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# USE OF LOW-POWER UNMANNED AERIAL VEHICLES FOR CONTROL OF AN URBANIZED AREA

***Ivan Ivanov***

*"Georgi Benkovski" Bulgarian Air Force Academy*
*e-mail: IKIvanov@af-acad.bg*

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***Abstract***

*The article presents an analysis of the current classification of unmanned aerial systems according to the European Aviation Safety Agency related to the use of unmanned aerial vehicles for urban area monitoring. The possible tasks solved by unmanned aerial vehicles in an urbanized area were investigated. An analysis of the crisis events – floods, fires, and landslides in the Pleven region of the Republic of Bulgaria for the period from 2010 to 2020 was made and a model for the use of unmanned aircraft was proposed.*

## Introduction

Under the control of an urbanized area using unmanned aerial vehicles (UAVs) in this article should be understood the processes of monitoring and management of objects and parameters in specific conditions of the situation in this area. Control can be permanent, periodic, and episodic.

Ground-based measuring stations and/or long-duration fixed-wing unmanned aerial vehicles are sufficient for continuous monitoring. Periodic and episodic control of an urbanized area is carried out in a certain period of time, in a critical situation, with fixed-wing and rotary-wing unmanned aerial vehicles. Low-power UAVs of the "multicopter" type are suitable for periodic and episodic monitoring of an urbanized area.

The tasks of UAVs for aerial surveillance in an urbanized area require knowledge of the specifics of the objects, the environmental conditions, the capabilities of the UAVs and the requirements for the extracted information.

## Problem status and area of research

The crisis situations in the Pleven region of the Republic of Bulgaria are investigated, using data from the National Statistical Institute. The classification of unmanned aerial systems (UAS) regulated by the European Aviation Safety Agency and scientific articles have been used to define the tasks of UAVs in urbanized areas.

There are various classifications of UAVs and UASs in the scientific press. With the adoption of regulation [1], the requirements for the design of UAVs with a maximum take-off mass of up to 25 kg are fulfilled by using a marking with the designation “CE”, which applies to products sold in the European Union. All UAS that are placed on the market also have a number between 0 and 6, which defines the class of the UAS (C0, C1, C2, C3, C4, C5 and C6). The UAS classes presented in Table 1 [1] are regulated for the European Union.

*Table 1. UAS classes*

| | Unlimited category | | | | | | |
|---|---|---|---|---|---|---|---|
| | C0 | C1 | C2 | C3 | C4 | C5 | C6 |
| Max. Take Off Mass | <250 g | < 900 g or max.kinetic energy<80J | <4 kg | < 25 kg | < 25kg | < 25 kg | < 25 kg |
| Max. speed at flight | 19 m/s | 19 m/s | not applicable | not applicable | | | < 50 m/s |
| Max. height of flight | 120 m | 120 m | 120 m | 120 m | | not applicable | not applicable |
| Loss of connection | not applicable | A reliable procedure to restore the connection | A reliable procedure to restore the connection | A reliable procedure to restore the connection | | | |
| Power supply | electrical | electrical | electrical | electrical | | | electrical or other |
| Distance from pilot in mode “follow me” | 50 m | 50 m if equipped | not applicable | not applicable | | | |
| Identification | not applica-ble | Unique serial number and remote identification | Unique serial number and remote identification (unless tied down) | Unique serial num-ber and remote identification (unless tied down) | | | |
| Geo-restriction | not applica-ble | Mandatory | Mandatory | Mandatory | | if equipped | if equipped |

From the presented requirements for the classification of UAS, it is established that they can be used for periodic and episodic control in an unlimited category of use, and the low-power ones will be in classes C0, C1, C2 and C3.

The advantages of low-power UAVs are safety, flexibility, and a variety of sensors on board. Safety is concerned with the preservation of human life in flights to perform dangerous missions for the pilot on board. Their flexibility in performing certain tasks is increased. UAVs can better maneuver in small spaces and can even fly into buildings. They are able to take off at any time and deliver the necessary information in a short time. Different sensors such as digital, high-quality video cameras combined with infrared sensors provide their day and night monitoring capabilities. Sensors for various gases facilitate the study of the environment.

Possible uses of UAS for civilian application can be in six areas: disaster response and management; national security; critical infrastructure protection; communications missions; environmental protection; scientific-research activity [2].

In these application areas, low-power UAVs can perform tasks in urbanized areas presented in Fig. 1.

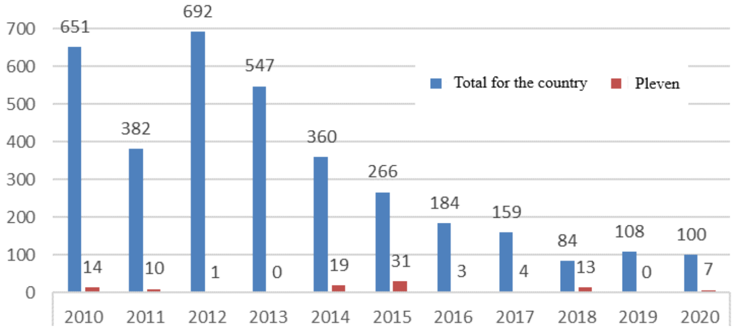
TASKS

- Monitoring and prevention of fires
- Flood surveillance
- Monitoring at earthquakes
- Securing areas affected by high winds and storms
- Determination of nuclear, chemical and biological contamination
- Searching for survivors in disaster areas
- State border surveillance
- Observation of public events
- Cooperation with unmanned ground vehicles
- Monitoring of objects from the energy system

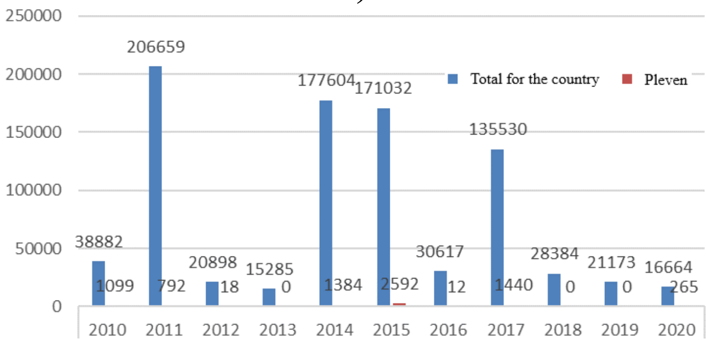
- Monitoring of wires from the power transmission network
- Vehicle traffic monitoring
- Retransmission of communication signals
- Research on pollution with harmful emissions
- Monitoring of oil spills
- Monitoring of water sources
- Survey of constructions
- Mapping
- Delivery of goods, medicines, medical devices
- Provision of a mobile wireless sensor network
- Meteorological observation
- Search, detect and track terrorists

*Fig. 1. Possible tasks to be performed by low-power UAVs in an urbanized area*

The urbanized territory of Pleven region is 254.58 $km^2$ and constitutes 5.47 % of its total territory [3]. In Fig. 2 are presented data from [4] about floods in the Pleven region for the period from 2010 to 2020.



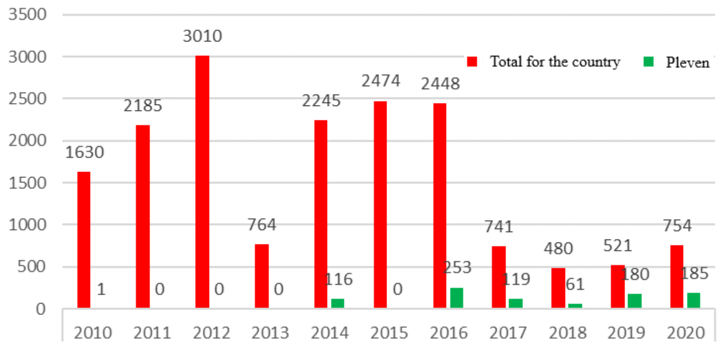

*a)*




*b)*

*Fig. 2. Floods in Pleven region 2010 – 2020: a) Number; b) Established damages – thousands of BGN*

The number of floods in the Pleven district compared to that of the country is relatively small. Their average annual number for the considered period is 11. The established damages were maximum in 2015 – BGN 2,592,000, while the annual average for the period was BGN 950,000.

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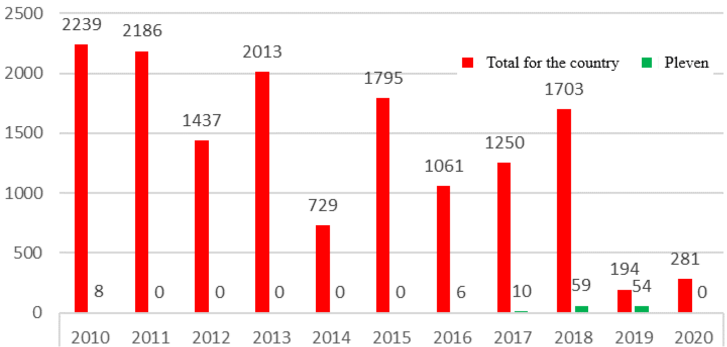
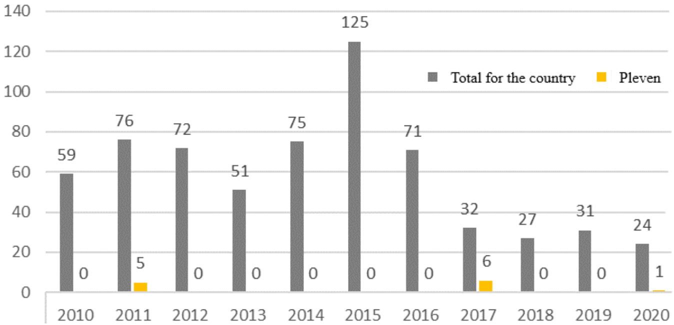



*b)*

*Fig. 3. Fires in Pleven region 2010–2020: a) Number; b) Established damages– thousands of BGN*

In Fig. 3 are shown the number and established damages of the fires in Pleven region [4].

In the last four years of the considered period, the fires in the Pleven district have a relatively large share of those in the country. The established damages from fires were the largest in 2018 and 2019 and reached BGN 59,000.

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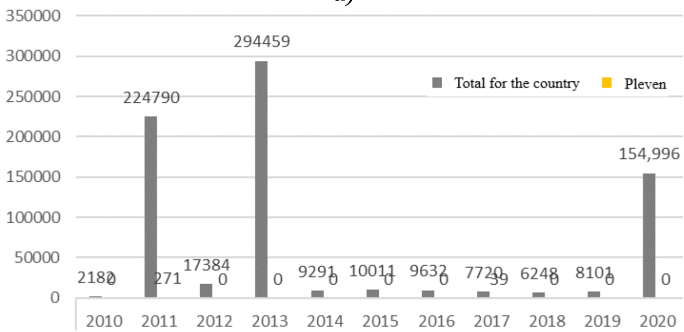


*b)*

*Fig. 4. Landslides in Pleven region 2010–2020: a) Number; b) Established damages – thousands of BGN*

The data on landslides in Pleven region for the period 2010–2020 are presented in Fig. 4 [4].

A total of 12 landslides were registered for the Pleven region for the period under review, with the established damages amounting to BGN 310,000.

To control an urbanized area, a system can be built with a structure presented in Fig. 5.

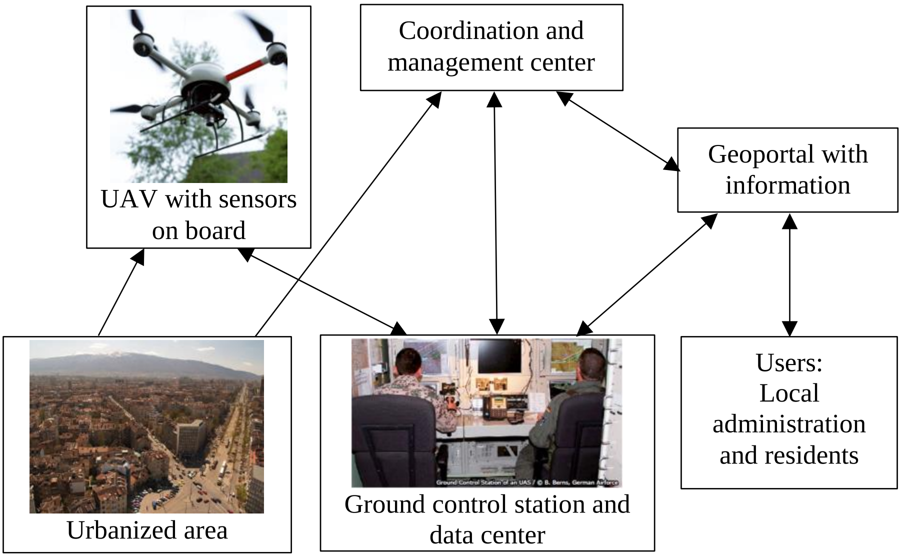


*Fig. 5. Structure model of an urbanized area control system*

Unmanned aerial vehicles must be sufficient in number so that with their characteristics they can perform their tasks in an urbanized area of a certain size [2, 5–8]. The sensors on board the UAV need to be suitable for the task at hand. The control station and data center need to have the capability to maintain the UAV, process the data and transmit it for visualization to the users. The coordination and management center is permanently based and coordinates the activity of the mobile groups equipped with UAVs.

According to [9], an electric powered multicopter has characteristics presented in Table 2.

*Table 2. Technical characteristics of a multicopter*

| | Electric powered multicopter | |
|---|---|---|
| | hover mass | hang time/battery mass |
| Payload mass 5 kg | 25 kg | 1 h/7,5 kg<br>0,5 h/3,75 kg |
| Payload mass 1 kg | 5 kg | 1 h/1,5 kg<br>0,5 h/0,75 kg |

For unmanned platforms, UAV multicopter type with electric power supply classes C0, C1, C2, C3 with a maximum take-off mass of up to 25 kg are suitable.

For monitoring objects and researching environmental parameters, it is appropriate to use: UAV multicopter type with a payload of at least 1 kg, wind resistance up to at least 10 m/s, with a built-in camera and image stabilization system and sensors registering the monitored parameters of the environment. To reduce costs and increase the number of UAVs, it is possible to use C0, C1 and/or C2 class multicopters with a maximum take-off mass of up to 4 kg. Examples of such quadcopters are: for C1 - MD4-200 [10], for C2 - DJI Phantom 4 Pro [11] and for C3 - MD4-1000 [12] (Fig. 6).

MD4-200

DJI Phantom 4 Pro

MD4-1000

*Fig. 6. Types of quadcopter models*

The coordination and management center for the Pleven region should be based in the area of the “Georgi Benkovski” Bulgarian Air Force Academy in the city of Dolna Mitropolia. The mobile groups, consisting of a motor vehicle, 3 drones and a ground control station can be located in the outsourced aviation education complex of the Bulgarian Air Force Academy in the city of Pleven.

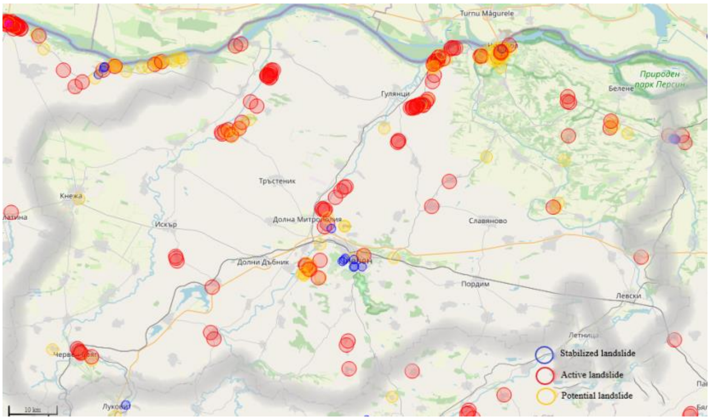


*Fig. 7. Map of landslides in Pleven region*

In Fig. 7 are shown the landslides in Pleven region [13]. A possible urbanized area for UAV survey is an active landslide and dam near the village of Gorni Dabnik.

The observation route of the designated area is presented in Fig. 8.


*Fig. 8. Survey route*

The route is 22311 m long. The UAV is a multicopter flying at a speed of 10 m/s at 50 m above the terrain of the area. The farthest point on the planned route is at a distance of 3050 m from the take-off position, which is within the range for telemetry control and data transmission for this area. The estimated time to complete the mission is 51 minutes and 38 s including take-off, en-route flight, and landing. Provided that the task is performed with low-power UAVs with electric power, their flight time is usually 30 min. The above-mentioned circumstances give reason to state that two multicopters flying on different parts of the route will successfully fulfill the task of monitoring an area with a possible manifestation of a crisis situation. In case of loss or major damage of the UAV, it is necessary for the mobile team to have at least one spare UAV.

## Conclusion

The variety of tasks that low-power UAVs of the “multicopter” type can perform to save and improve people's lives requires the construction in a given area of a system of UAVs with the possibility of a wide range of sensors on board. The information provided by the UAV, after processing, analysis, and summarization, will be used to make informed decisions by the local authority and for good awareness of the residents of a certain urbanized area. A good practice would be the exchange of information between such systems built in other urbanized areas.

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# ИЗПОЛЗВАНЕ НА МАЛОМОЩНИ БЕЗПИЛОТНИ ЛЕТАТЕЛНИ АПАРАТИ ЗА КОНТРОЛ НА УРБАНИЗИРАН РАЙОН

***И. Иванов***

**Резюме**

Статията представя анализ на съвременната класификация на безпилотни авиационни системи според Европейската агенция за авиационна безопасност, свързан с използването на безпилотни летателни апарати за мониторинг на урбанизиран район. Изследвавани са възможните задачи, решавани с безпилотни летателни апарати в урбанизиран район. Направен е анализ на кризисните събития – наводнения, пожари и свлачища в област Плевен на Република България за периода от 2010 г. до 2020 г. и е предложен модел за използване на безпилотни летателни апарати за тази цел.