UNMANNED AERIAL VEHICLES IN OPERATIONAL ACTIVITIES – EXAMPLE OF SELECTED VOLUNTEER FIRE BRIGADE UNITS

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Abstract

This article presents the results of research concerning the use of Unmanned Aerial Vehicles (UAVs) in operations in selected Voluntary Fire Brigade (VFB) units. In addition to literature research, a survey method was used. A SWOT analysis was also carried out based on the answers provided in the questionnaires. The provided information shows that VFBs most often use UAVs for searching for missing persons, monitoring mass events, tracking illegal rubbish dumps, as well as during firefighting operations including monitoring of large area fires. Also noted were such cases of UAV usage as smoke surveys from chimneys, monitoring of internal fires, locating wild boar herds during African swine fever (ASF) or initial assessment of the health of an injured person. As part of the SWOT analysis, 12 strengths and weaknesses of the UAV were identified, as well as 5 opportunities and threats related to their implementation and application. The article ends with conclusions and recommendations for further research and implementation related to UAVs. This may serve to assure further development of this technology and give an overview of any pros and cons of its implementation in operational activities in the general security and safety sector, including rescue units.

Keywords: unmanned aerial vehicles, VFB, search and rescue groups, safety, drones

1. Introduction

Unmanned aerial vehicles (UAVs), which are colloquially known as drones, are aircraft that do not require a specialized crew on board – pilots, on-board technicians. They do not have the ability to take on board passengers either (Bukowski, Szala, 2018). Their entire operation and flight handling is done on the ground with the help of a trained pilot.

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The use of automatic systems is becoming commonplace these days, and in some situations a necessity. In the era of international crises and all sorts of hybrid activities, it is indispensable to include UAVs as an additional tool to fulfil specific purposes. Unmanned aerial vehicles are used to patrol the borders of the state, making it possible to seal them (Parczewski et al., 2021). They fulfil their role in warfare, which we can see on a daily basis during the ongoing Russia-Ukraine conflict, where the use of autonomous and automatic systems fulfils both the role of viewing the battlefield – exploration and reconnaissance activities, and in direct warfare, where drones and attached military equipment wreak havoc. Drone assistance in the case of organizing evacuation and all kinds of medical support is becoming increasingly common. This provides support not only for the military, but also for the civilian population, which during wartime may be sometimes cut off from the availability of means of survival, and very often in need of medical supplies (ts2space, 02.05.2023). Due to the nature of the battlefield, often the only means to get to those in need is to use a drone, which has been technically prepared in advance. The reliability of UAVs may also be seen in the context of conducting operations by search and rescue groups. With the right equipment, it is often possible to carry out the above-mentioned activities even in conditions where human access is impossible. The purpose of this article is to point out relevance that drones have in search operations. It is particularly important to point out any advantages and disadvantages of automatic devices observed in the course of research, and to draw conclusions that can serve to develop and, in some aspects, also improve the existing unmanned systems.

It stands to reason to point out that the way the Volunteer Fire Brigades use UAVs can help identify key technologies worth developing and integrating, as well as defining new areas of their use. The research will also identify gaps observed by the units with respect to relevant law, technology, procedures, etc. On the basis of the conducted research, it will not only be possible to disseminate best practices, but also to highlight issues related to the safe operation of UAVs in operations.

In this article, the authors focus on the activities of search and rescue groups in selected Volunteer Fire Brigades (VFB). The focus is primarily on UAVs, and where warranted and confirmed in the research it has been expanded to include the characteristics of other elements of the UAV – the possibility of using RGB cameras, thermal imaging cameras, sensors (chemical substances, radioactive radiation), the use of software to support operations and additional mechanisms that allow, among other things the transport of necessary items and airdrop at a specific location. UAVs can also support each of the four phases of emergency management: mitigation, preparedness, response, and recovery, which was shown in Figure 1.

For the purposes of the research, it has been assumed that the term "operational activities" is understood as all activities of a uniformed formation (in this case – Volunteer Fire Brigades units) aimed directly at combating and/or minimising a threat to life, health, property or the environment. A characteristic of those

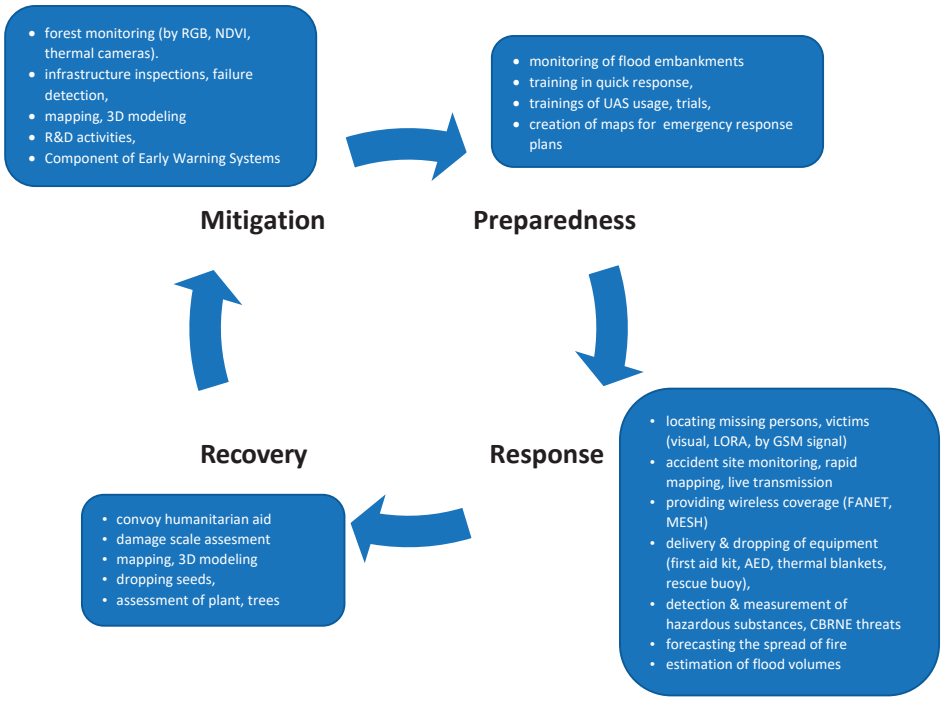

Figure 1. Opportunities for UAV use during each phase of emergency management

activities is the necessity of making quick decisions – under time pressure, with a sudden influx of a large amount of information in a short period of time, sometimes in an unknown terrain, in difficult, dynamic, long-lasting and unpredictable conditions putting a psychophysical strain on the firefighter-rescuer body. Operational use of the UAV requires, among other things:

- access to and use of approved, certified, autonomous positioning systems – GNSS (Global Navigation Satellite Systems),
- preparation of flexible airspace elements (Restricted Zones, geographic zones – DRA).
- relevant global, European and national legal and technical regulations (conditions and rules for operation, training, maintenance of continuing airworthiness, legal liability, supervision).
- appropriate properties and performance characteristics of the Unmanned Aerial Systems other than for civil/commercial use,
- providing maintenance (readiness of unmanned systems/platforms to perform tasks),
- highly qualified and competent UAV pilot (Pilot-in-Command – PIC), commanders, observers, image technicians/analysts, planners.

2. Specifics of Volunteer Fire Brigades (VFB) operation – example of search and rescue operations

Volunteer fire departments are uniformed, equipped with specialized equipment designed to fight fires, natural disasters or other local threats including carrying out specialized rescue operations as well as search operations, fire protection units (Polish Journal of Laws of 2023, item 194). Although in light of the legal regulations in force in Poland, the leading entity in the conduct of search activities is the police, this type of activities commonly involve the participation of forces and resources outside the police (Kochańczyk, Fellner, 2019). The entities to be singled out here are: units of the State Fire Service, the aforementioned volunteer fire brigades, as well as mountain volunteer rescue teams, specialized search and rescue groups or other entities orchestrated by the Police such as the Air Volunteer Rescue Service (Facebook, 07.05.2023). As indicated in the scientific literature (Podlasiński, Spinek, Ciekanowski, 2023), the area of joint activity of the police and fire departments is in particular search in open areas, during which Commercial Off The Shelf (COTS) UAVs equipped with RGB and thermal cameras, rangefinders, strobes and directional lights are used (for example: DJI M30T, DJI Matrice 300 RTK, DJI Matrice 200/210, DJI Mavic 2 Enterprise, DJI Inspire, DJI Phantom 4, Autel Evo II). As of 20.02.2023, 41 VFB units with drones were identified. These are units which, in addition to their normal activities in this area, have the possibility of extending their competences to include additional activities – search, observation of forest areas during heightened states of alarm of fire danger in the forest. These can also be tasks delegated by local government institutions, i.e. detection of exhaust fumes emitted from chimneys of houses or workplaces.

It should be noted that a relatively large number of studies have been carried out in scientific literature on the use of drones in disaster management (Restas, 2015; Daud, 2022), search and rescue operations (Karaca et al., 2018; McRae, 2019) or in firefighting (Partheepan et al, 2023; AL-Dosari, 2023). The research focuses also on optimising algorithms for flight planning, image and video analysis, drone swarm missions (Alsammak et al, 2022).

In search and rescue operations, the speed of response of the emergency services is a very important factor, especially in terms of reaching the scene and quickly identifying the threat (Atif, Ahmad, Zhao, Rodrigues, 2021). At this point it is necessary to have a closer look at the totality of the processes that occur from the occurrence of a hazardous phenomenon, through the response phase up to the action intended to neutralize the threat. A look at the totality of the aforementioned processes can also be seen through the interaction of the units involved in search and rescue operations and their equipment capabilities. In this context, the leading units are the State Fire Service and the Police, which systemically have specific tasks assigned to them, the relevant procedures outlined and trained personnel. Nevertheless, volunteer firefighting units should increasingly become involved as additional forces to assist in search and rescue operations.

The specific nature of operations, especially search and rescue operations, determines the need for long-distance flights in an unknown terrain (fields, meadows, sparsely populated areas, etc.). Both pilots and equipment should be ready, if necessary, to quickly change the flight type from VLOS (Visual Line of Sight) to BVLOS (Beyond Visual Line of Sight). Regulations should also allow such a change.

The international context of the issue taken up is not insignificant. In terms of operational capability, it should be stated that, in accordance with Regulation (EU) 2018/1139 of the European Parliament and of the Council of 4 July 2018 on common rules in the field of civil aviation and establishing a European Union Aviation Safety Agency, its provisions state that EU regulations shall not apply to: 1) aircrafts while carrying out search and rescue, firefighting or similar activities, as well as 2) personnel and organizations involved in the activities and services performed by those aircrafts (Regulation, 2018). However, it is possible for Member States to apply this Regulation (instead of their national law) to aircraft carrying out search and rescue, firefighting or similar activities. Member States making use of this possibility should cooperate with the Agency, in particular by providing all the information necessary to confirm that the aircraft and activities concerned comply with the relevant provisions of this Regulation.

3. Methodology

In order to present the issue of the use of UAS in the operational activities of volunteer fire departments in the most complementary way, several research methods have been adopted. The first research method used was an analysis of literature, i.e. available scientific sources, industry literature on drones, their construction, technical aspects and the possibility of equipping them with state-of-the-art equipment allowing the implementation of VFB operations, such as search missions. For the purposes of desk research, the authors searched scientific databases and repositories such as: Web of Science/Clarivate, ScienceDirect, Google Scholar, BASE (Bielefeld Academic Search Engine), Centre for Open Science (CeON Centre for Open Science), and OpenAire. It should be very clearly emphasised that only a few articles on the use of UAVs in volunteer rescue units were reported during the literature review (Domanski, 2022; Niedzielski, 2022; Miętkiewicz, 2020).

It also proved to be a good source of cognitive knowledge on the topic in question to follow news about drone operations, which were posted on national and local news sites, websites of VFB (Facebook, 10.05.2023) units and their social media profiles (Facebook, 10.05.2023). This complemented scientific knowledge, including theoretical data, as the websites and social media posts often included news describing the practical use of UAVs during real operations, exercises or training, supplemented by valuable photographs and video footage. As mentioned earlier on,

the article presents preliminary research aimed at bringing the topic of drones to VFB. In this way, the authors wanted to encourage people to share the knowledge they have gathered by taking part in the research, in order to show new insights into the technology in question and its usefulness in all operations in the future.

A better study of the phenomenon of the use of UAV in search and rescue operations dictated the use of a survey research method. Surveying is one of the most common research methods owing to the possibility of studying a specific target group (Stryjewski, 2018). The purpose of the method chosen by the authors was to check the way in which VFBs with drones use them for rescue operations and what is their opinion about advantages and disadvantages of these devices. What is more, the period of the COVID-19 pandemic ended in the year of the study. For this reason, it was decided that this was the perfect time to verify whether – and possibly how – the UAVs were used to reduce or combat its effects.

The survey form consisted of six questions. One of them was a metric, indicating the VFB unit from which the survey was obtained. The other five questions were:

1. *For what purpose was the UAV deployed to the unit?*
2. *What activities are being undertaken with the use of the UAV?*
3. *In the context of the COVID-19 pandemic, were there any activities implemented using the drone? If so, please indicate which ones, and if not, in your opinion, can UAVs be used for pandemic-related activities and why?*
4. *What are the advantages of using UAVs in operational activities?*
5. *What are the disadvantages of using UAVs in operational activities?*

The answers, obtained from drone operators from volunteer firefighting units, were used to see how unmanned aerial systems are used and for what purposes they serve volunteer firefighters. One of the questions included an indication of the COVID-19 pandemic. According to the authors, the question relating to the pandemic is very important owing to the possibility of acquiring further knowledge of the use of UAVs to combat its effects. This assures an expansion of available knowledge, so that researchers of the topic may be able to have a broader view of the described technology and its adaptability to the indicated activities.

It was decided that the research was to be supplemented by a SWOT analysis extracted from the survey responses.

3.1. Description of the group of respondents

While devising this article, the authors endeavoured to enlist the cooperation of volunteer fire departments that have drones in their possession. To this end, with the help of available sources for contact: Facebook, Instagram or telephone contact, an attempt was made to conduct a survey. A survey form was developed and sent to 41 VFB units working with UAVs. The survey was conducted in the period of 22.11.2022 to 12.03.2023, and 8 completed forms have been received. The units that responded are shown in table number 1

Table 1. VFB units that participated in the survey

No.	Until name	Date the survey was sent by VFB
1.	VFB Boguszów	21.11.2022
2.	VFB Chełmek-Osada	20.02.2023
3.	VFB Jarogniewice	23.11.2022
4.	VFB Kłobuck	20.02.2023
5.	VFB Kunice	25.02.2023
6.	VFB Niegoszowice	23.11.2022
7.	VFB in Dobrzyca	20.02.2023
8.	VFB in Jantar	12.03.2023

Work on UAV studies in search and rescue operations in VFBs began in November 2022. The first research forms obtained – from VFB Jarogniewice, VFB Boguszow and VFB Niegoszowice – were used to prepare a presentation at the International Scientific Conference "Technological, Technical and Strategic Innovations in Rescue" organized on December 5–8, 2022 by the Main School of Fire Service and the Lviv State University of Life Safety. In order to implement the article, attempts were made to get more units to cooperate. Due to communication difficulties and the lack of willingness to cooperate, resulting from, among other things the lack of motivation to share their achievements using UAVs, especially in an operational context – this research should be treated merely as preliminary. It is intended to show that the use of unmanned platforms by VFBs in operational activities exists and to identify specific areas in which it is used. It represents a case study on drones by VFB, which can be developed by involving the cooperation of other units and in such a way gaining new experiences.

4. Results

The research required for the article was started in November 2022 and completed in March 2023. To fully demonstrate the usefulness of drone technology deployed by VFB, it is worth examining in detail all questionnaire responses received from VFB. A 41 questionnaire was sent to units with UAVs. The willingness to cooperate was expressed by 8 VFBs. The results of the survey are as follows:

1. For VFB Boguszow, the motivation for deploying the drone was a desire to improve the quality of rescue and firefighting operations, with particular focus on the work of firefighters in mountainous areas.
2. For the Chelmek-Osada Volunteer Fire Department, on the other hand, it was first of all important to properly secure operations in water areas, forests and hard-to-reach areas.

3. VFB Jarogniewice treats the drone as an additional "tool" to be used in search for missing persons in an open terrain. In addition to the drone itself, it also incorporates the innovative "SARUAV" software. This software allows searching for missing persons with the use of drones. Thanks to it, it is possible to plan a search mission and to detect automatically missing persons on aerial photos taken in advance (Dilectro, 10.05.2023).
4. In VFB Klobuck the drone could be deployed thanks to the kindness of one of its members. The purpose of the deployment is similar to the rest of those mentioned above and also focuses on search and reconnaissance activities.
5. A slightly different use of the drone is at the VFB in Kunice. The UAV is mainly used during large-scale outdoor fires due to the large amount of forest and wasteland in this locality.
6. The VFB in Niegoszowice is motivated in implementing the drone technology in a desire to seek new solutions in rescue. An additional incentive is the possibility of encouraging young people to join the ranks of volunteers – a technological stimulus to promote and implement the development of necessary techniques in rescue in the broadest sense.
7. The VFB in Dobrzyca uses its drone to support the tasks of other uniformed formations – mainly it is the Police and the State Fire Service. This is the main motivation for the adaptation of an unmanned platform.
8. The last VFB in Jantar associates the drone technology with the hope of improving the efficiency of operations, especially in the context of searching for people.

When asked about activities that are carried out by unmanned aerial vehicle, the surveyed units indicated among others: firefighting activities, search for missing persons, monitoring of large-scale and internal fires, illuminating the scene from the air and creating situational maps for rescue operations. The full list of answers is provided in the table below. In addition, for comparison purposes, the responses of volunteer firefighters were compared with the opinions of firefighters from the State Fire Service (Fellner, 2023; Kłoczewiak, Koczkodaj, 2023).

Some units reported the use of a UAV for prevention activities related to the COVID-19 pandemic. The use of UAVs for this purpose mainly involves observation of places commonly frequented by people. During the pandemic, Poland had restrictions in place, requiring citizens to observe, among other things social distancing, covering their mouths and noses in public places and prohibiting assembly. The drone was mainly used to monitor citizens' compliance with the imposed regulations (GoHero, 10.05.2023).

Volunteer firefighters used unmanned aerial vehicles to help police and traffic wardens control breaches. In the case of VFB Jarogniewice, it was to assist the Police in checking places of illegal groupings of people. A properly retrofitted UAV can be used for tasks typical for crisis management – broadcasting messages to indicate how to behave at the time of danger. This requires arming the UAV with high-pitched speakers.

Table 2. List of actions and purposes of UAV usage – opinions of firefighters from VFB and State Fire Service

No.	Volunteer firefighters	Firefighters from the State Fire Service (Fellner, 2023)	Firefighters from the State Fire Service (Koczkodaj, 2023)
1.	rescue operations during a search for missing persons in afforested areas, swampy areas, bodies of water	visual and thermovision observation of the direction of movement of the fire front,	assisting the ground unit in finding the access road to the fire site
2.	firefighting activities	assistance in making fire lines when overcoming terrain obstacles,	easy driving of cars thanks to operational numbers visible on the roof of the vehicle
3.	cooperation with the Police and the Municipal Police in carrying out their operational tasks	monitoring the burnt area, determining the points of possible ignition sources of the fire,	checking the fire area, marking it on the map
4.	in the case of VFB Chelmek-Osada, these are activities in the area of sea beaches – Stegna, Jantar, Sztutowo, Krynica Morska	coordination of the company activities during firefighting operations,	command support by viewing activities from any camera in real time
5.	monitoring of mass events	maintaining constant correspondence with the commanders of individual combat sections, directing rescuers to the sources of fire, warning against further fire outbreaks,	searching for people in the water – the use of high-resolution thermal imaging cameras and proper image interpretation allows quick finding a person in water
6.	tracking down illegal landfills – important from the point of view of widely understood environmental protection and prevention of landfill fires, where there is a very high risk of toxic substances spreading in the air	verification of the effectiveness of firefighting operations.	
7.	interaction with the Forest Service during African swine fever (ASF) – the drone was used to locate herds of wild boar		searching for missing persons using a thermal imaging camera and a high-quality camera with hybrid zoom
8.	monitoring of large-scale fires		Illumination of inaccessible terrain using a lamp mounted on a drone

table 2 cont.

No.	Volunteer firefighters	Firefighters from the State Fire Service (Fellner, 2023)	Firefighters from the State Fire Service (Koczkodaj, 2023)
9.	monitoring internal fires using a drone with a built-in thermal imaging camera – detection of fire embers, fire sources invisible to rescuers		using a laser rangefinder to determine the exact position of the searched object
10.	development of situational maps for rescue operations		the camera with a large zoom allows making observations from a long distance
11.	verification of the site of a construction disaster		monitoring the safety of rescuers during major fires, especially on roofs or in large spaces
12.	using UAV for preliminary assessment of the condition of an injured person		checking the temperature on the roof with a thermal imaging camera, which helps to avoid accidents of rescuers
13.	illuminating the scene from the air		using flighthub 2 for effective mission management and information distribution, including map annotations and
14.	belaying rescuers in conventional operations		adapting rescue operations
15.	use for monitoring exhaust fumes emitted from chimneys of single-family houses and workplaces – a set of sensors for measuring air pollution concentrations was installed in the drone to identify particulate matter, ozone and hydrocarbons		creating fire analysis maps to better understand the situation and improve future rescue efforts
16.			Inspecting disaster sites, such as collapsed buildings to assess the situation and identify hazards in inaccessible places to rescuers

4. SWOT analysis of the legitimacy of drone use in search and rescue operations

Further questions in the survey form concerned the identification of strengths and weaknesses in the use of UAVs in operations. For this purpose, the SWOT analysis method will prove helpful, where: **S** – Strengths, **W** – Weaknesses, **O** – Opportunities, **T** – Threats.

SWOT analysis is one of the most widespread methods of strategic analysis (Luft-Noworol, Durasiewicz, 2008). As regards the identification of advantages and disadvantages of drone technology adopted by the VFB, use was made of the results of surveys conducted in selected units and our own knowledge and observation. The synthesis of the two components will help illustrate any excellence and imperfections, risks and opportunities brought by using a drone in the fire department. The answers given in the survey were compiled and aggregated. Repetitive and synonymous statements have been removed. A comprehensive SWOT analysis is presented in Table 3.

Table 3. SWOT analysis of the use of UAVs in operations

No.	Strengths	Weaknesses
1.	easy operation	limited coverage in urbanized areas
2.	fast operation	limitations due to weather conditions
3.	possibility of "live" video transmission	relatively short battery life
4.	precision in searching designated areas	limited flight range
5.	constant supervision of the development of the fire situation	high purchase cost
6.	ability to quickly find the threat	high cost of purchasing batteries
7.	mobility	expensive additional components
8.	very good visibility of the field of action	limited possibilities of retrofitting accessories
9.	ability to explore a large area in a short period of time	depending on the model, long flight preparation time
10.	ability to carry loads	relatively low carrying capacity – depending on the model
11.	possibility of installing additional equipment – thermal, RGB cameras, detectors, sensors	expensive software to support search and rescue operations
12.	possibility of developing situational maps	expensive costs of possible repairs, and in extreme cases clearly unprofitable

table 3 cont.

No.	Opportunities	Threats
1.	supporting the activities of search and rescue groups	unreliability of equipment
2.	promoting drone technology	possible destruction of objects by accidents in the air
3.	transfer of modern technologies in the activities of volunteer fire departments	replacing people with modern technology may lead to a decline in the quality of search and rescue operations
4.	motivation for volunteers to gain knowledge on the use of modern technologies	dangers during flight – possible collisions into other flying objects
5.	people trained in the use of unmanned aerial vehicles can be useful for other purposes related to their use	hazard of being used not only for operational purposes of volunteer firefighters – risk that illegal actions would be undertaken

This SWOT analysis is intended to identify the crux of the implementation of unmanned aerial vehicles in VFB operations. Its usefulness will be seen especially in the context of planning the use of UAVs for highly demanding operations. This will be possible thanks to the identification of the strengths and weaknesses of use in the course of the SWOT analysis. The aforementioned analysis may prove useful for units that wish to deploy drones. In this case, its indications will direct any pros and cons of drone technology being used for operations. Importantly, it will also provide opportunities to expand the existing knowledge and may prove to be the impetus for the application of the technology or its complete rejection. To summarize the usefulness of applying SWOT analysis in this article, it can be assumed that:

1. it is useful in the context of recognizing the strengths of drone technology, especially in the context of using it for VFB organizational and operational purposes;
2. identifies the main shortcomings and obstacles to the use of drones – their technical weaknesses, difficulties in use in harsh weather conditions;
3. points out the potential opportunities that the implementation of drones would provide – in terms of the possibility of expanding the competence of the VFB and strengthening the readiness for search, rescue and reconnaissance operations;
4. identifies the potential risks posed by the application of modern unmanned technology – in close reference to possible dangers such as use in areas prohibited by law, the possibility of an accident with another object in the air or on the ground, and misuse.

5. Conclusions

The development of modern technology, particularly drones, brings many advantages, benefiting both those who use them and those for whom they provide some form of support in emergency situations. Analysing the use of drones in selected VFB as an example, the authors focused also on the motivations behind volunteers' introduction of drones into operations. Despite the fact that the technology is nothing new, especially its use, the authors encountered adversity – this mainly concerned the lack of willingness to cooperate in the research. On the other hand, the compiled research results have proven to be very useful in the preliminary exemplification of the phenomenon through a case study. In our opinion, all the collected information will serve for further work on the use of unmanned platforms in all kinds of rescue activities.

At this point, words of appreciation are due to the volunteer firefighting units that took part in our experiment. Their expansive knowledge, backed by many years of practice, has contributed to the formulation of preliminary analyses that will promote modern unmanned technologies, pointing out their strengths and weaknesses, as well as the opportunities and risks that may arise during use. It will also give food for thought to future, as yet undecided VFB units, as the results of our research mainly focus on showing a positive picture of the technology. Undoubtedly, among such ascertained advantages is the fact of having modern technology at disposal, meant to support to a very large extent the execution of effective operations. The survey identified 15 different types of UAV applications in VFB activities. It is worth emphasising that it goes far beyond those defined or proposed by equipment manufacturers. Unmanned aerial vehicles are devices whose task is to effectively explore large areas of land where operations are being carried out. Their great advantage is their adaptability to current operations. As mentioned earlier, thermal cameras, RGB cameras, high-resolution cameras, sensors for measuring air contamination and motion sensors can be added to UAVs. A major benefit of owning a UAV is the possibility of developing a volunteer firefighting unit. UAVs need properly trained people to operate them. After training, the VFBs unit gains rescuers with expanded competencies. As an effect, the VFB's combat potential and usefulness in the general system of civil protection become increased. Focusing on the negative sides of the use of UAVs, it should be mentioned that usually any shortcomings are usually due to poor technical preparation and practical training in their use. From the technical viewpoint, referring to the typical disadvantages of UAVs, the conducted research has shown that they mostly concern the issue of purchase price and operation. The purchase of an unmanned aircraft is not the cheapest. Models that are suitable for professional guidance cost tens of thousands of zlotys. A significant obstacle that can hinder the implementation of an unmanned system is the relatively high cost of operating the technology. It is also worth mentioning that the application of modern technologies in VFB formations guarantees strengthening of the entire rescue operation in Poland, as it currently accounts for about 700 thousand volunteer

firefighters (including units in the National Firefighting and Rescue System and outside the system)(ppoż.pl, 10.05.2023).

It is clear that the 19.5% return rate of surveys does not justify attributing the findings of this study to all VFB units. With each subsequent month and year, there will be more and more entities deploying UAVs in service. That is why it will become necessary to repeat the research, involving more units. Nevertheless, the research provides insight into the operational use of UAV by Volunteer Fire Brigades units, which is not often addressed in the scientific literature. In the subsequent papers, it is proposed to use firstly the strategic analysis TOWS ("from the outside of the unit to its inside") instead of SWOT ("from the inside of the unit – to the outside"). This can show even more clearly how the external environment affects the firefighting unit.

The authors are aware that the research conducted in article does not cover the entirety of issues related to the operational use of UAVs in Volunteer Fire Brigades. In subsequent research, whether executed by surveys or the Delphi method, it is reasonable to identify key technologies that accelerate rescue operations and enhance their safety, and to try out new applications of UAVs – and other remote technologies – during workshops and exercises.

An interesting direction of research may be an in-depth analysis of gaps, barriers and obstacles faced by Volunteer Fire Brigades units. This is applicable to difficulties not only in the operational, procedural or technological dimension, but also in financial, legal and logistical terms. It might also be worthwhile to analyse in the future the impact of using drones by volunteer rescue formations on social acceptance of such technology.

Taking into account the international context, comparative studies of volunteer units from different EU countries and the rest of the world should be indicated as a further interesting research area. This will most likely enable the acquisition of new knowledge and revision of the research results obtained so far.

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BEZZAŁOGOWE STATKI POWIETRZNE W DZIAŁANIACH OPERACYJNYCH – PRZYKŁAD WYBRANYCH JEDNOSTEK OCHOTNICZYCH STRAŻY POŻARNYCH

Abstrakt

W artykule przedstawiono wyniki badań nad problematyką operacyjnego użycia bezzałogowych statków powietrznych (BSP) w wybranych jednostkach ochotniczych straży pożarnych (OSP). Prócz badań literaturowych posłużono się metodą badań ankietowych. Przeprowadzono także analizę SWOT, bazując na odpowiedziach udzielonych w kwestionariuszach. Z udzielonych informacji wynika, że jednostki OSP najczęściej stosują BSP do: poszukiwań osób zaginionych, monitorowania imprez masowych, namierzania nielegalnych składowisk śmieci, a także podczas działań gaśniczych, w tym monitorowania pożarów wielkopowierzchniowych. Odnotowano także przypadki użycia BSP do badań dymu z kominów, monitoringu pożarów wewnętrznych, lokalizacji stad dzików w czasie afrykańskiego pomoru świń (ASF) czy wstępnej oceny stanu zdrowia osoby poszkodowanej. W ramach analizy SWOT wyspecyfikowano po 12 mocnych i słabych stron BSP oraz po 5 możliwości i zagrożeń związanych z ich implementacją, użytkowaniem. Artykuł zwieńczono konkluzjami i rekomendacjami dalszych kierunków badań i wdrożeń w obszarze UAV. Może to przysłużyć się dalszemu rozwojowi tej technologii oraz dać pogląd na wszelkie za i przeciw jej implementacji do działań operacyjnych w sektorze bezpieczeństwa powszechnego, w tym jednostkach ratowniczych.

Słowa kluczowe: bezzałogowe statki powietrzne, OSP, grupy poszukiwawczo-ratownicze, bezpieczeństwo, drony