Journal scientific and applied research, vol. 6, 2014
Association Scientific and Applied Research
International Journal

Original Contribution

ISSN 1314-6289

USE OF UNMANNED AERIAL VEHICLES FOR THE NEEDS OF GEODESY AND CADASTRE

Dimiter Petrov
E-mail: petrov_2@abv.bg

Abstract: *During the last decade, the use of different in construction and use unmanned aerial vehicles are being used. They have the common name drones.*

The crucial stimulus for the unmanned aviation worldwide, is the successful use of unmanned aerial vehicles (UAV) by the American and Israel Armies during the warfare in the Persian Gulf, Yugoslavia, the Near East, the Arab Israeli conflict, etc. During these events, the unmanned aircraft became famous as an effective means for reconnaissance, false targets for hitting by the zenith rocket complexes, cargo supply and performance of a variety of other tasks.

Key words: *unmanned aerial vehicles, aerial shooting, photogrammetry, multicopters*

At the present time, according to data of the UVS International, 52 countries in the world manufacture UAV and according to data from the Ministry of Defense, now 32 countries produce and distribute over 250 models UAV and their increasing use is based on the following reasons:

- low risk levels for the highly qualified staff who maintain the system;
- ability to perform a wide range of tasks in different conditions during the day and night, regardless of the weather conditions and environment which is inaccessible for a human being;
- value which is a few times lower considering the potential during the exploitation cycle;
- levels of achieved efficiency which are comparable and even higher than the piloted aerial vehicles when performing a wide range of tasks which concern the realization of the advantages of the third dimension;
- elimination of all limitations which are set by the presence of a human being on the board of an aircraft; these limitations mostly concern the duration of the flight, the overload when maneuvering; the height of the flight, etc.;
- multiple times higher longevity than the one of the piloted systems;
- considerably lower value and shorter duration of the preparation of the managing crew (teams);

- affordability of manufacturing, preparation of crew (teams) and deployment of systems with similar vehicles for countries with lower economic potential which increases the quality level of the national security in times of peace and war;
- stimulate the development of high technologies and helps the accumulation of highly qualified and quality human potential.

According to the vision of the Ministry of Defense of Republic of Bulgaria, using the UAV in the mission "Contribution to National Security in Peacetime" is suitable in the following directions:

- observation of zones, areas and roads on the territory of the country;
- monitoring of the territorial waters and shipping;
- participation in the security of the critical energy infrastructure;
- chemical, bacteriological and radiation intelligence;
- early discovery and observation of fires;
- air traffic control;
- securing of search and rescue operations of crews of aircraft and ships in disaster;
- ecological monitoring of earth and water;
- cadastral surveys of areas, territories, etc.

The multiple use of the unmanned aerial vehicles is a prerequisite for the creation of aerial vehicles with different tactical and technical characteristics. This requires the introduction of a certain system for the classification of UAV which can be done using different criteria [2], such as by the presence of an engine (with or without an engine), by the type of engine – engines with internal combustion, reactive or electric, by the type of the wings – with fixed or rotary wings, etc.

The categories of NATO for classification of UAV (Table 1) are based on the maximum total flying weight and flight altitude. The important criteria for the categories are the flying weight and every category is divided on the basis of maximum flight altitude of the UAV.

Table 1

Class	Category	It's part of:	Altitude:	Radius of use:	Supports:
Class I (up to 150 kg)	Small (>20 kg)	Company (launching system: catapult)	Up to 1650 m	Up to 50 km	Battalion, regiment, battle group
	Mini (from 2 to 20 kg)	Platoon, squad (manual launching)	Up to 1000 m	Up to 25 km	Company, platoon
	Micro (< 2 kg)	Team or single operator	Up to 650 m	Up to 5 km	Squad

Class II (from 150kg to 600 kg)	Tactical	Tactical formations	Up to 3300 m	Up to 200 km	Brigade
Class III (over 600 kg)	Battle	Strategic/national	Up to 21 450 m	Over 200 km	Theatre commander
	HALE	Strategic/national	Up to 21 450 m	Over 200 km	Theatre commander
	MALE	Operational/Theatre of War	Up to 15 000 m	Over 200 km	Commander of Joint Forces Command

The weight of the unmanned aerial vehicle influences a number of other characteristics, and some of the main ones are the wingspan – they influence the lifting force and type of engine. UAV with light weight use mainly electric engines and the heavy ones – turbo and turbo-reactive engines.

Classification according to the endurance and range.

These two characteristics are mutually related. Obviously the bigger the endurance in the air, the larger the range of the vehicle is. This defines the possibility to perform tasks farther or closer to the aerodromes and the time between refueling. According to this characteristic, the UAVs are divided into three groups:

- Long endurance – vehicles with continuous duration of the flight 24 hours. The range of these systems is from 1500 km to 22 000 km;
- Medium endurance - vehicles with continuous duration of the flight from 5 to 24 hours. These are the most common UAV.
- Short endurance-systems with duration of the flight less than 5 hours. These are the basic means to observe and track compact and relatively small territories.

Classification according to the maximum altitude of the flight.

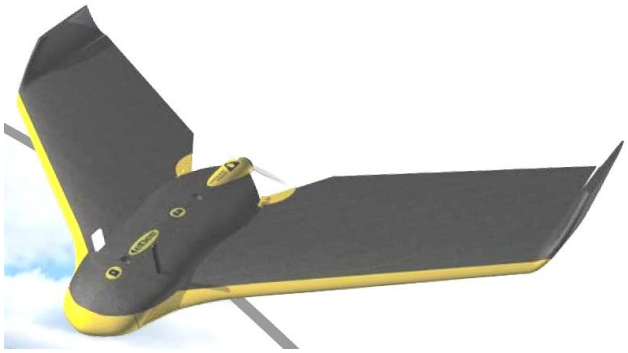
The altitude of the flight is very important when choosing the aerial vehicle and it should be taken into consideration with the details and the scope of the images which are received by the survey devices which are mounted on the UAV. Using this characteristic, we can divide the unmanned aerial vehicles into three groups:

- Low altitude – these are systems which fly at an altitude up to 1000 m. Micro UAVs are the main constituents of this group.
- Medium altitude with the range of the altitudes from 1000 m to 10 000 m. Most of the unmanned aerial vehicles fall into this group;
- High altitude – these are UAVs which fly at altitudes over 10 000 m. Because they are potentially dangerous for the civil piloted aircraft, they are provided with high-tech systems against collision.

An example of a classification of UAVs has been made in [4] according to the wing type which creates the lifting force which lifts the vehicle in the air. By this characteristic, the UAVs are divided into two big groups (systems like dirigibles, kites and balloons are not included):

First group: UAV with fixed wing.

The systems of this group are the main constituents of UAVs which are used for military purposes, especially the ones of the type Predator and Global Hawk (for the UK), which are equipped with powerful engines. The light UAVs with fixed wing are mostly used in the cartography and photogrammetry. Their flight is performed by electric engines. These are platforms which are controlled comparatively easy and they can provide images with parameters which are proper for photogrammetric processing. The specific thing when using this type of UAV is the need to ensure ample space for taking off and landing. The use of this type aircraft in the contemporary conditions is very common. The most frequently used aircraft of this type in Bulgaria are the ones produced by the companies Gatewing X100 Trimble (Belgium), SenseFly eBee (Switzerland), SmartOne SmartPlanes (Sweden). The produced in Russia UAVs deserve mentioning for their technical characteristics and the main representatives are ZALA 421-08Φ with flight duration up to 80 minutes and altitude of taking photos up to 3600 m and Supercam-350F with flight duration up to 270 and altitude of taking photos from 200 to 1000 m.



SenseFlyeBee

UAVs of this type are fitted with special aero and navigational equipment which includes a navigation system with inertial correction (GPS/ГЛОНАСС), integrated digital telemetric system, integrated 3-axis magnetometer, radio modem, system for self diagnosis, humidity sensor, temperature sensor, electricity sensor, sensor for the engine temperature and a transmitter for localization in case of malfunctioning.

ZALA 421-08Φ

Group two – UAVs with rotary wing

An important place among this type of unmanned aerial vehicles are the ones which fly on the principle of the helicopters – the so called multicopters[5].

The multicopter is a remotely controlled aircraft which flies thanks to two or more pairs of propellers, situated diametrically and opposing each other. It is usually moved by electric engines. The weight which they can carry is 1-2 kg. According to the number of the lifting rotors, we can distinguish the following types of multicopters:

- Quadrocopters – with four rotors
- Hexacopters – with six rotors
- Octacopters – with eight rotors
- Dodecopters – with twelve rotors

In order to get a lifting force and stability during the flight, the pairs of the rotors rotate in different directions clockwise and counterclockwise. According to the speed of the rotation between the pairs of rotors, the copter lowers its position or goes higher. In order to stay stationary in the air, or to "hover", all rotor blades should rotate at equal speed and every pair should balance each other. In order to fly in one direction, the multicopter should misbalance. The speed of the blade which is opposite of the flight direction should increase. This makes the multicopter bend at a certain angle. For example, to fly forward, the rear rotor should rotate faster. This is called „nick". The term „nick" is used for the forward/backward movement. The movements left/right are called „rolls". The rotation around the vertical axis Z is called „yaw". To rotate „yaw" the multicopter needs power which rotetes it this power appears when we change the rotary speed of the front/rear and lef/right rotor blades. An example: to rotate around its axis in a clockwise direction, the front/rear blades of the multicopter should rotate faster and the left and right rotor blades should slow down its rotation.

Мулти (хекса) коптер

From the point of view of using the unmanned aerial vehicles for taking pictures from the air, the increased number of rotors means fewer vibrations, higher stability during flight and more qualitative images. However, the greater number of engines to move the rotors increases the electricity expenditure which means more powerful batteries (smaller payload) or shorter flight.

The stability of the multicopter flight is ensured by a special flight controller. Its main task is to control the flight stability. In order to do this, the flight controller processes the incoming data from a number of different sensors and follows the lifting force of every engine. As a result, it creates commands for the compensation of external interventions such as wind or air currents. The orientation of the multicopter in space is performed by another controller, the so called Navi control, connected with GPS, electronic gyroscope and radio altimeter. To control the system online, a remote control is used at a certain frequency which is used by the pilot to send commands.

The use of the multicopters for taking pictures from the air in order to collect geospatial data for the area and the sites is connected with the following characteristics:

Advantages:

- Taking off and landing at limited in size or availability landing places while operating from urbanized zones;
- Range of the flight speed from Vmax to 0 with the possibility to "hover" over certain points from the route;
- Higher maneuvering abilities in a horizontal plane with a radius of turning close to zero;
- Possibility to safely land in the mode of autorotation;

Disadvantages:

- Shorter duration of the flight;
- Smaller range of flight;
- Smaller load capacity.

Because of the above mentioned characteristics, the multicopters are primarily used for the need of façade photogrammetry as well as to take photos of compact objects: open quarries and mines, monitoring of compact industrial installations, control of landslides, etc.

The disadvantages of the existing traditional methods to obtain data from the air by means of spacecrafts (space photographing) and piloted aircraft (aerophotographing) are the reason why the UAVs are used for the needs of geodesy and cartography as a quality new technical approach. The data from the space photographing allow images with maximum total resolution – 0.5 m which is not enough for large scale cartography, making of cadastre maps and solving engineer problems, connected investment planning. Besides, it is not always possible to select cloudless pictures from the archive. In case of ordered space photography, the efficiency and furthermore, the distributors do not always show flexibility according to rates and charges.

Traditional aerophotography which is performed by piloted aircraft or helicopters of a similar kind require serious financial resources for maintenance and fuel supply which leads to increase of the final price.

Practice shows that using the standard aviation complexes is not economically unprofitable in the following situations:

- Aerophotographing of not too big objects and small in size territories. In this situation, the economic and time loss for an institution to photograph per unit area are considerably larger than the similar indicators when photographing larger areas, especially for objects which are far from the aerodrome for taking off and landing.
- When it is necessary to perform regular photographing in order to monitor linear objects: pipe systems, interconnectors, transport highways.

In a similar way, the basic prerequisites for using UAVs for photogrammetric need are:

1. Profitability (especially when photographing small objects);
2. Possibility to aerophotograph from not very high from the objects and thus taking a photograph with high resolution;
3. Efficiency when receiving the pictures;
4. The possibility to use the systems in zones of extreme situations without risking the lives and health of the pilots.

In conclusion, the development of the systems for aerophotographing by using unmanned aerial vehicles in combination with the digitalization and computerization of the photogrammetric technology, leads to significant decrease in the rates. Thus the practical application of the photogrammetry becomes more common in the creation of cadastre and specialized maps, as well as for the performance of various tasks and projects, connected with ore or inert

materials mining, evaluation of the condition and pollution of the environment, illegal construction and other spheres of social life.

References:

[1]. Conception for Air Observation and Reconnaissance by Means of Unmanned Aerial Vehicles by the Bulgarian Armed Forces – Ministry of Defense, March, 2012

[2]. Зинченко О.Н., «Ракурс», Москва, Россия Беспилотные летательные аппараты: применение в целях аэрофотосъемки для картографирования 10.08.2011

[3]. CLASSIFICATION OF UNMANNED AERIAL VEHICLES Dr. Maziar Arjomandi School of Mechanical Engineering The University of Adelaide, Adelaide, South Australia, AUSTRALIA, 5005.

[4]. Petry, Gordon, UAV in the UK, Geomedia Magazine Vol. 3/2013

[5]. Tutorial for Using a Multicopter – Advertisement website of Company VSEOS Ltd.. http://www.veos.bg/