitization and automation of functions and special procedures that support safe, efficient and secure access to airspace for a large number of drones.

In April 2021 (with a transitional period until January 2023), the EU Commission adopted the U-space package (three regulations), which together establish the basis and create conditions for safe, secure and green operation of drones and for safe joint operation of drones and manned aircraft in a section of our airspace known as U-space. These three regulations are: (1) Commission implementing regulation (EU) on a regulatory framework for the U-space, (2) Commission implementing regulation (EU) amending Commission Implementing Regulation (EU) 2017/373 as regards requirements for providers of air traffic management/air navigation services and other air traffic management network functions in the U-space airspace designated in controlled airspace and (3) Commission implementing regulation (EU) amending Regulation (EU) No 923/2012 as regards requirements for manned aviation operating in U-space airspace.

Today, the EU aviation regulatory framework already provides for and allows all types of operations with drones, but these operations are subject to strict and time-consuming approval procedures, which usually come with added operational restrictions. Within the U-space, the aim is to improve the general state of awareness about the operation of drones and to streamline and automate authorization procedures - we are dealing with a high level of digitization and automation. The aim is to remove as many restrictions as possible and to support the development of a competitive market for drone services in the EU. Due to the demand for the services of drones in urban and suburban environments and around logistics hubs and airports, the already mentioned U-space will initially develop right there.

¹ Uredba o sistemih brezpilotnih zrakoplovov, Uradni list RS, št. 52/16, 81/16 – popr. in 195/20.

² European Union Aviation Safety Agency or the European Union Aviation Safety Agency, which takes care of the safety and environmental protection of aviation in Europe.

As the complexity of traffic patterns is high and the demand for drone services is increasing, this needs to be addressed through special traffic management provided by U-space. It will come into force in January 2023, so before that date, EU Member States can start innovative U-space designs themselves, which they are not obliged to install in their space by that date. Before implementing the U-space, Member States will also need to prepare for the implementation of a number of requirements, e.g. requirements for the certification of U-space service providers and the provider of a common information service (i.e. CIS - common information service) carried out under the U-space Implementing Regulation (Brezovar, 2021 (accepted for publication)).

U-space is also included in the "Strategy for sustainable and smart mobility - guiding European transport on the right path for the future"³, which was presented in December 2020. The strategy lays the foundations for a green and digital transformation of the EU transport system. The strategy mentions drones in several places, indicating the important place that drones will occupy in the future of European transport. The strategy explains that proactively shaping our future mobility through the development and validation of new technologies and services is key to maintaining the benefits. The EU will therefore provide favorable conditions for the development of new technologies and services and all the necessary legislative tools to validate them. In the near future, we can expect a higher incidence and wider use of drones (unmanned aerial vehicles) for commercial uses, autonomous vehicles, hyperloop technology, hydrogen aircraft, electric passenger aircraft, electric water transport and clean urban logistics. A stimulating environment is crucial for such groundbreaking mobility technologies so that the EU can become a major destination for the deployment of such technologies for innovators. Start-ups and technology developers need a flexible regulatory environment to test and deploy their products. The Commission will work to facilitate testing and testing and to ensure that the regulatory environment is suitable for innovation in order to support the introduction of market solutions. The Commission fully supports the deployment of drones and will continue to develop appropriate rules; inter alia for the U-space system, to make it appropriate to enhance safe and sustainable mobility.

³ Available at <https://eur-lex.europa.eu/legal-content/SL/TXT/HTML/?uri=CELEX:52020DC0789&from=FR>.

2.3 Global success story of UAVs

Drones are able to perform deliveries that are very difficult to be performed by manned aircrafts. They are air vehicles and associated equipment that fly autonomously or remotely controlled. Drones bring significant economic savings and environmental benefits. At the same time, they also reduce risks to human life. Drones are increasingly used in commercial as well as in civilian applications. Evolution on the technology, regulations and society acceptance is in favor of an accelerated deployment of drones for professional applications.

The UAV market already has a great variety of hardware, software, and operational products to offer. The key element for global UAV success story largely depends on local regulation. The international regulatory bodies work together in the context of JARUS (Joint Authorities for Rulemaking on Unmanned Systems) initiative. In addition to national authorities, Europe participates in this work through EASA (European Aviation Safety Agency) (Hussein, 2021).

There have been a recent promising developments in Europe with the publication of: procedures for the operation of unmanned aircrafts (EU C. I., 2020), regulation on unmanned aircraft systems and on third-country operators of unmanned aircraft systems (EU, 2020), and Vertical Take-off and Landing (VTOL) certification (EASA, 2020).

Amazon CEO, Jeff Bezos, first introduced drone delivery. With the advancement of online business and B2C delivery, Bezos had thought of an approach to decrease the delivery time in a developing market. Amazon was developing a substitute method for delivering their products by drones. During the episode, Bezos introduced the world to Amazon's new Octocopter, which will be the essential delivery device behind this new service. Bezos guaranteed that Amazon would have the capacity to deliver their products in less than 30 min from its warehouses to the customer's home (Bamburry, 2015). Amazon's reputation to ensure satisfaction has given Amazon a major advantage in the retail industry.

Last-mile delivery is considered to be a choke point for the delivery of packages to consumers, especially for e-commerce companies. This final segment of the supply-chain accumulates the largest costs, stemming primarily from transport and labour costs (Joerss, 2016). This corroborates the reason why Amazon and UPS are investigating drone deliveries in urban areas as a viable solution. However when this materialises, the Very Low Level (VLL) urban airspace (i.e. , the portion of the airspace assigned for drones by regulatory bodies) will experience high densities of drone traffic flying in close proximity to natural and man-made obstacles. To explore these commercial demands, Unmanned Traffic Management (UTM) programs such as U-Space in Europe, are developing critical services such as deconfliction management and dynamic capacity management (SASAR-JU, 2019).

Drone delivery services have gained buzz in the media because internet businesses have been developing quickly during last few years. The utilization of business drones may turn into a key advantage and a key difference that assists internet business organizations to achieve almost instantaneous deliveries, which will create enormous advantages for web-based business retailers over the globe that can help separate them from each other as the opposition warms up for consumer satisfaction and retention (Chen G. Y., 2016). Realizing a future that makes drones a regular part of our daily lives will require answers to the following potential issues and obstacles. Like other delivery services, it is essential for drone operators to understand their duty towards their customers (Nok, 2015).

US regional airline Mesa Air Group started to conduct commercial drone deliveries in the last-mile food and beverage market in the USA. In that way, Mesa is becoming the first scheduled airline to lunch drone delivery in the USA. They ordered four delivery drones Flirtey Eagle to aerospace technology developer Flirtey. An electric-powered, advanced drone conducts deliveries to homes and businesses. Flirtey's autonomous software platform conducts autonomous flight operations. Should the initial trials prove successful, the parties plan to expand their business across the USA and to New Zealand (Symonds, 2021).

The SESAR U-Space outlook study postulates delivery drone services to be viable by 2035 (SESAR, 2016). In order to be synchronized with the SESAR U-Space program, a forecast to estimate the number of drone-eligible parcel deliveries for the five European countries until 2050 has been performed. To be conservative with the

drone-based parcel delivery demand forecast, the average economic growth rate is used, which stands at 1.8 percent for Europe as of 2019 (CBS, 2019).

Drone-based delivery of small consumer packages and fast-food meals has the potential to make a large contribution to transportation in urban areas. Drones represent an agile and sustainable transport mode for e-commerce companies and quick-service restaurants, especially when high-volumes of high-speed deliveries are required. Drone-based delivery may contribute to ease traffic congestion in our already congested urban cities.

3 First steps towards unmanned aircraft package delivery at Post of Slovenia

Drones have been on Posts' radar for a while now because they are able to deliver where no person can. The USPS is using drones for delivery routes around water, hilly terrain, or unpaved streets. La Poste has been using drones to make deliveries to remote Alpine villages. Not only are these towns tough to get to, they are also especially treacherous in the winter. Driving on icy, snowy roads puts postal workers in danger, and makes it less likely deliveries will make it to their destination on time. (Escher Group, 2021)

Slovenian Post carried out its first trial flight with an unmanned aircraft, i.e. a drone, which delivered a package to the Poštarski dom mountain hut on Vršič in the final phase of its flight. The company is undertaking this innovation project to look for new business opportunities and take an active approach to forming regulations that govern flying and operating unmanned aircraft in Slovenia. Many companies around the globe already use this method to successfully deliver packages, whereas the current European legislation does not yet permit flying outside one's field of vision. Post of Slovenia used a specific VTOL drone for their delivery trail, which is able to fly longer distances as it takes off and lands vertically and flies horizontally.



Figure 1: First trial flight with an unmanned aircraft for Post of Slovenia which delivered a package to the Poštarski dom mountain hut on Vršič

(Source: Archive of Post of Slovenia)

Post of Slovenia is initiating its first trial flights with unmanned aircraft as a preparation for the time when the company will be able to deliver essential packages to places that cannot be reached as quickly or efficiently by conventional vehicles. In view of the current delivery trends, the company is no longer far from the moment when, instead of mere trial flights, will be able to carry out actual drone deliveries. Post of Slovenia wants to be actively involved in the process of creating regulations that govern flying and operating unmanned aircraft in Slovenia, with the clear aim of looking for new business opportunities. Although technology has enabled this for quite some time now, regulations that govern airspace are proving to be an obstacle. At the moment, Europe does not have much maneuvering space to accommodate mass deliveries of this type. There is great potential for using drones in deliveries for a variety of purposes. These include delivery of laboratory samples from remote areas, delivery of goods from ships to land, and even delivering online purchases to end customers. Post of Slovenia sees great potential in drone delivery, also for the segment of online shopping delivery, as a service with the highest added value.

The main advantages of using this type of vehicle include reduced pollution, optimization of logistics channels, quick deliverability of essential goods and materials to remote and difficult-to-access areas, etc. In addition, great potential can be found in supplying and delivering postal items to mountain posts and cabins, while collecting and removing waste on the way back to the valley. The same goes for emergency delivery of medicines and medical devices, which would fulfil the aim of remaining a relevant and comprehensive link between the Slovenian economy and the population.



Figure 2: Delivery of blood samples from a remote health center by drone (multicopter).

(Source: Archive of Post of Slovenia)

The area of deliveries by means of unmanned aircraft is dominated by technologically more advanced countries, such as the United States, China, New Zealand, Australia, Germany and Switzerland, along with companies such as Alibaba, Amazon and Google. China is predicted to begin providing drone deliveries of one-ton cargoes across distances of up to 1,500 km as early as 2025. The EU has ambitious plans as well, as the European Commission sees the future of unmanned aircraft in agriculture, the energy sector, supervision of law and order, online stores and mobility in general.

Further steps of Post of Slovenia in this area involve participation in RDI (research, development and innovation) projects and demo projects to set up environments in which autonomous deliveries are possible, and the establishment of/joining a consortium of major Slovenian companies that see the opportunity to create business models of the future in the area of commercial use of autonomous aircraft and other autonomous vehicles. Additionally, these companies are ready to influence the creation of the currently applicable legislation with their experience to date.

Post of Slovenia carried out the first trial flight with an unmanned aircraft in collaboration with a Slovenian company OneDrone, the first Slovenian operator of unmanned aircrafts of the highest category, which enables aircraft operations in the most challenging conditions, and with start-up company ElevonX, which produces unmanned aerial vehicles (UAV) and even entire systems. The start-up developed the SkyEye modular unmanned aerial vehicle (UAV) system and brought it into a serial production.

4 How do we see the future

The market size for drone services is expected to grow from €3.8 billion in 2018 to €55 billion by 2025, and Insider Intelligence forecasts that the number of consumer shipments using drones alone will reach 29 million by 2021 (Insider Intelligence, 2021). This is (tentatively) supported by some other estimates e.g. Statista Research Department predicted in August 2021 that the global commercial drone market would reach a size of around 58.4 billion USD (i.e. 50.4 billion EUR) in 2026. The market is projected to grow at a compound annual growth rate of more than 16 % between 2021 and 2026 (Statista Reserch Department, 2021).

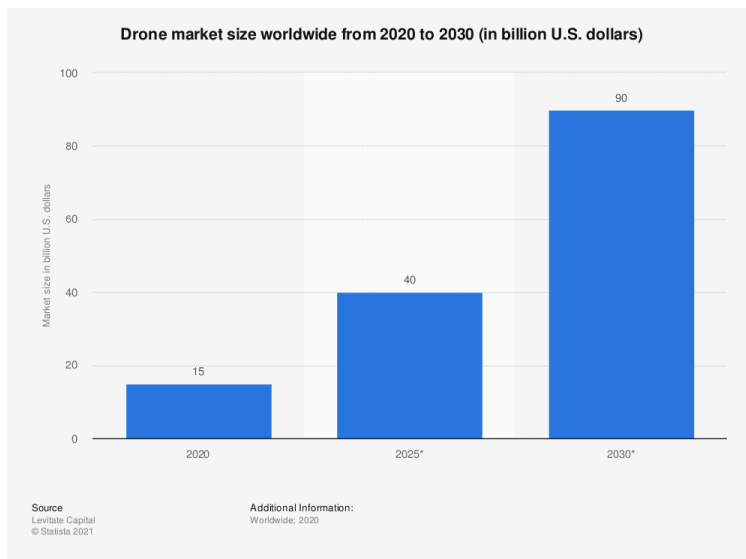


Figure 3: Drone market size worldwide from 2020 to 2030

(Source: Levitate Capital, Statista 2021;

<https://www.statista.com/statistics/878018/global-commercial-drone-market-size/>)

Given the many estimates of the size of the global “drone” market (Grand View Research , 2021) and huge venture capital investments in the “drone” industry, we can conclude that drone delivery is no longer just some science fiction thing but more a fact that will happen in the future.

Regarding the new EU regulations Commission Implementing Regulation (EU) 2021/664 of 22 April 2021 on the regulatory framework for U-space, we are convinced that now is the right time to start research and development work in this field in companies such as Post of Slovenia.

Next step is creation of a U-space system that will control and manage all autonomous craft in the 0-120m altitude range and will allow communication between all craft in the range (drones, helicopters, emergency helicopters, paragliders and anything else that comes within the flight range). The U-space system will allow controlled, reliable and, above all, safe flight for all stakeholders.

4.1 Drone capabilities for U-space

The capabilities expected for enabling U-space services are divided into three groups to support different types of service: foundation, initial, and advanced services (SESAR-JU, 2018) as shown at Figure 4.

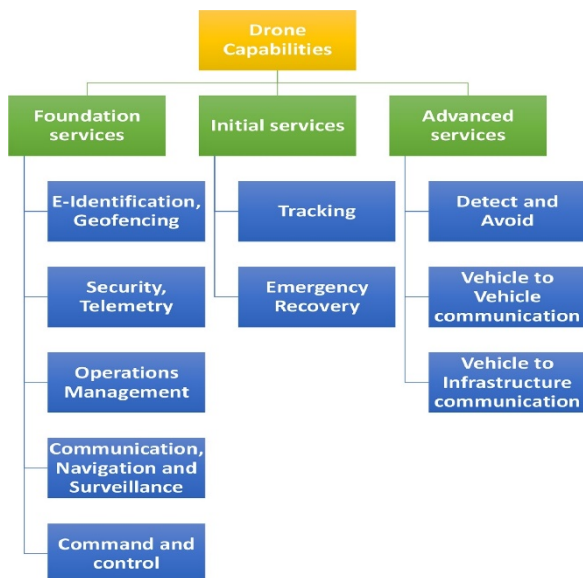


Figure 4: Drone capabilities for U-space
(Source: Hussein, 2021)

Capabilities for the foundation services include geofencing, security, telemetry, operation management, e-identification, communication, command and control, surveillance, and navigation. E-identification is the ability for identifying the drone and its operator in the U-space. Geofencing is the drone ability to be compliant with time, geographical, and altitude restrictions defined by the geo-fencing service. Security is making the drone able to protect itself and its data (i.e. interaction with infrastructure and other vehicles) from attacks. Telemetry is the ability for transmitting measurement data from a drone to another drone or to a service provider for meeting the demands of relevant services. Communication, navigation, and surveillance that makes the drone able to meet performance requirements of the communication, navigation and surveillance in the specific environment in which it will operate. This capability consists of on-board sensors and equipment (e.g. voice

radio relay, data link, etc.) as means to achieve the required performance. Command and control is the drone's ability to communicate with a ground control station for conducting the flight (normally through a specific data link). Operations management is the ability for planning and managing the drone missions. This involves accessing and using of all relevant information for planning, notifying, and operating a mission.

The initial services capabilities include tracking of the drone by providing flight parameters that include at least its position and altitude, and emergency recovery, which is the ability of drones to take into account failure modes such as link failure, command and control (C2) failure. It also takes measures for ensuring the safety of the vehicle itself, other vehicles, and property and people on ground.

The advanced services of the U-space are vehicle to infrastructure communication (V2I) which is the drones' ability for sharing information with infrastructure components and vehicle to vehicle communication (V2V) that is making drones able to communicate information to each other. The nature of the exchanged information and its performance depend on the application. Another advanced service is detect and avoid which is ability of drones to detect hazards, or cooperative and non-cooperative conflicting traffic, and to take the appropriate actions to comply with the applicable rules of flight.

4.2 Mobile telecommunication infrastructure

Mobile telecommunication networks could be the best solution to provide scalable connectivity solutions for U-space services and BVLOS operations in the future. Mobile telecommunication infrastructures/solutions for the U-space services should enable increased flexibility in the design and implementation of new types of services making reference to the U-space services requirements. The mobile telecommunication infrastructure should be capable of meeting appropriate U-space services performance requirements for coverage, quality of service, safety, security and reliability (resilience, failure modes, redundancy), while minimizing environmental impacts and respecting the privacy and safety of citizens.

Current mobile telecommunication networks can already provide sufficient connectivity and enable U-space services in some environments and use cases. In the future, developed mobile telecommunication solutions for U-space services could enable scalable, flexible and adaptable services, also for demanding environments and use cases.

However, there are some challenges to meet to enable cooperation in the telecoms and aviation sectors. The telecoms industry providing the mobile telecommunication services is market driven. In addition, current commercial mobile networks are typically built and optimized for users on the ground. Large numbers of users in the air will cause interference to the mobile networks and users on the ground, if not implemented in a controlled manner. Coverage and service requirements are also not currently optimized for users in the air. Close cooperation between the two sectors is needed, firstly to understand the performance requirements that U-space services put on the mobile telecommunication services, and secondly to develop a compromise on how the requirements can be met by the mobile telecommunication networks and services. The technical requirements of U-space services should be realistic and possible to meet in practice. This will also require developing new common business models for the cooperation between U-space and mobile telecommunication service providers (Brezovar, 2021 (accepted for publication)).

U-space must be able to adapt to new communication technologies and automation, both ground-based and airborne, and increasingly allow for more advanced forms of interaction with the overall U-space ecosystem, predominantly through interoperable communication systems capable of digital information and data exchange such as the 5G mobile telecommunication infrastructure. Ultimately, the next generation of mobile telecommunication infrastructure must be persuaded to encompass the range of UAS/UAM demand, business models, applications and technologies, and to support safe and efficient U-space operations that also include manned aviation and existing ATM systems to ensure a fair and equitable access to the airspace.

Although mobile telecommunication networks can provide connectivity for many challenging environments and operations in the future, there will always be environments where mobile networks are not the optimal connectivity solution, such as high altitudes or remote locations.

5 Conclusion

Urban parcel transport faces a lot of difficulties for a reason of the high population, lack of infrastructure, traffic congestion and pollution problems. Globalization and technological blooming caused a strong increase in demand of products and services. Consequently, several cities have tried to implement sustainable city logistics, which would allay cities' problems related to distribution of goods. Motivated by the challenges associated with the logistics of delivering items to remote areas we have introduced a drone delivery system aimed at covering the population living in hard-to-access locations. In the proposed system, we assume there is a set of locations with a certain demand for daily items.

Drone delivery has been talked about for almost a decade, and very intensely since 2013, when Amazon unveiled its plans in the field with the Prime Air project. Other technology giants soon jumped on the train, including Google with its Wing project. The media coverage of these initiatives has created the illusion that drone delivery is already quite commonplace in the world, but in reality we are still a long way from it. Most of these projects are still deep in the development phase and far from commercialization and everyday use. According to our assessment, delivery by drones will first be established in the supply of more remote locations in less populated areas (eg. delivery of consignments to remote mountain farms or perhaps the supply of mountain lodges). In the delivery of special cargo (medicines, biological samples, etc.) the time to serious commercial supply in this area will be measured in years rather than months.

The main advantages are certainly the speed of delivery and the reduction of the burden on human resources. Neither can be neglected the ecological component (electronically powered drones operate without emissions; the noise burden on the environment is also reduced).

The key challenge, at the moment, is legislative constraints (which only laid the foundations for flights outside the pilot's field of vision with the new EU legislation) and the lack of adequate infrastructure for the integration of unmanned aircraft into the airspace.

Automatic flight of unmanned aerial vehicles over long distances will be possible when two key conditions are met:

- Standardization and certification; The new EU legislation is based on unmanned aerial vehicles that will correspond to one of the classes (C0, C1, C2,...). Aircraft that obtain one of the required markings will be required to be certified by a notifying authority, which will verify them in accordance with applicable standards. As the EU standards that drones must meet have not yet been developed, it is impossible to certify these aircraft. As a result, only low-risk operations may be carried out with all currently available unmanned aerial vehicles (industrially and privately manufactured), which in the case of long-distance flying outside the pilot's field of vision means flying over a sparsely populated area in closed airspace.
- Lower airspace management; Unmanned aerial vehicles typically fly at altitudes up to 120m above the ground in uncontrolled airspace where visual flight rules apply. This means that pilots of aircraft see each other and avoid each other on that basis. Because drones are small and cannot be seen by other airspace users, all responsibility for avoiding a collision lies with the pilot of the drone. A remote pilot can ensure collision avoidance only when the drone is in its field of vision. The solution brought by the future is a new type of U-Space, in which remote identification and a contract with the operator of this airspace will be mandatory for all users. In such an airspace, the operator will take over the tasks of air traffic control, take care to avoid collisions between users and provide priority to aircraft on emergency flights (e.g. rescue helicopter). As part of the current airspace management, it is already possible to close parts of the airspace in which it would be possible to safely test the flights of unmanned aircraft over long distances. A step forward would be the possibility of reserving part of the airspace for the duration of the operation, which operators could perform in a simple and fast way, and the final solution will be U-Space. Businesses and individuals who would like to operate longer flights with drones have no influence on the development of standards, which is likely to be time-consuming, and all the conditions for a test run of U-Space airspace have already been met.

The new EU legislation sets clear conditions that must be met by drone system operators and the conditions for conducting operations with different levels of risk. Low-risk operations are already possible today over long distances (flying out of sight over a sparsely populated area in closed airspace), and more risky operations will be possible with the arrival of appropriate standards and the establishment of the necessary infrastructure (U-Space). The new EU legislation is designed in a modern way with a view to the future, but unfortunately, it is not yet fully feasible. As the rules are very complex, it is crucial that drone system operators start setting up the organizational structure, staff training and operations with drone systems at the highest possible level in a timely manner, as this will make the transition to a higher level fast and secure.

For delivery purposes, we test different types of drones, which differ in both range and payload. In the initial phase, we test multicopters with a maximum flight time of around 45 minutes (which in theory means distances of up to 30 km) and VTOL systems (a combination of a fixed-wing aircraft and a multicopter) that can fly in electric versions for two hours or more (meaning also more than 150 km range).

Increasing the payload weight reduces the flight time, so it is crucial to capture the right ratio between aircraft size / weight, flight time / range and payload weight. Since the vast majority of shipments (despite the expansion of the online store) fall into the class up to 2 kg, most delivery drones are currently optimized for such cargoes.

City logistics providers are being put in a high pressure due to cost-efficient and consumer-oriented delivery of e-commerce products. City logistics aims at the fast and reliable transportation of goods. The complexity of planning operations requires sophisticated planning systems, setting up on quantitative optimization models. Citizens come to the forefront with their desires and needs and raise the quality of their lives with an emphasis on a healthy environment, economic prosperity and social justice. All of the above must be taken into account if we want to implement delivery drones also into city delivery.

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