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Challenges in the aviation system caused by the emergence of delivery drones

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Abstract: Using unmanned aerial systems is spreading in several industry sectors. New and previously not seen demands are evolving in the service provider sector. Due to the continuous technological development in the aviation and drone segment, this equipment can fulfil delivery tasks beyond the previously elaborated data collection operations. The professionals should present the possible and potential adverse effects of drones caused by the emergence and large-scale spread of the devices beyond the demonstrated benefits and advantages.

Keywords: delivery drone; drone; UAV; UAS; drone law; drone operations

I. INTRODUCTION

The market connected to unmanned aerial vehicles (UAVs or simply drones) is a unique industry area with continuously growing capitalisation whose value has reached 127 billion US dollars, according to the estimations in 2021 [1]. Furthermore, the global scale of the market - limited only to the equipment - will grow from 14 billion to 43 billion US dollars in 6 years between 2018 and 2024. Thus it is expected that more than 100 thousand new jobs will be forming worldwide [2].

Previously, the main direction unmanned aerial vehicles' development was focuning on data collection and monitoring. Nowadays, technological developments are focusing on active interventions. New solutions are supporting the creation of novel use-cases of the UASs that will help to mitigate traffic congestion and connect other adverse effects caused by road transport through the active usage of the UAVs [3].

New technology solutions can satisfy the increasing demand for faster transport needs. Its organic part is the use of unmanned aerial systems, which are applied for special transport operations. These solutions are available even today at those locations where the road infrastructure is not available, or its quality does not support effective road transport (e.g. for the transport of medicines, vaccinations, and medical equipment) [4], [5], [6], [10].

The global market of the logistics sector, which is supported by unmanned aerial vehicles, is continuously growing. According to the forecasts, it will grow from its 5.3 billion US dollars value (2019) to 11 billion US dollars by its value by 2026 [7].

The topic of this article was given by the drones appearing in the commercial transport of goods. Their applications are raising several questions (so-called challenges) beyond the potential benefits, and these questions should be analysed from the viewpoint of air transport, environment protection and logistics. These challenges should be managed. Otherwise, the use of drones will be impossible, or the application of drones will affect the other players of air transport adversely, and they can deform commercial services.

In the last few years, the big international courier express and delivery companies have conducted intensive research to find innovative freight delivery solutions for the last-mile logistics of goods. In addition, Amazon, DHL and Google have devoted significant resources to find solutions for the usage of UAVs in future air transportation, thus providing a breakthrough in the sector.

This topic should be revealed because innovations have high priority in the last-mile transport while the parcel is transported from the warehouse to the consumer. This process is the most time-consuming, expensive, and polluting phase of the supply chain (explicitly calculated for a delivered parcel). Approximately 50% of the total cost is last-mile delivery. Therefore, the market of package delivery executed by unmanned aerial vehicles is on the verge of a real revolution. Based on the forecasts, the global market of drone delivery services will reach 7.4 billion US dollars by 2027 with an annual 41.8% growth rate [8]. Other analyses are calculating over 50% annual growth rate and based on them, the capitalisation of the global market will reach 31 billion US dollars by 2028 [9].

Developments are made by international freight transport companies with road transport dominations and manufacturer companies with significant aviation experience [8]. Companies expect that due to the developments, UAV-executed freight delivery will become faster, greener, and much more environmentally friendly than conventional road transport.

With the developments, special applications can be used to support electricity or even hydrogen-based power of UAVs in the future. Thus it is possible that UAVs will not emit pollutants, and they can use the three dimensions of the space during the operations, so the ground-based traffic congestion will not affect their progress. A further advantage of delivery drones is that they can easily and quickly prepare for the flight (ready to fly). Loads can be easily inserted, batteries can be changed quickly (even under a few seconds), and the launch can be done seamlessly [31].

II. Challenges

Innovations connected to delivery drones present only advantages in most cases. They emphasise that the application of this equipment positively contributes to environmental protection. Thus their usage is green and environmentally friendly, providing the elaboration of quick and reliable freight services. However, it can cause a false idea in people with less comprehensive industrial knowledge. Beyond the positive effects, this solution also has negatives. Technical, legal and regulatory challenges that arise with their use are not usually discussed. The more such services appear, the more significant these challenges will be, because drones executing freight transport activity in very low-level airspace significantly influence the operation of the aviation sector (even in the vicinity of airports and heliports). Beyond the operational issues, several demands are emerging concerning manufacturing and operation that needs a particular environment, which may overwrite the presumed advantages.

In this article, the author points out with the analysis of multiple factors that further innovations and attitude formation are needed for the rentability and widespread of UAV-based freight delivery and to conduct safe operations. Technology, legal, regulatory, sociology and psychical factors can be identified as challenges. The author is analysing the challenges according to the following factors:

- Infrastructural challenges (air and ground equipment, components, life cycle).
- Energy-related challenges (source, cost and use of electrical energy).
- Demand and supply challenges (social attitude, solvent demand and social needs for these services).
- Legal challenges (possibility of use).
- Limitations due to physical accessibility.
- Effects on aviation players (restrictive effects on conventional aviation players, or the contrary, limitations caused by conventional aviation).

In order to better understand the individual factors, the author illustrates the effects of the limiting factors with the help of numerous application and calculation examples.

1. Infrastructural challenges

The infrastructure of UASs can be divided into the following parts:

- Unmanned aerial vehicle(s) > UAV: This is the freight transport drone. It executes the delivery task between the warehouse and the destination.
- Primary infrastructure: the set of all equipment and services needed to perform the flight operation directly. It consists of the followings:
  - Ground-based infrastructure: Service locations and the equipment and services used there (take-off and landing sites, where appropriate, the launch and recovery equipment, equipment required for operation preparation – equipment for charging batteries, etc.),
  - Airside base infrastructure: The set of equipment and services necessary for the operation of the air transport system (communication systems, airspace, tools for navigation, etc.),
  - Operational management base infrastructure: The management systems and components which are necessary for delivering goods and the delivery service (staff and the operational control centre).
- Secondary infrastructure: tools for servicing and maintaining the UAVs, maintenance base, educational facilities, simulators, etc.

A. Challenges by the unmanned aerial systems

The industrial sector of unmanned aerial systems has been significantly developed in the last decade. However, new technologies have arisen to solve the inconquerable problems in the past, limiting the spread and evolution of delivery drones. Nowadays, the most current and researched topic is finding answers for the most critical safety and security issues of drone flights and operations. These answers are significant in the case of UAV-based delivery services. Flight operations are executed in BVLOS mode (beyond the visual line of sight) and fully autonomous due to the complexity of the operations and the great size of the covered area by the service. It requires the availability of advanced onboard electronic systems with high-level automation. This allows the execution of the missions fully automated between the take-off point and the destination without any human intervention by identifying all risks, hazards and barriers, thus supporting the execution of the necessary safety measures if needed.

The biggest challenge is the capacity limits of the applied UAVs from the operational point of view. They are limiting the maximum size and mass of the deliverable package and the maximum range of the service. In all cases, the service is performed with a well-defined drone fleet with precisely defined performance parameters. The followings are the most critical factors for the planning of the service (planning the maximum utilisation of devices):

- maximum range of the UAV with one single charging of the applied battery (maximum flying time),
- maximum size and mass of the deliverable package,
- the time necessary for the delivery at the destination,
- the time necessary for the re-deployment of the UAV after a mission when it comes back (time to recharge or change the battery and insert the new package),
- the possibility of a round trip (during the delivery, the device picks up another package and delivers it before returning to the warehouse),
- the possibility of delivering multiple packages to different addresses simultaneously.

Nowadays, the UAVs under design and construction can deliver and return only, so in case of an operation, the transport utilization can be a maximum of 50% on a time basis (see the application examples in the next chapter). The delivery and the re-deployment processes after the return need time, which further decreases the utilization. Thus, even in the best case, effective package delivery takes place in a maximum of 40-45% of the time spent in operation.

The determination of the active service period depends on the business policy, the length of the daylight and the weather. Delivery can be conducted only in daylight during favourable weather conditions from the viewpoint of operation when the recipient can receive the package. Otherwise, the receipt cannot be fulfilled. These conditions further limit the utilization of the service because favourable operational conditions are only available occasionally during the year (e.g. all day between 8. AM. and 10 PM.).

Currently, drones can limitedly take part in freight transport. UAVs can transport parcels with a maximum of 1-2 kg weight, and their dimensions cannot exceed the dimension of a small shoebox. There are UAVs with more significant transport capacities (5-10 kg or even 20-30 kg). However, their design does not allow retail freight transport (they are fixed-wind UAVs instead of the multicopter design). The range of the UAVs depends on the maximum horizontal operational speed, the battery capacity and the weight of the transported load. Generally, it can be stated that a UAV with a multicopter design can fly for 15-20 minutes with the specified maximum load with one fully charged battery [11], [15].

Contrasting drone freight transport with road transport, it can be seen that drone delivery is much significantly dependent to the weather than road transport, and it has much lower utilisation if a single UAV is examined.

Further aspects are the prime and operational costs of the UASs. There may be one or more orders of magnitude differences between the prime cost in the case of a drone and a truck (even in the case of an electric-powered road truck, which cost equals 5-20 drones). In contrast with the costs, the capacity of the road truck is higher by one or more orders of magnitude. Thus its profitability and transport capacity are higher. From the viewpoint of operational costs, there may be significant differences. In the case of UASs, the following must be taken into account: cost of the electricity for the charging, maintenance costs, costs of the installation and operations of the mission control centre, costs of the supervisory staff, administration costs, insurance fees, costs of the continuous operation of the aviation safety and compliance monitoring solutions, system usage fees, etc. Because the UAV cannot deliver a considerable amount of goods, thus the higher operational costs are divided between a few parcels, resulting in high transport costs.

An example of the productivity of a UAV-baes delivery service:

Delivery is carried out between 8 AM and 8 PM every day. Supposing that a UAV can deliver 1,5 parcels hourly on average on the operational territory (15-15 minutes flying to and from the destination, 5-5 minutes are the delivery and the re-deployment time), thus 18 parcels can be delivered within 12 hours by a single UAV, while its flying time is 8 hours. However, if the speed is increased and the turnaround time is decreased, and 24 parcels can be delivered within 12 hours, more is needed because a single truck can deliver this amount of goods within a few hours. Moreover, the UAV is not carrying and parcel during the back trip. Thus the capacity *utilisation is maximum 50% - theoretically – counted for the serviceable timebase.*

From the viewpoint of this analysis, it is worth considering additional items from a technical point of view. First, the effects of the aircraft's production and the components' life cycle on the environment must be considered.

The fuselage, containment and engines resist environmental factors (weather, mechanical strains, etc.). Propeller blades should be exchanged periodically or in case they get damaged. Propellers are typically made with composites that can be easily and quickly manufactured and changed. When they become waste, recycling and waste management should be solved. From an environmental point of view, the most sensitive component is the battery. They must be charged after all operations, or a fully charged item should be placed into the UAV during the re-deployment processes. Charging is generally taken place separately from the UAV. The battery life cycles rapidly deteriorate, and manufacturers guarantee only a few hundred cycles. When the battery reaches the given cycle value, it cannot be safely used for the missions. Therefore, operators should provide that batteries are disposed of as waste. These obligations induce that drone delivery services may generate a significant amount of waste. The operators should manage them appropriately and professionally because this waste cannot be disposed of as communal waste.

For instance, the previously illustrated calculation can be used, supplemented with the information that the manufacturer determined a 500 cycle usage limitation. If the UAV completes 18 missions per day, after each 28 working days, one battery should be replaced by a new one due to deterioration. In the concrete situation, the operation is much more complex. Supposing a continuous operation, a single UAV uses more batteries according to the charging time. Generally, the fully charged status can be reached by 1-2 hours of charging time – with conventional, not fast charging. In the example, a single UAV uses four batteries, and all of them are available. Therefore, four waste batteries will be generated based on the parameters after 2000 mission. Count the average: one battery every month per a single UAV. The current calculation is connected to the currently available technology. It should be considered that in the case of fast charging, the deterioration can emerge sooner, at a lover cycle requiring oftener battery replacement.

When the drone delivery service will widespread and more delivery drones are used, thus thousands of batteries (thousands of tonnes) will appear as waste. Their safe disposal or reuse must be ensured.

B. Challenges by the primary and the secondary infrastructure

In order to operate the service, logistic centres (warehouses) are required from the UAVs can start the missions. Moreover, operation control centres are also needed, where service control and supervision are fulfilled. Therefore, while one operation control centre may be enough, more logistic centres (warehouses) should be installed according to the range of the applied UAVs, the covered territory by the delivery service, and the number of applied UAVs.

According to this, building one logistic centre (warehouse) in a region is not enough because the proper fulfilment of the service will need more. It will increase the investment and operation costs (more buildings should be built, more staff is needed, and operational costs are getting higher and higher. Thus, the fixed costs connected to the service are also increasing). It will have a significant effect on the specific costs. The infrastructure building costs are higher than the investment and operational costs of the UAVs, and this increase may even be several orders of magnitude. When the facilities are used for combined transport services (road and air), road-based freight transport may cross-finance the drone delivery service, decreasing the specific costs of the combined delivery service.

From environmental protection viewpoint, the adverse effects can be identified because the previously used economies of scale aspects are deteriorating. More buildings need much more energy, and if the source is not renewable, it may significantly increase the environmental load.

Moreover, the storage capacity is limited, and it needs more frequent freight transport due to the numerous but smaller warehouses. Therefore, it will increase the road-based freight transport needs. It is fulfilled by big, conventional, fossil-based trucks because electric-powered trucks are only limitedly available.

2. Energy-related challenges

In order to meet the environmental aims, the energy needed for the operation of the UAVs should be produced with the help of green resources, and its costs should be competitive and affordable. In the case of electric-powered vehicles, electricity is generated by renewable sources. In the case of non-electric powered vehicles (e.g. hydrogen-powered), the energy source should provide green and renewable conditions [30].

When the power energy source comes from non-renewable and non-green sources, then the drone delivery service cannot be considered an environmentally friendly transport solution, despite no pollutant emission at the location of the service.

There are numerous efforts to use electricity from green sources or green energy resources for innovative solutions, but the accessibility to these is limited. A solution could be installing renewable power plants (solar power plants or wind turbines) by the operators to cover the energy demand of the service. Energy demands arose in the following areas connected to the UAV-based delivery services:

- Direct energy needs of the UAVs – continuous charging of the batteries have significant energy demand.
- Energy required for primary and secondary infrastructures (direct energy demand of logistics centres, operation control centres).

The price of 1 kWh of electricity and the purchase possibilities of operators should be considered when calculating the energy needs. When the company is interested in using green energy from renewable sources, it is ready to pay higher fees for such electricity. The source and the electricity production are irrelevant if the main goal is cost reduction and the cheapest operation. The higher power costs will affect the service fees. Thus the costs will be paid by the customers.

From environmental protection and energetic viewpoint, the emergence and widespread of hydrogen-powered UAVs in the future can be a significant improvement possibility. However, green hydrogen production has to be developed for this advance, and safe containment and transport technology solutions must be elaborated for the onboard hydrogen. Moreover, the energy density of hydrogen is much higher than conventional batteries. Thus hydrogen-based technology can provide more flexibility for drone delivery services in the future. Further solutions are also the scope of research like the autonomous docking technology for battery replacement or charging, the lase-beam-based in-flight recharging and the combination of hybrid operation (combination of fuel cells, solar panels and super condensers) [11].

The currently applied and available lithium-ion batteries are limiting the spread of drone delivery services because their capacity does not allow long-distance flights. Technology developments are continuous, and battery capacities are expected to double by around 2025 compared to the capacities of the early 2020s years. However, the new capacities are lagging behind the possibilities provided by internal combustion engines. It is why drone delivery cannot be an efficient and competitive alternative to road delivery [12].

3. Demand and supply-related challenges

Drone delivery services are still evolving, and only a few parcel delivery companies have started the service in the retail sector as an experimental and pilot project. Accordingly, this service is at the beginning of the Garter hyper cycle where research and development and early-stage retail solutions are found [13], [16], [17].

Several factors are influencing the demand for this service. Such as the fees, the real accessibility to the delivery (physical access – see next chapter), quantity and weight of the transportable goods, speed of the transport and the sensibility of the society to the innovations [32].

During the early stages of innovation, when its price is high (due to the need to cover innovation costs), it will be used by interested people eager to know the technology. Thus the demand will be low. With the evolving of the lifecycle and the growing accessibility of the service, the price will consolidate. However, the high complexity of the technology, high investment and operational costs and low capacity utilisation result that the fees of the drone delivery service will be much higher than road transport. In order to provide the continuous operation of the service, complex and expensive solutions have to be ensured at all times compared to road freight transport: safety management, compliance monitoring system, maintenance, operation control centre, detailed administration, unique and redundant communication systems, aviation-related systems, trained staff, training, etc. The extra fast delivery may increase the transport needs. It can be improved by increasing the service coverage from the supply side. However, this solution has a significant cost increase due to the need to install more logistics centres with more density.

Based on the available information, Amazon offers one delivery by a UAV for 63 USD [14]. This amount is approximately twentyfold of the road freight transport. The question arises whether the extra cost is commensurable with the advantage of the 30-60 minutes delivery, considering the maximum 2.5 kg limit of the parcel to be delivered.

4. Limitations due to physical accessibility

Delivery drones applied in the retail sector as pilot solutions can fulfil delivery operations only over significantly limited territories. Warehouses and destinations must be in appropriate proximity to each other, moreover the destination must be appropriate for the delivery made by UAVs. At the destination, over the delivery spot, the UAV lowers the parcel on a rope, or drops it, thus the location must be suitable for placing of the parcel by air. It is not realisable in dense downtown environment, in the surroundings of multi-storey apartment houses. Thus, the drone delivery service is limited to those locations, where the parcel placing can be safely conducted, like in the suburban, garden city houses.

Locations affected by drone delivery services can be found in complex airspace environments.

Complex airspaces may limit the accessibility to the service and the execution of the service because territories of half cities can fall under a No Drone Zone or in controlled airspace. Integrating the transport of UAVs into the conventional air traffic management system could be a solution that will be realisable with the emergence of UTM systems.

5. Legal challenges

Due to their nature, drone delivery operations can be executed in autonomous mode in BVLOS operations. Control, monitoring and surveillance of the UAVs are made from an operation control centre. Autonomous operations mean that during the execution of the mission, the remote pilot cannot intervene in the flight. Except the application of emergency procedures [18], [19]. The service can be provided only with autonomous operations because remote pilots can not control each UAV one by one during the fulfilment of the delivery. This nature necessitates further aviation safety requirements because safe operations must be ensured in all situations, even if unforeseeable obstacles, difficulties or malfunctions appear. Autonomous systems can identify and avoid static and moving obstacles (humans, animals, other drones or aircraft, cars, etc.) in the flight path without human interventions like self-driving vehicles. These operations can be performed only in the specific or certified category according to the EU regulations [18], [19]. These categories require that the operator has adequate operational authorisation issued by the competent authority. To gain this authorisation, the operator should comply with several technical, legal and operational requirements. During the operation of the service, the operator continuously has to prove the satisfaction of the safety requirement at the highest level. This over-regulation may limit the spread of drone delivery services in Europe.

6. Effects of drone delivery on the conventional player of the aviation

UAVs used for drone delivery use the same airspace as conventional aircraft but much lower. Conventional aircraft and UAVs can be separated because drones use airspace 50-150 meters above the ground, and other aircraft use much higher airspaces. However, there are situations when conventional aircraft use this low-level airspace, like in case of take-off and landing in the vicinity of airports or heliports and in case of special missions. Common airspace usage can result in conflict situations, near-bys and even collisions [25], [26], [27], [28], [29]. These risks are increasing with the growth of the number of applied UAVs. Implementing strategic mitigation measures can manage risks, but these measures cannot fully solve the potential risks independently that originated the common and joint airspace usage. The remaining risks originating from the operation of UAVs can be mitigated by using tactical and operative risk mitigation measurements [19]. Although risks cannot be eliminated, they can be lowered to a commonly accepted level.

Due to the emerging conflicts, a drone delivery service can be operated only with several restricting provisions in a metropolitan area in case of a complex airspace structure. These restrictions will temporarily or permanently limit access to this service from a spatial aspect.

By the analysis of the airspace over Budapest, it can be stated that the No Drone Zones and the national flight limiting regulations permanently exclude 60 km2 from the access of the service in Budapest. This permanently excluded area is 11% of the city, and the rest 89% may be the subject of temporary restrictions regularly.

7. Positive and negative effects of the service – summary of the main factors

Main issues and contributions are summarized in **Table 1**.

Table 1. *Main issues and contributions*

Positives	Negatives
- New service areas are evolving; - New technology solutions are developed; - A new mode of freight transport is applied; - The third dimension can be used for the transport of freight; - Transport is getting faster; - Inaccessible areas become accessible by this mean of transport.	- Limited accessibility to the service in certain areas; - Detailed regulation is needed; - Difficulties in the integration of conventional air traffic management; - Limited transport capacity (mass and range); - Not obvious savings in the operational costs; - Additional load on the environment.

III. Currently available best practises

1. Retail drone delivery services

Delivery by UAV is the most promising application of drones because they can avoid congestion, and transported goods can be delivered on the optimal and shorter flight path, so the transport needs less time than road transport. Several companies offer this service on limited territories even though this freight transport technology is in the experimental and early application phase.

Amazon Prime Air service got authorisation from the American Federal Aviation Authority in the summer of 2022. Based on the authorisation, Amazon can execute BVLOS delivery operations. Service is suited for the transport of limited goods in limited territories. It is available in Lockeford, California State, at locations in the 15 miles vicinity of the warehouse. The weight of goods is limited to 5 pounds. The covered area is approximately 2000 km2 [14]. According to the promises, the company can deliver the ordered parcels in one hour.

Beyond Amazon, DHL, Google, Mercedes-Benz and UPS are continuously conducting research and development activities to use UAVs in city logistics [20].

2. Non-commercial drone delivery solutions

Beyond the retail drone delivery services, there are special and unique UAV-based freight transport solutions with real added value. These services are used for non-commercial transport services at locations where road transport is not available due to its insufficiency. A state-of-the-art example of this solution is the operation when UAVs are used to transport medical equipment, life-saver medicines, vaccinations or other medical and biological samples in the countries of the third world at out-of-the-way locations. Fix-wing UAVs execute these operations because the delivery distances are generally longer than 50-100 km. Therefore operations are performed autonomously in BVLOS operations. This transport method is commonly used in the countries of the third world, and some companies are specialised in this.

Zipline Company executes these kinds of operations in Ghana and Ruanda in Africa, in Japan and in the United States of America. Fixed-wing UAV are deployed by a launcher and over the destination the parcel which is equipped with reusable parachute is dropped out from the UAV. After the drop, the UAV returns to the centre, where it is caught by a special net-based structure. Thus the physical operation infrastructure can be installed on the smallest area. Otherwise runway should be necessary for the operations. One centre can cover 22500 square km and one centre can control 20 UAVs simultaneously. UAVs have 160 km range, their cruising speed is 110 km/h and they can transport maximum 1.8 kg parcels [21], [22].

The solution of the Swedish EverDrone company is exemplary. It transports automated external defibrillators and other life-saver medical equipment by autonomously operated UAVs in BVLOS at those locations where they are needed in rural environments. Then, over the destination, the UAV lowers the life-saver equipment by rope, which allows the reanimation or the medical treatment before the arrival of the ambulance, thus increasing the life expectations of the patient [23], [24].

IV. PARTICIPANTS OF THE DRONE DELIVERY SERVICE

The following list contains the main participants of the service, with the major information:

- **Client** > the customer, who would like to buy the product with drone delivery.
- **(Web)shop** > who sells the products and stores in warehouse, from the drone can be launched for the delivery.
- **Drone delivery service providers** > who provide the delivery service and operate the drones between the warehouses and the destinations (with the service operation control centre(s)).
- **Maintenance service providers** > who provide maintenance services for the drones.
- **Network operators** > who provide the data transmission network between the drone and the operation control centres.
- **Authorities** > who provide the oversights and other compulsories in order to fulfil a safe drone operation.
- **System integrators** > who provide integration between the different information systems. It is important to operate the service, because it is fully automated and flight are conducted autonomously.

V. SUMMARY

Based on the presented challenges, it can be stated that the large-scale appearance of drone delivery services in retail will generate environmental protection, transport organisational, air transport related and several other problems. Moreover, they may cause more oversized loads globally than the new services' benefits. The benefit is the acceleration of the delivery, but they have further demand-generating effects, which accelerate and increase the challenges.

During the elaboration of UAV-based delivery service, the operator should plan who, when and how and for what purposes will use it. There are several application areas where these kinds of services have significant importance and where they can offer real added value. These services are the following:

- Emergency transport of medicines, medical and life-saving equipment, vaccinations, biological and blood samples, etc., at locations where the road infrastructure is not available or the quality of the infrastructure does not offer the appropriate road transport.

- Transport of biological samples and human organs between hospitals and laboratories if air transport provides more efficacious (faster and safer) transport than road transport.
- Transport of equipment and materials used by emergency, law enforcement, search and rescue services (e.g. bomb detection and deactivation devices, removal of dangerous materials, search for missing people, etc.).

These applications are examples of how UAVs can contribute to social well-being and security in several fields of life. New services and solutions will be available in the future. The development of the technology can't be stopped, but future applications will face new challenges and restrictions that are out of sight today.

Social and well-being aspects should be taken into consideration because the decreasing service fees and increasing accessibility of the service will result in massive needs. It will mean that many devices (UAVs) will fly over the cities in the low-level airspaces. Will society tolerate the noise pollution of the ever-moving, freight-carrying UAV traffic in the suburbs? Now, this seems like a utopian idea, but there may soon come a time when people can hear only the noise of UAS instead of the bees' buzzes and birds' songs when they are sitting in the garden.

AUTHOR CONTRIBUTIONS

Z. Sándor: Conceptualization, Experiments, Theoretical analysis, Writing, Review and editing.

DISCLOSURE STATEMENT

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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