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POSSIBILITIES OF USING DRONES IN HEALTHCARE IN TERMS OF THE SLOVAK REPUBLIC

Oliver Bubelíny, Milan Kubina, Juraj Šedík, Vincent Jedinák

Abstract

Information and communication technology means bringing solutions to both profitable and non-profit environments. The result is real-time data that can be evaluated, or more efficient communication. The last possibilities of the involvement of information and communication technologies in the management of the company also include drones. Drones are unmanned aircraft designed to obtain data or transport material. The article aims to point out the possibilities of using drones for the transport of medical material in the conditions of the Slovak Republic. The article describes the legislative restrictions on drones in Slovakia, their brief characteristics and division, as well as a specific case of solving the situation in the city of Ružomberok.

Keywords: *drones, UAV, health management, management*

1 THEORETICAL REVIEW

Unmanned aerial vehicles (also known as drones) can fly without a pilot on board. The literature also uses the acronym UAV (Unmanned aerial vehicle), UAS (Unmanned aerial system), or RPAV (Remotely Piloted Aircraft Vehicle. Unmanned aircraft can be operated autonomously or remotely controlled by a pilot (Gupta et al. 2013). Drones can be classified into classes based on various attributes, such as operating altitude, range, communication range, payload, aircraft size, the material used, and other attributes. Around the world, drones are used by military units, with each component using a separate classification due to specific parameters for tactical deployment. In general, drones can be divided by type weight, and maximum range. This division is used by manufacturers and researchers, and values may vary slightly (Singhal et al. 2018; Brooke-Holland 2015; Alghamdi et al. 2021; Arjomandi 2006; Ramesh and Lal 2020). Table 1 describes the distribution of drones by type, weight, and range.

Table 1 Distribution of drones by type, weight, range

Type	Weight (kg)	Range (km)
Nano	0,2	5
Micro	2	25
Mini	20	40
Light (ľahké)	50	70
Small (malé)	150	150

The typology of drones is one of the basic divisions. Drones can have many different styles or body shapes depending on the style of flight and the intended use:

- Drones with fixed wings - are built on the basis of conventional aircraft. These drones need a runway or must be thrown by hand or thrown off by another launcher to take off. Such drones also need a runway or must be caught by a net. Such a composition of drones with fixed wings has advantages in load capacity and longer flight time due to low energy consumption during gliding. (Alghamdi et al. 2021)

- Rotor drones - these are drones built by means of one or more motors installed on the arms, in direct proportion; higher stability equals more rotors. This type has the advantages of vertical takeoff and landing, it can also float in a steady position. Multi-rotor drones can fly in any direction and suddenly change speed, altitude and direction. However, these drones usually have a shorter communication range and flight duration. The multi-rotor body can be designed as a traditional helicopter, tricopter, quadcopter, or designed with different numbers of engines and arms. (Alghamdi et al. 2021)
- VTOL - this type is a hybrid of the two above styles. VTOL drones usually use multirotor for take-off, landing, and hovering. In the case of normal flight styles, they move horizontally with fixed wings. VTOL drones can be configured by attaching quadcopter rotors to fixed wings (e.g., Aerosonde HQ drone from Textron Systems). Other VTOL configurations include tilting rotors and tilting wings. For drones with a tilting rotor, some rotors on the wing tilt vertically and horizontally. An example is the Tiltwing UAV type, which has wings that are horizontal during flight, but in the case of vertical take-off and landing, the rotors rotate upwards. (Alghamdi et al. 2021)

However, the composition of the drone does not have to be strictly classified in one of the mentioned categories. Any autonomous e.g., a remotely operated aircraft that complies with aeronautical laws may form its own category.

1.1 Legislative terms for the use of drones in Slovakia

Within the legislative conditions for the use of drones, the Slovak Republic is bound from 1.1.2021 to apply Commission Implementing Regulation (EU) no. 2019/947. This regulation comprehensively unifies the rules throughout the EU for the use of drones or unmanned aerial vehicles and unmanned aerial vehicles.

The EU Commission Regulation contains 3 categories for the use of drones:

- Open category - Most hobby users fall into the open category. This means that they can operate flights without the need for any permission. Nevertheless, in the open category of operation, there is an obligation to register with the UAS register of operators and to carry out the relevant training and checking. In Slovakia, there is an obligation to register with the Transport Authority. This category contains three sub-categories, which are divided according to the weight of the drone and the distance from people and buildings. In all three sub-categories, the maximum flight altitude in uncontrolled airspace is 120 m. (Transport Authority 2019; Easa 2021)
- Special category - This category of use includes those drones that do not fall under the category of open operations. These are flights over 120 m, or flying in built-up areas and over people at a shorter distance than allowed by the previous sub-categories. This special category of operation is subject to an operating permit from the Transport Authority (Easa 2021).
- Certified category - The operation of a UAS in a "certified" category requires UAS certification according to Delegated Regulation (EU) 2019/945 and operator certification and, where applicable, the issue of a remote pilot license. Also, if, on the basis of the risk assessment provided for in Article 11, the competent authority considers that the risk associated with the operation is higher than described in the previous categories, it may transfer the user to that category. (Easa 2021)

1.2 Methodology

The aim of the article is to point out the possibilities of using drones for the transport of medical material in the conditions of the Slovak Republic. Content analysis of documents from primary and secondary sources was used to process the article. The primary sources are scientific publications in the field of drone use in for-profit and non-profit environments. This also includes resources from the area of drone operation legislation in Slovakia. Secondary sources complement the scientific views of the authors mainly on the parameters of individual drones. The method of modelling, creativity, synthesis, and comparison was used to process the specific situation in the city of Ružomberok.

2 POSSIBILITIES OF USING DRONES FROM RUŽOMBEROK CITY

The proposed solution is in the field of medical logistics in the last stage of delivery, also known (from the business sphere) as the last mile. The city of Ružomberok was purposefully chosen for the implementation of the proposed solution. As of 03.01.2020, the town of Ružomberok had 27,679 inhabitants (Batiz 2020). The city is divided into several parts, which are as follows:

- City districts: Biely Potok, Černová, Hrboltová, Vlkolínec, Rybárpole
- Housing estates: Baničné, Kľačno, Polík Roveň
- Other parts: Nová Černová, Nová Hrboltová
- Settlements: Hrabovo, Jazierce, Malinô, Podsuchá, Vyšné Matejkovo, Kosovo

The model solution is oriented to the city of Ružomberok, where the Central Military Hospital of the Slovak National Uprising Ružomberok is located on Gen. Street. Miloša Vesela 85/16 (point A) and specialized workplaces on Považská street 1380/2, 034 01 Ružomberok (point B). The simulated place of infection is the urban part of Rybárpole, where most of the marginalized Roma community lives in the area of the textile street (point C, figure 1).

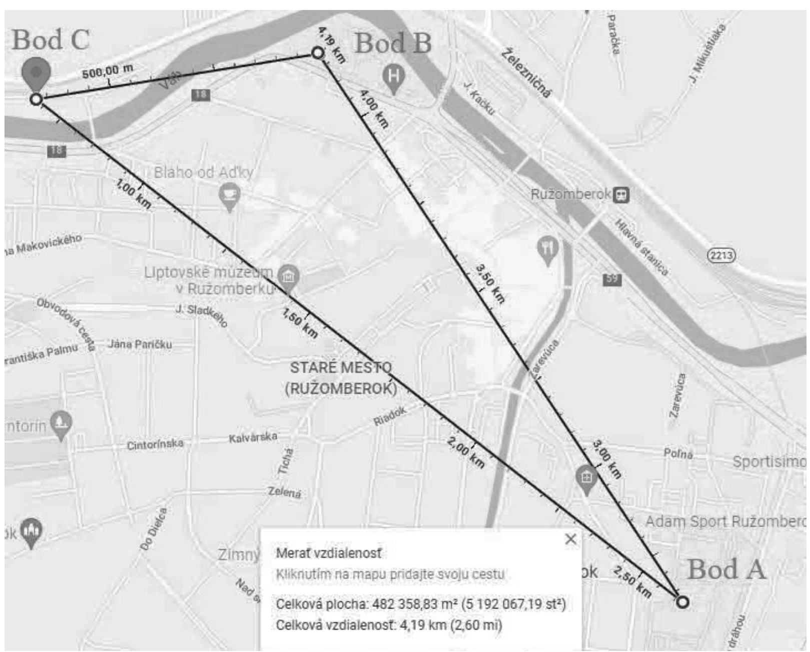

Figure 1 Distance between points

The choice of this locality is due to more demanding living conditions for the population, which is associated with lower hygiene, which forms the basis of various diseases, including the pandemic disease COVID-19. In the event of an outbreak of COVID-19 in this locality, it is important to close the whole area in quarantine, even if there is no absolute infection of the entire population.

2.1 Selection of an appropriate type of drone

The main advantage of implementing drones in testing is the elimination of medical personnel during the transport of biological samples. Other benefits include more flexible test kit deliveries and, in some circumstances, reduced costs.

Types of multi-rotor drones are suitable for the purposes of two-way logistics in an urban environment. The advantages of this type are better maneuverability, floating in a steady position, and performing specific tasks. Disadvantages include lower range (compared to other types of drones), lower speed, and higher sensitivity to external conditions. Multicriteria decision-making was used to select a suitable drone model. The development of the multicriteria decision-making method took place in the open-source program R with the help of the "AHPhybrid" package. Two qualitative and three quantitative criteria were set as criteria. The distribution of the weights of the criteria can be found in Table 2. Two options were chosen, namely the drone DJI Matrice 600 PRO and Matternet M2 V7.

Table 2 Distribution of the weights of criteria

Criterium	**Priority**
Customization / adjustment	0,463
Range	0,172
Timei in the air	0,158
Communication	0,153
Price	0,054

Individual weights were assigned based on the author's best judgment. The consistency ratio was set at 0.073. An acceptable consistency ratio is considered to be 0.10 or less (Liu et al. 2017).

The criterion of customization - the adjustment had a much higher weight compared to other criteria because in the case of helpfulness and cooperation with the given company, it is possible to find a tailor-made solution even in the case of a more drastic intervention in the integrity of the product. On the contrary, the price criterion was almost neglected, because the financial side of the project is purely within theoretical limits. The results of the analysis show that the M2 V7 drone is the best alternative for designing a model solution. The M2 V7 drone from Matternet is a specialized drone for laboratory logistics. Matternet is the developer of the world's leading logistics platform for urban drones. M2 drones have been flying over Swiss cities in BVLOS mode since 2017 in cooperation with the Swiss Post (Press 2021). To support maximum autonomy and minimize the intervention of participants in the logistics process, Matternet offers stations that, together with the Matternet M2 drone and cloud platform, enable safe and easy delivery using drones. Table 3 describes the individual specifics of this drone.

Table 3 Individual specifics of Drone M2 V7

Features	Drone M2 V7
Air type	Quadcopter
Drive	Electric motor
Maximum payload	2kg
Flight speed	10 m/s
Flight altitude	120 m above ground level
Control	GSM connection to Matternet Cloud for automated operations
Safety element	Automatically mounted parachute
Max range	20 km with 1 kg payload
Communication	GSM Cellular

The main advantages of the stations are increased security for participants in operations and minimal service skills. Stations do not have to have the same typology, on the contrary, different shapes and sizes of stations are required for specific solutions. Drones are also able to land on the roofs of cars (Rosenthal 2017). Author Sedov et al. developed a theoretical model for mass testing of the population with the help of drones. To carry out such a solution, M2 drones were also used to estimate the number of tests transported. It is estimated that the M2 drone can carry 100 tests (Sedov et al. 2020).

2.2 Model situation - use of a drone

After closing the area to quarantine, to the place of infection, i.e., point C, it is necessary to send a doctor which the biological samples will be performed and other procedures necessary to ensure the successful operation. After the decision to use the M2 drone to transport test kits, it is necessary to get acquainted with the current weather conditions, because the M2 drone cannot fly in stronger winds than 12 m / s and rain or icing conditions (Mattternet 2017). If the M2 drone is capable of flying in current weather conditions, it is necessary as a next step to meet the legislative requirements associated with the flight of the drone, which can mean notification to the transport authority of the intention to fly with the drone. After the consent of the Transport Authority, which is the administrative body, it is necessary to establish communication with the field worker, who should prepare the landing platform or station. After the successful establishment of the landing platform, the drone body can be filled with test kits. Subsequently, the drone M2 can leave the control center (point B) from the station resp. platforms. Since the flight is autonomous, after filling, no further interaction with the drone is required. However, it is possible to monitor the flight via the Matternet cloud platform. The M2 drone locates the station based on the internal systems and lands safely, without the help of the operator. The worker then safely removes the load from the drone. After unloading, the drone returns autonomously to the starting point.

The most important points are suitable weather conditions and permission from the Transport Authority to carry out the operation. Due to the fact that the M2 drone is fully autonomous, it is only necessary to ensure the processes related to the filling and emptying of the boxes carrying the test sets. The distance between point B (control point) and point C (point of infection) is about 636 meters, ie at a flight speed of 10 m / s, as specified by the manufacturer, the drone should cover the distance in question in 1 minute and 3.6 seconds. Transport by road takes about 4 minutes, depending on traffic. If necessary, the drone can intensively cover the distance of points B and C about 30 times, unless it is necessary to replace the battery.

The model solution can be extended by the place of evaluation of biological samples, which is in the object at the place marked by point A. The total distance is measured as the crow flies from point B (place of control) to point C (place of infection), then from point C to point A (place of evaluation), and finally from point A to point B. The total distance is 4.19 kilometres. The net flight time at a flight speed of 10 m / s between points should be around 6.9 minutes. Transport by road would take 13 minutes in ideal traffic. An extended model solution is also feasible.

3 CONCLUSION

The aim of the article was to point out the possibilities of using drones for the transport of medical material in the conditions of the Slovak Republic. The result was a model example of the use of a drone in testing the population for COVID-19 in the conditions of a closed area of the city. Modern information and communication mean thus bring new possibilities and new approaches to solving situations in the for-profit and non-profit environment. Drones represent an interesting tool for monitoring cities and other institutions for monitoring and data collection, but also for the possibility of transporting material. The use of drones in healthcare has its merits. Within the greatest benefits they will bring, it is possible to identify the speed of transport, facilitate transport, reduce the risk of contamination, and the minimum need for additional staff. On the contrary, it is currently possible to identify several negatives, such as the need for employee training, legislative gaps in the case of flights, the problem with bad weather conditions, and battery capacity. However, the presented article with a specific model case in the town of Ružomberok shows that the involvement of new technologies and drones in healthcare represents a completely new sphere of transport of medical supplies even at a time when the standard road network is significantly crowded. As part of the further expansion of the topic of drones in healthcare, it is possible to consider the possibility of distributing defibrillators (AEDs) to places where the patient needs them. Ultimately, drones and information and communication technologies can save a patient's life.

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