

**USE OF UNMANNED FLYING SYSTEMS
IN ACTIVITIES OF VOLUNTARY FIRE SERVICE FOR SAFETY OF LOCAL
COMMUNITY**

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ABSTRACT

Unmanned systems (marine, airborne and land-based) represent a rapidly growing market. They find more and more applications and are already used not only in the military but also in activities related to a broadly defined security. The purpose of this paper is to indicate areas of operation of unmanned UAS flying systems in the operations of the Voluntary Fire Services on the example of the unit in Charzykowy. The paper defines the strengths and weaknesses of using such systems in activities carried out in the difficult forested area of the Tuchola Forest, crossed by numerous lakes and rivers. A special role is played here by the description of actions carried out in response to the occurrence of extreme weather phenomena in Pomerania in August 2017. As shown by the research carried out, unmanned aircrafts can be successfully used in the structures of services involved in the estimation and removal of the effects of natural disasters and a number of other missions.

Keywords: unmanned aerial systems, UAS, security

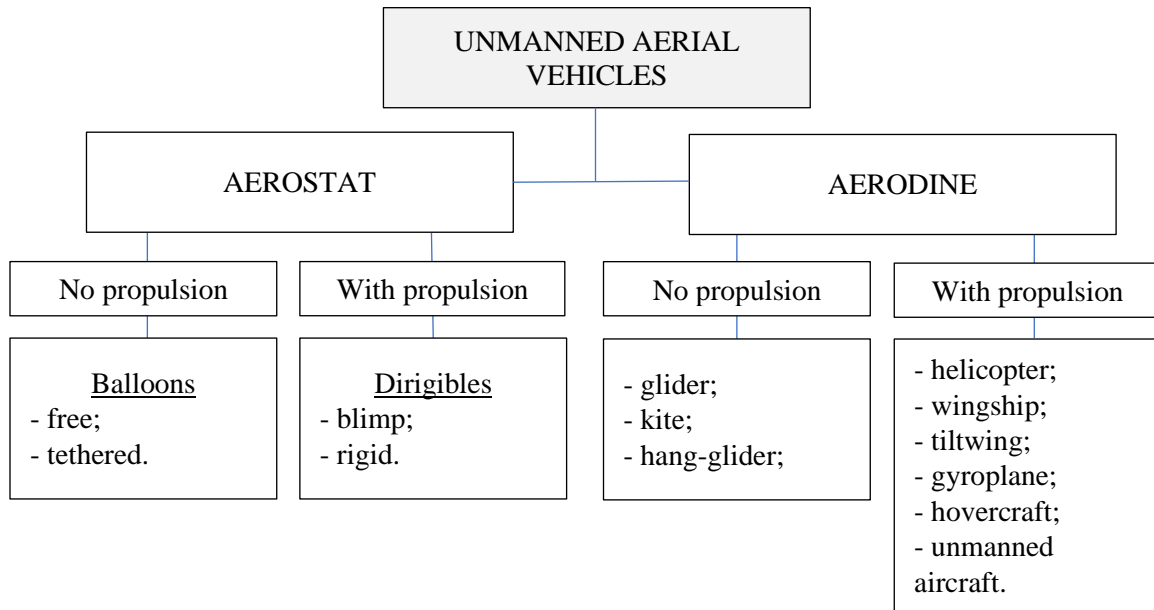
INTRODUCTION

Unmanned systems, otherwise known as autonomous systems, are currently undergoing very dynamic development and their range of applications is constantly expanding. Security services are increasingly using autonomous systems to carry out tasks that require long-term observation, supervision, or to increase the level of staff safety (distancing the operator from the source of threat). Such systems, characterised by high efficiency, are subject to intense evolution of propulsion systems, power supply subsystems, on-board equipment and, due to artificial intelligence, the ability to perform increasingly complex tasks independently. The aim of this study is to present the results of research concerning the use of Unmanned Aerial Systems (UAS) or Unmanned Aerial Vehicles (UAV) in the structures of a selected unit of Voluntary Fire Service (VFS), on the example of Charzykowy VFS. The author decided to devote special attention to activities aimed at combating the effects of extreme weather events that took place in the northern provinces of the country in early August 2017. Secondly, the author aims to identify the strengths and weaknesses of the use of this type of technology. For the purpose of the study, a rich review material (reports from the course of action) and photographic documentation of the activities described in the article presented were collected. At this point the author would like to express his thanks to Łukasz Kwiatkowski of the Charzykowy VFS, who shared his experience with using the UAS in activities aimed at improving the safety of inhabitants of the Chojnice district.

1. Short introduction to UAV

In the literature on the subject, there are many terminological names related to unmanned aircraft. In AAP-6 we find phrases such as *Remotely Piloted Aircraft (RPA)*, which describe an aircraft driven from a remote control station by an operator trained and certified in accordance with the standards set for manned aircraft pilots. These platforms are part of the Unmanned Aerial Systems, i.e. systems consisting of an unmanned aircraft, a support system and all the equipment and personnel necessary to steer the Unmanned Aerial Vehicle (AAP-6, 2014). This has resulted in a number of classifications and breakdowns, one of which is presented in Fig. 1.

Figure 1. UAV breakdown (one of several available in the literature)



Source: (Leśnikowski, 2016).

NATO has introduced its own classification of unmanned aerial systems (UAS). It includes several classes of units (weight) and categories defining airborne equipment. The classification also indicates the range of ceilings and the range of operational use together with examples of designs. It also defines the application of UAV at different levels of operation (strategic, operational, tactical) (ATP 3.3.7, 2014).

The development of unmanned technologies has led to the undoubted advantages of UAV also being recognised by the State Fire Service as well as the Volunteer Fire Service. The main areas of application of the new platforms are (*Drones...*, 2017):

- monitoring large-area fires,
- inspections of buildings threatening to collapse,
- reconnaissance and command in rescue and firefighting operations,
- monitoring the state of the environment to ensure maximum safety for human teams,
- detecting hidden fire embers,
- looking for people with the use of thermal imaging,
- securing mass events (scouts' rally on Sobieszewo Island in 2018),
- monitoring of hydrant networks and prevention of illegal water intake (problem of rural municipalities),
- improvement of the command process.

Charzykowy VFS is equipped with a drone (quadcopter) - Phantom from DJI (Phantom 4 Pro) with a range of up to 7 km and a flight speed of up to 72 km/h and a maximum flight time of 30 minutes. The main features desired in the course of the daily operations of voluntary units include: almost instantaneous readiness for operation, low weight of the system which makes it easy to transport, the fact that it may be controlled by a single operator, and online video transmission providing a quick view of the situation at the incident site.

Photograph 1. Phantom 4 Pro Quadcopter from DJI



Source: www.dji-ars.pl/dji-phantom-4-pro-v2-0-refurbished.html. (02.04.2020).

2. UAV in VFS activities

The Voluntary Fire Service Unit in Charzykowy is located in the Chojnice district in the area of Bory Tucholskie. The beginnings of activities of the formations the purpose of which was to help inhabitants of areas affected by natural disasters in this region can be found in the second half of the 19th century. As a result of many years of work, training and huge involvement of volunteer unit leaders and the local community (providing equipment with appropriate parameters), in 1994 the unit was incorporated into the structures of the National Rescue and Firefighting System. The unit described belongs to one of the most active formations of this type in the district. Today, the unit has one heavy rescue and firefighting vehicle (GCBA 5/42 MAN TGM 18.340) and two light rescue and firefighting vehicles with the technical and road rescue function (SLRr - Ford Ranger, body by Frank Cars) and GLBA Rt Ford Transit. The Charzykowy VFS is also equipped with a Whaly 435 Evinrude 40 HP motorboat and an aluminium hull boat (osp.charzykowy.pl, 01.04.2020).

The objectives and tasks of the Charzykowy VFS are included in its statute and encompass (Statute of the Charzykowy VFS):

- activities aimed at fire prevention and cooperation with the State Fire Service, local government authorities and other entities in this respect,
- participation in rescue operations carried out during fires, environmental threats and other disasters and incidents,
- informing the population about existing fire and environmental risks and ways of protection against them,
- promotion of physical culture as well as sport, cultural and educational activities,
- performing other tasks resulting from fire protection regulations;
- environmental protection activities,
- supporting the development of local communities.

The specific terrain, a significant part of which are forest areas with a large number of large lakes and rivers, influences the nature of activities undertaken, which include (according to the history of events in 2018);

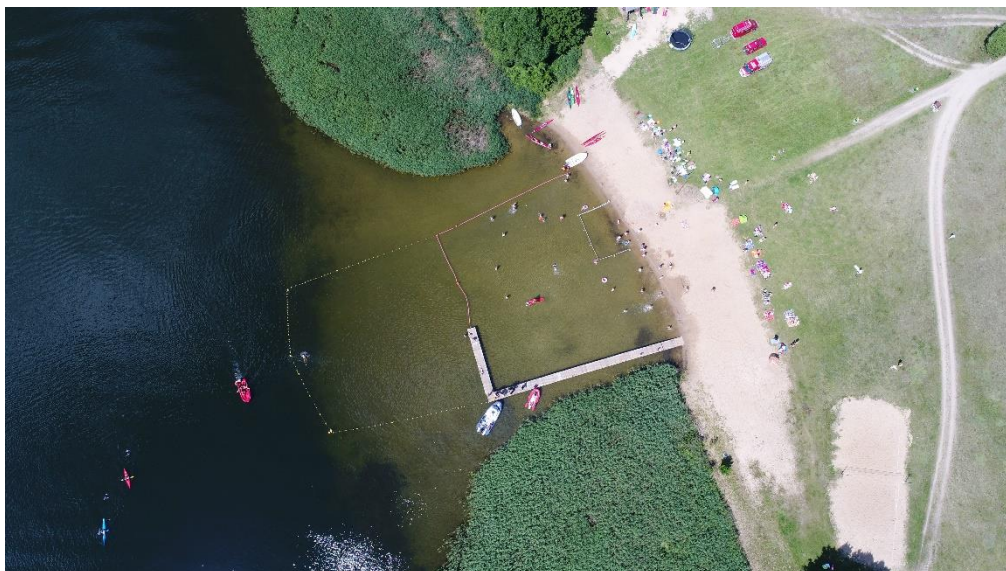
- extinguishing fires of buildings, agricultural crops, providing assistance to victims and saving property,
- providing assistance to victims of traffic accidents (mainly car accidents);
- removing fallen trees blocking county roads,
- neutralization of spills of substances of different origin on roads in the district,
- removing the effects of storms (securing property, residential and commercial buildings),
- removing the effects of flooding caused by heavy rainfall,
- searching for missing persons in inland waterways,
- securing mass events (triathlon competitions),
- saving trapped animals (frozen onto ice),
- activities to support local initiatives (cleaning of lake shores, tournaments, competitions, holidays, etc.).

Unmanned aerial equipment is used as part of the activities of the Charzykowy VFS to **search for missing persons**. Due to the fact that there are large forest complexes in the area, a quick search from the air is particularly desirable and may quickly result in finding the missing persons. The cases reported often concern elderly people with limited perception and awareness of their own behaviour, therefore long stay out of their loved ones' care may result in

hypothermia (or overheating of the body), an accident, getting lost in the forest, exhaustion, and even death, e.g. as a result of drowning. Similarly, the Charzykowy VFS drone was used to search for farm animals (bulls) which managed to get outside the farm and dispersed, posing a real threat to people and animals.

Another group of activities with the use of the drone is **searching for missing persons in water bodies** (including drowning victims). In this case, the air platform offers an opportunity to quickly search the basin, including hard to reach places (reed fields, etc.) and immediately dispatch rescue forces to the injured. Under certain conditions (high transparency of water and light sandy bottom) it is also possible to indicate places of potential drifting or location of corpses on the bottom of the body of water to provide further directions to diving groups (photograph 2).

Photograph 2. Search for corpses in lake waters



Source: from Łukasz Kwiatkowski's collection

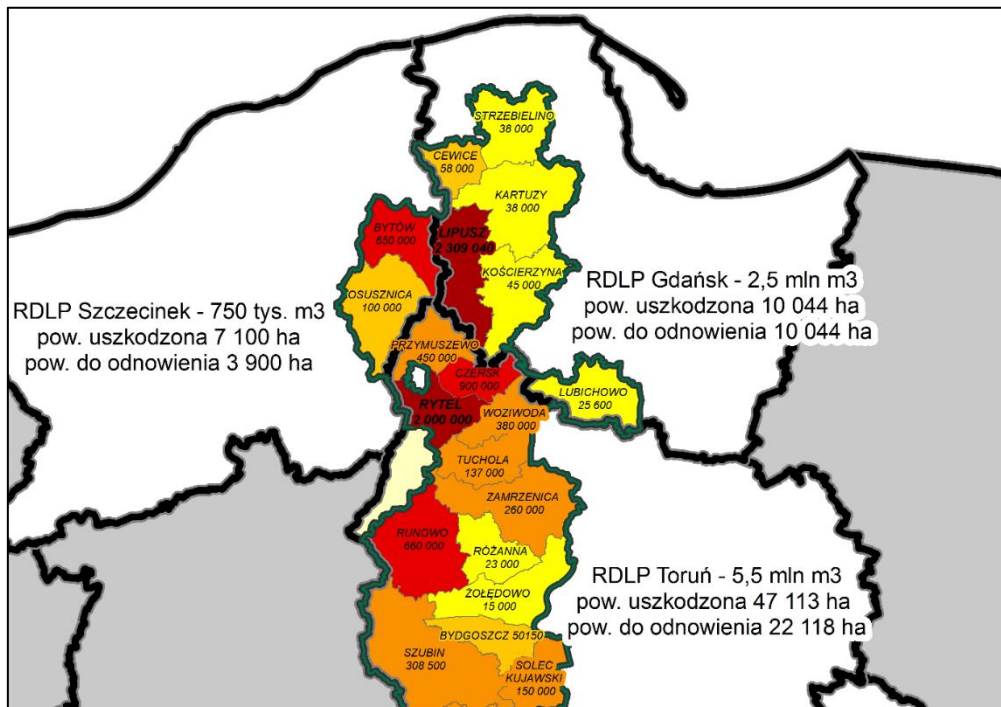
3. Pomeranian tragedy

On the night of Friday 11.08.2017 to Saturday 12.08.2017, the Chojnice district was hit by storms which caused 5 deaths. The victims of the devastating element included girl scouts camping in the forest near Suszek. Numerous roofs were torn down, agricultural crops were destroyed, and the storm knocked down huge stretches of trees in the Rytel forest district. Tens of thousands of consumers remained without electricity. Firefighters, including leaders of volunteer units, set off bringing help to the victims. The storm system, described by specialists

as a bow echo, was responsible for creating hurricane winds with speeds reaching 100, and locally even 150 km/h.

Apart from human tragedies, the element was responsible for significant losses in natural resources (Fig. 2). The area affected includes 22 reserves, 15 bird protection areas and 134 habitat conservation areas (Natura 2000). Tree stands of the "Bory Tucholskie" National Park were destroyed, with the damage sustained in about 20% of the park's area (about 1000 ha), half of which was significant. It was not until 10 days after the hurricane that the most important roads were cleared and power engineering teams were given access to the damaged lines. (Trębski, 2019).

Figure 2. Map of losses in forest districts over 10 000 m³ due to hurricane winds (fragment)



Source: Based on: Forest Protection Department of National Forests Directorate General (www.lasy.gov.pl).

The scale of the damage is confirmed by the fact that the initial estimations of foresters mentioned 22,300 hectares of destroyed forest and about 3.6 million m³ of felled trees (in the Kujawsko-Pomorskie Voivodeship, within the range of the Regional Directorate of National Forests – 8,000 ha and 1.1 million m³, in the Pomorskie Voivodeship – 14,000 thousand ha and 2.5 million m³). To emphasize the scale of the tragedy, according to the plan, a total of 2 million m³ of wood is harvested in the course of one year under sustainable forest management in all of the Toruń RDNF districts. (*Thousands of hectares...*, 2017).

Out of 27 forest districts under the jurisdiction of RDNF (24 in Kujawsko-Pomorskie, 3 in Pomorskie), damages caused by storms were reported by as many as 25 forest districts. The greatest damage was caused in the Rytel forest district (8,000 ha of trees, 1.5 million m³ of wood) and Czersk - 3,000 ha of trees (200,000 m³ of wood). Severe losses were also suffered in the forest districts of Woziwoda: 800 ha of forests, 200,000 m³ of wood, as well as Zamrzenica - 200,000 m³ of wood. Significant losses were also recorded in the forest districts of Runowo, Szubin and Przymuszewo (*15,2000 hectares...*, 2017). The data were preliminary estimates in nature due to huge problems with reaching many places cut off for road transport.

As a result of improper operation of the system, the inhabitants and huge crowds of tourists spending time in the area of the Tuchola Forest were not informed (warned) about the possibility of hurricane winds. Before the tragic events, the information about the threat (warning generated about the possibility of hail storms, heavy rainfall - grade 2 on the 3-point scale, and wind gusts up to 100 km/h) was not passed on to persons responsible for making crisis management-related decisions. (Zajkowska, 2019). According to the information from the Institute of Meteorology and Water Management (IMWM), strong winds at speeds exceeding 15 m/s (54 km/h) pose serious risks. The IMWM generates warnings about winds with average speed exceeding 15 m/s and winds with gusts reaching at least 20 m/s (72 km/h). Gusts of wind are considered to be momentary increases in wind speed that exceed the average wind speed by 5 m/s for a period of 2 or 10 minutes (Hazards ...2011).

For comparison, in 2012, a whirlwind rolled through Bory Tucholskie, with a 550 h forest and 80,000-100,000 m³ of trees growing there falling victim to it (Stopiński, 2012). By 2017, foresters managed to clean up and restore the area. Access to the forest was banned in areas destroyed by hurricane winds due to danger posed by broken trees.

In the first hours of the activities, according to the firefighters, it was the scale of the phenomenon that turned out to be one of the biggest challenges, having led to a complete change in the landscape as a result of huge stretches of forests that have collapsed. Roads covered in debris and obstructed made it difficult, and in many places even impossible for the teams consisting of local volunteers who knew the area very well to move around and reach injured people.

The effectiveness of the drone was once again confirmed during the activities after the storm that struck the area in 2017. The enormity of damage and fatalities caused by the destructive actions of natural forces often exceeded the organizational capabilities of the services and anything the equipment available could handle. The scale of the tragedy during the holiday season brought about a threat to the life and health of residents and visitors

(holidaymakers, including numerous groups with children). The situation in the first hours and days was complicated by the lack of access to mobile phones, electricity, insufficient supplies of fuel, lubricants and chainsaws.

The drone was used to **prepare photographic documentation** of the tragic event at the scouting camp in Suszko, which was necessary in police operations and subsequent prosecution proceedings. Among other things, the distance between individual points was measured. The flights over the scene of the tragedy also made it possible to estimate the damage to the tree stand.

Photograph 3. Evidence gathered with the use of a drone



Source: from Łukasz Kwiatkowski's collection

The collapse of huge stretches of forest (most of them coniferous), criss-crossed by meandering rivers (mainly the Brda), caused by the storm, disturbed the water flow, which resulted in the water banking up and flooding (photograph 3). The river, which in the following days posed a threat, was systematically cleared on the basis of materials provided from **air monitoring**. The actions taken by firefighters equipped with a small drone were of particular importance due to the fact that the existing landscape had been destroyed and many landmarks ceased to exist or changed their form. This disoriented the teams consisting of local firefighters with very good knowledge of the area.

The VFS unit in Charzykowy uses its air drones in numerous activities carried out for the safety of the local community. Every action undertaken is also an element of the operators

gathering the necessary experience in the use of specialized equipment. As any system, UASs have certain features that make them particularly useful and desirable in the activities of volunteer units.

Photograph 4. Actions to monitor the level of the Brda River as a result of a storm



Source: from Łukasz Kwiatkowski's collection

The strengths of UASs, which are particularly useful in VFS operations, include:

- readiness for immediate use without the need for lengthy preparations,
- mobility due to easy transporting to the place of operation (small size and low weight allowing it to be transported in a passenger car),
- possibility of on-line data transmission with the use of appropriate equipment,
- available modular construction of modern drones to equip the platform with appropriate task sets (modules),
- popularity and general availability of this type of construction on the commercial market,
- increasing possibility of obtaining training and licenses,
- applications for easy familiarization with the air situation (*drone radar*).

Important restrictions on the use of UAS include:

- susceptibility to hydrometeorological conditions (particularly: strong wind and precipitation) affecting especially small platforms,

- operating time depends on battery capacity,
- cost of purchase, especially for systems equipped with specialized sensor heads and an operator console enabling the viewing of the situation together with the necessary acquisition of operator licenses, may exceed the capacity of voluntary units.

4. SUMMARY

Unmanned devices may significantly increase the effectiveness of actions taken by volunteer fire-fighting units. Increasing the effectiveness of the tasks carried out, resulting e.g. in shorter searching for missing persons or monitor mass events. This contributes significantly to the increase of the level of safety of local communities.

The use of unmanned systems in the estimation and removal of the effects of natural disasters (based on the example of extreme weather phenomena – strong storms which occurred in the Pomeranian Voivodeship in August 2017) had a positive effect consisting in:

- shortening the time of preliminary estimation of the scale of the phenomenon;
- monitoring of access routes blocking the direct access of rescuers in the affected areas;
- checking the Brda riverbed from the air for the location of potential build-ups and obstructions as well as flooding;
- collecting evidence for the authorities conducting proceedings after the tragedy in Suszek (police, prosecutor's office);
- possibility of collecting data and carrying out optical reconnaissance, necessary to determine the overview of the situation (after appropriate retrofitting) in case of thick smoke;
- particular advantages of the systems discussed include the distance of operators from the sources of threat.

The fact of using unmanned aerial systems in the structures of volunteer units shows a great involvement of their members, considering that they must acquire funds to purchase them, and secondly, it is a manifestation of efforts to use modern equipment and systematic improvement of firefighters' qualifications and acquisition of new licenses in activities carried out for the safety of local communities.

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