QUADCOPTERS POSSIBILITY FOR EXTRAORDINARY EVENTS AND CRISIS SITUATIONS

Miroslav JANOSEK, Jan KYSELAK
miroslav.janosek@unob.cz, kyselak@utb.cz

Abstract

The article focuses on the use of quadcopters in the event of extraordinary events or crisis situations. In short, the reader familiarizes with the history of the creation and development of quadcopters and suspends the selected legal norms underlying the operation of these machines. Last but not least, the article presents some examples of the use of these machines, especially in the field of population protection, both in the Czech Republic and in the world, and considers their future perspective.

Key words
Drone, Emergency Situations, Extraordinary Events, History, Legislation, Perspective, Using, Quadcopters.

INTRODUCTION

In essence, every day is accompanied by a host of extraordinary events threatening our health, property, the environment or even our lives. Solving these events requires not only the deployment of adequate forces, but also means adequate to effectively eliminate specific problems. The Unmanned Aerial Vehicles (the UAVs) or the so-called Drones are one of the means that can be successfully combined with the solution of both these extraordinary events for several decades. In essence, these are means that are capable of unmanned flight. They can be remotely controlled by the operator, they can fly according to predefined (pre-programmed) flight plans or even by dynamic autonomous systems. UAVs are essentially part of the Unmanned Aircraft Systems (UASs), which consist of a UAVs, a ground control unit and a communication system that provides the appropriate connections.

A special type of UAVs, which has recently become more and more of the forefront of interest in rescue workers, is the so-called Quadcopters (we can also see the quadrotor helicopter or quadrotor). These machines, however, are nothing new. The first prototypes are more than a hundred years old. It was not, of course, the UAV at the time, as we know it today – it was piloted vehicles (vehicles with human crew). Quadcopters have the undisputed advantage over a classic UAVs that they can start and land perpendicular to the ground (hence does not need any runway), they can change the flight direction without any problems and can also hang on the spot. Their dimensions can be very variable, depending on the purpose of use. With a wide variety of accessories that can be used by quadcopters, these tools rank among the most important and invaluable helpers in a wide variety of areas. The authors of this paper try to approach the issue of using these quadcopters in the field of population protection. At the same time, they also assume that this contribution can also be an impulse to further extend the use of these invaluable helpers.

1 HISTORY OF THE ART AND DEVELOPMENT OF QUADCOPTERS AND THE PRINCIPLE OF FLIGHT

1.1 History of the art and development of quadcopters

The history of UAVs and the ideas for their construction can be combined with the name of the American inventor Nikola Tesla and with 1898 when he patented so-called automation – the remote control of the motor boat on the water. However, this inventor was also interested in constructing UAVs. If we go further into history, we can talk about the first use of UAVs as early as 1849 in the form of hot air balloons with explosives. These primitive UAVs were used on the barraged enemies of the Austro-Hungarian Army in Venice. The first designed UAV was probably in 1916 an aircraft called the Areial Target engineer Archibald Montgomery (inventor of rockets, torpedoes, etc.). In 1918, UAVs were successfully tested (again in the form of an aircraft named Kettering Bug – Fig. 1), which was able to hit the target up to 64 km. These UAVs have also been widely used (and are still used today) as shooter shooting targets. In the 1960s, UAVs were shifted from research to exploration, for example in the Vietnam War or during the Arab-Israeli War. In the coming years, when both the US and the USSR are concentrating on space research, the development of these UAVs has shifted to Israel. An important role of UAVs, particularly in the area of monitoring, can be found in the conflict in Bosnia and Kosovo in the 1990s but elsewhere. The current development of UAVs focuses mainly on flight length, the ability to control up to thousands of kilometers, or high-quality image sensors (such as the UAV MQ-1 Predator deployed to find Osama Bin Laden). Further development of the AUVs was aimed at developing an armed version of missiles using not only armed conflict (Afghanistan, Iraq, Pakistan, Yemen, Somalia), but also in the fight against terrorists. Even the Czech Republic was interested and is constantly interested in the development of the UAVs – it is known in the 1990s developed reconnaissance aircraft Sojka III (this was disqualified from the equipment of the Czech Army in 2010) or the currently developed and already used quadcopters at the Military Technical Institute – closer see below. [1]

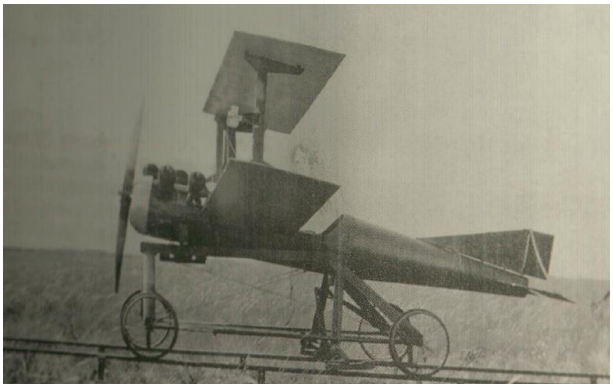

Fig. 1
Kettering Bug – one of the first UAVs [1]

Also, the development of special UAVs – quadcopters has its own history. The early pioneers actually first attempted rotor flight using multicopters, because using more than one rotor seemed to be the natural solution to the problem of VTOL flight.

The very first experimental attempts of taking off with a rotorcraft were mostly done with multirotors. Around 1907 Jacques and Louis Breguet, French brothers, built and tested Gyroplane No 1, a quadcopter. They managed take-off, although the design proved to be very unstable and hence impractical. In 1924 French engineer Étienne Oehmichen flew his quadcopter a distance of 360m (1,181ft) setting a world record. In the same year he flew a 1km (0.62miles) circle in 7m and 40s. Around the same time George de Bothezat built and tested his quadcopter for the US army – Fig. 2, completing a number of test flights before the program was scrapped. Closer to [2].

Early designers experimented with quadcopters, because the alternative, using a single main rotor with a tail rotor to counterbalance the torque created by the single main rotor seemed wasteful, complex and inefficient. The tail rotor on a single rotor helicopter design consumes between 10 and 15 % of the engine power yet it creates no lift or forward thrust. Part of the main rotor rotates over the fuselage, pushing down washed air against it, reducing effective lift. Making large rotor blades, 4 or 5 m long or even longer was a huge problem and larger rotors to this day are proportionally much heavier than smaller ones.

Early quadcopters would typically have the engine sitting somewhere centrally in the fuselage of the copter, driving the 4 rotors via belts or shafts. Belts and shafts however are heavy and importantly, subject to breakage. As the 4 rotors of a quadcopter are all slightly different from each other, a quadcopter is not naturally stable, simply running 4 rotors at the same speed, while producing enough lift to hover the copter, does NOT produce stable flight. On the contrary, quadcopters have to be constantly stabilized. In the absence of computers, this meant a monumental workload for the pilot.

As a result, multicopter designs were abandoned in favor of single, or on rare occasions for very large transport helicopters, double rotor designs.

With the advent of electric motors and especially microelectronics and micromechanical devices, a few years ago it became possible to build reliable and efficient multirotors – so we know quadcopters the today. [3]

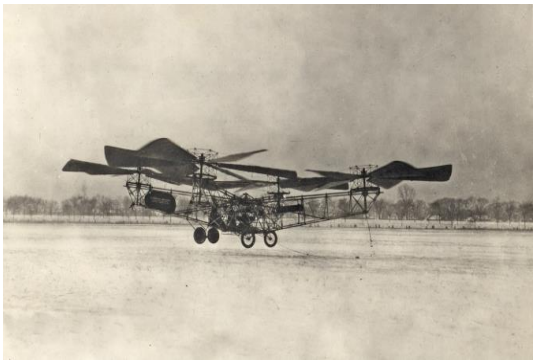

Fig. 2
Army Maj. Thurman H. Bane pilots the helicopter
designed by George de Bothezat at McCook Field, Ohio, in 1923 [4]

1.2 The principle of flight of quadcopters

A quadcopter, also called a quadrotor helicopter or quadrotor, is a multirotor helicopter that is lifted and propelled by four rotors. Quadcopters are classified as rotorcraft, as opposed to

fixed-wing aircraft, because their lift is generated by a set of rotors (vertically oriented propellers).

Quadcopters generally use two pairs of identical fixed pitched propellers; two clockwise (CW) and two counterclockwise (CCW). These use independent variation of the speed of each rotor to achieve control. By changing the speed of each rotor it is possible to specifically generate a desired total thrust; to locate for the centre of thrust both laterally and longitudinally; and to create a desired total torque, or turning force.

Quadcopters differ from conventional helicopters, which use rotors that are able to vary the pitch of their blades dynamically as they move around the rotor hub. In the early days of flight, quadcopters (then referred to either as 'quadrotors' or simply as 'helicopters') were seen as possible solutions to some of the persistent problems in vertical flight. Torque-induced control issues (as well as efficiency issues originating from the tail rotor, which generates no useful lift) can be eliminated by counter-rotation, and the relatively short blades are much easier to construct. [5]

2 QUADCOPTERS AND LEGAL STANDARDS

The basic source of aviation law is the Convention on International Civil Aviation, convened on 7 December 1944 in Chicago. At a time when all the cities were lying in the dust with a carpet bombardment of large aircraft capable of carrying many tons of bombs, the first signatories of the convention (among them Czechoslovakia) were determined to "make a significant contribution to creating and maintaining friendship and understanding among peoples to the world humanity through the development of civil aviation ", and to strike" between the states and nations that co-operate on which world peace rests ". The Convention entered into force on 4 April 1947 and the International Civil Aviation Organization (ICAO) was established in the same year. At the time of the emergence of international aviation law, it was clear that under the conditions of peace and post-war reconstruction there would be a major development of civil air transport. In order for it to work smoothly, it was necessary to provide for a legal solution that would bridge national boundaries. The Chicago Convention is the basic platform for any further regulatory aviation, and the drones are also based on these legal bases. If we understand the drones of any unmanned aircraft, it has been remembered since the very beginning by the Chicago Convention, in a very restrictive sense, since, under Article 8, an "unmanned airplane" flight over the territory of a Contracting State should always be subject to a special mandate. The Czech Civil Aviation Act also provides for a pilot-free flight over the territory of the Czech Republic through a special permit (Section 52 of the Civil Aviation Act). However, the two standards (national and international law) become, in terms of the meaningfulness of the treatment, overcome in the reality of mass use of drones and new visions of their use. The General Drones Flight Limitation was adopted under completely different conditions and in a state of the art than they exist today. So, despite this general constraint, the states are already adopting standards regulating the drones' routine operation, making the original general constraints gradually becoming obsolete. The drones' air traffic control faces challenges particularly in the face of their miniaturization, where small drones are separated from otherwise remote and inaccessible airspace (which we perceive quite apart from ordinary life and which is wrought by conveyance planes leaving behind long ribbons of condensation lines or mocking sports airplanes flying over the landscape at a height of two meters) and moving to the immediate physical proximity of people, the streets, even the buildings. The entrance gates to the airspace and the exit gate make it no longer an airport, and the airspace becomes ubiquitous and begins no matter what is beyond our physical self. There is a tension between security interest and interest in protecting privacy and the environment and public

health on the one hand, and the interest in society-wide profiting from new technologies on the other. What interests are diverted in different countries will show the future.

Drones operate in a number of areas of law, including the regulation of the operation of flying equipment in the first place, but also, to a lesser extent, the protection of privacy and liability for civil law damage, as well as arms trade or the environment. Civil regulation of civil aviation is probably the most direct regulation of drones, but other general legal aspects of their operation can not be overlooked. So let's break the crucial problematic moments of the rights of the drones in connection with the environment of the Czech Republic and the European Union, let's start with air rules.

The basis of the national aviation regulation is the Act No. 49/1997 Coll. [6], on Civil Aviation, as amended. An aircraft is defined as an "aircraft capable of exerting forces which carry it in the atmosphere from air reactions that are not responsive to the Earth's surface. For the purposes of this Act, an aircraft model with a maximum take-off mass (i.e. the mass of the aircraft including all running fluids and of the cargo at which the airplane is able to carry out the flight) does not exceed 20 kg. Under such a device, it is necessary to introduce both a winged aircraft (and a motor and propeller or with a turbine or a non-powered glider), in particular a helicopter (or autogyro) whose rotors serve as bearing surfaces (the aircraft are, of course, air like balloons and airships).

An aircraft model may be designated as a flying device only under the following conditions, which must be cumulatively fulfilled, and are:

a) non-commercial (for competitive, sporting or recreational purposes only);
b) uninterrupted direct visual contact with the pilot during the flight;
c) absence of its own control and navigation elements (inability to operate autonomously) and
d) inability to carry a person on board.

An unmanned aircraft in general is an aircraft designed to operate without a pilot on board, irrespective of its weight, subject to an operating permit from the Civil Aviation Authority, unless it is the model of up to 20 kg maximum takeoff mass. Unmanned aircraft operation and model operation are subject to both national laws or directly applicable EU regulations and international aviation regulations based on the Chicago Convention. These are the so-called Aviation Regulations issued by the International Civil Aviation Organization (ICAO), the Aviation Associations Association in accordance with European Union regulations and the EUROCONTROL European Organization for the Safety of Air Navigation. The Civil Aviation Act confers normative force on these special norms. ICAO aeronautical regulations are governed by the Czech "L" aeronautical regulations. ICAO aeronautical regulations are based on Article 37 of the Chicago Convention. These are normative aviation standards issued for the purpose of unification of civil status modifications in individual countries. They relate in particular to the rules of flight, airworthiness of aircraft, designation of aircraft, competence of ground personnel, air services and so on.

Operation of unmanned aircraft and models is devoted to the special supplement X to the general rules of flying L 2. It is actually a purely Czech pendant of another international aviation code L 2 (anchored in our legal order pursuant to Section 102 [2] of the Civil Aviation Act). The issue of normative power provokes questions in the context that obligations can be imposed by our constitution only on the basis of the law. In fact, Amendment X issued by the Ministry of Transport without clear regulatory authority acts as a legal provision as part of a principle ban, while a substantial change to the civil aviation law or a special law to give the drones the statutory duty is not currently under surveillance. This legal provision can generally be characterized as follows: activities that are generally prohibited, the law defines the regulatory framework in which such activity is considered to be a holiday. The comprehensive positive adaptation of drones in the aviation area is lacking, and the limits of holiday have no

support in the law or in the law. The drone is principally bound to a special permit, the drone is considered to be a strange, unwanted thing for which an exception must be allowed on each individual case, but adherence to Supplement X is intended to guarantee its impunity, in fact, legal operation. The issue of adhering to the Supplement X for an emergency in the airspace will undoubtedly be crucial in assessing possible liability for a misdemeanor and a similar prism will appear to be seen in Supplement X even in the event of a judicial appraisal of liability for the damage caused. Whether the normative value of Supplement X in the constitution and the rule of law is at all controversial, it is worthwhile to know it and to adapt it not only for the sake of its own integrity but also for the safety of others not only pilots, crews and travelers but also of other individuals and anywhere, where the drone can penetrate. The deeper meaning of a certain standard may be the fact that certain activities are carried out and certain things are always done in the same, predictable way. The principle of Supplement X is the principle that an unmanned airplane flight may only be conducted in such a way as not to jeopardize the safety of flying in the airspace, persons and property on the ground and the environment. This regulation is a legally binding regulation for unmanned aircraft; for models up to a maximum take-off weight of 20 kg is only of a recommending nature, with the exception of Article 7, which defines the spatial conditions of flying. However, in principle, the recommending nature of the models may become mandatory, albeit only transferred, if a possible litigation (in particular damages) comes to the question whether the model's flight complies with the precautionary principle.

Adopting positive legal rules for drones would be more than desirable; the drones themselves do not seem to represent a fundamental ethical problem, and the partial ethical issues associated with them will need to be addressed relatively in relation to the specific ways of their use. The regulation of the drones is, of course, in diapers and our western neighbors. For example, in Germany, only this year, they have been reformed, in the form of a subordinate regulation. The rules contained in it are quite strict. Future European rules on drones operate on the platform of the European Parliament Resolution of 29 October 2015. The key to Supplement X is that the pilot-in-flight can only be operated in such a way as to jeopardize the safety of flying in the airspace, persons and property on the ground and the environment. This regulation is a legally binding regulation for unmanned aircraft; for models up to a maximum take-off weight of 20 kg is only of a recommending nature, with the exception of Article 7, which defines the spatial conditions of flying. However, in principle, the recommending nature of the models may become mandatory, albeit only transferred, if a possible litigation (in particular damages) comes to the question whether the model's flight complies with the precautionary principle.

The main rules common to models up to a maximum take-off mass of 20 kg as well as other unmanned aircraft are listed below. In principle, it is only possible to fly in Class G airspace, which means a height of up to 300 m above sea level and outside of the clouds. Derogated rules apply in particular to flights near airports (5.5 km from the center of the airport), respectively in their operating zones, controlled districts and their protection zones and other buffer zones or prohibited zones. The reliefs include models with a maximum take-off weight of up to 0.91 kg. They are allowed to fly up to a maximum of 100 m in the aerodrome zones. In the details it is necessary to refer to the quoted aeronautical prescription. Unmanned airplanes are also not allowed to transport dangerous goods and, in principle, do not dispose of any objects. The pilot is not allowed to move with other equipment during the flight control. Some rules may make an exemption to the Civil Aviation Authority. Unmanned airplanes must not be propelled by a rocket or pulse engine, and autonomous aircraft (whether pre-programmed or simply self-flying and unmanageable) are totally forbidden in the common airspace. Other operational limitations for unmanned aircraft (or models above 20 kg) are minimum distances from persons other than the pilot and the densely populated area (when taking off and landing

a horizontal distance of at least 50 m from another person, otherwise the horizontal distance is 100 m from other persons, means and buildings and 150 m from a densely populated area). The operation of an unmanned aircraft is subject to authorization (Section 52 of the Civil Aviation Act). Unmanned aircraft and their pilots are registered with the Civil Aviation Authority. A pilot may only be authorized to pilot these facilities on the basis of demonstration of the basic ability to safely drive an unmanned aircraft and have the theoretical knowledge required.

It should be noted that these limitations apply not only to the operation of an aircraft with a maximum take-off weight of more than 20 kg, but also to smaller and lighter devices, if they are not models, ie, especially if we use them for aviation and commercial activities main or auxiliary. Just the use of even a small unmanned, short-distance and underground surveillance device is subject to much stricter regulation, as opposed to flying, for its own pleasure, the most serious element of which is probably the need to obtain the appropriate permission from the Civil Aviation Authority for both the aircraft and the for the pilot. For aeronautical activities, we have to consider at first sight non-naive activities such as wedding photography by a professional photographer from a height using a drone – quadrocopter or a survey of the construction elements of a high-rise building by a camera controlled in the same way a plumber examines the lunar sewerage of a residential house. In such cases, the question arises whether the current provisional drones regulation is not purposelessly strict. Let's go back to Article 8 of the Chicago Convention on Unmanned Airplanes, and let's recall that the situation around unmanned aircraft is diametrically different today. While a heavier airplane was born into a legal vacuum in the early 20th century, the current law enforcement of unmanned aircraft continues to a large extent in the form of airborne bombs. In this respect, even in the near future, the law could be changed, but on the other hand, nobody wants a massive expansion of drones operated by non-residents, who make their fellow bad pilots of strokes bruise, cut off their skin or cause other, more serious and more fatal injuries. [7]

3 ACTUAL USE OF QUADCOPTERS, THEIR FUTURE AND OTHER VISIONS

There are currently plenty of ways to use quadcopters. Their possible use also corresponds to their distribution. One of the basic ways of partitioning is the division into the military for which it was originally developed and non-military – usable outside the military environment.

3.1 Military Quadcopters

These quadcopters belong to Class I Military drones. Military drones can generally be divided into three classes [8]:

A. Class I (< 150 kg): micro, mini or small drones.

There are several types of Class I drones that can be used in the Computerized Command Control Communication & Information solutions to provide Intelligence, Surveillance, Target Acquisition and Reconnaissance capabilities (ISTAR).

B. Class II (150-600 kg): tactical.

The tactical UAVs are specially designed to be used in the organic battalion level or in Special Forces as assets for purposes of medium range surveillance.

C. Class III (>600 kg): strategic.

The Class III UAVs are usually referred to as Medium Altitude Long Endurance (MALE), MALE systems as well as High Altitude Long Endurance (HALEs) UAVs. The MALEs are especially ideal for surveillance as well as reconnaissance on a non-threatening area. They have a wide range of applications namely being used to determine the position of the

enemy or the movement of certain populations that are not involved into a conflict. They have state of the art infrastructure and they have also been used to compile lists of targets.

Military UAVs can also be classified based on the specific roles they are meant to play in particular military operations. Based on this we have the following UAVs [8]:

A. Target and decoy UAVs.

These can be used to provide ground as well as aerial gunnery at a target which simulates an enemy missile or aircraft.

B. Reconnaissance UAVs.

These UAVs are used to provide intelligence at the battlefield.

C. Combat UAVs.

Combat UAVs have been used to provide attack capability for some high-risk missions.

D. Research and Development UAVs.

Have been used to further develop UAV technologies that can be integrated into UAVs that have been deployed in the field.

The US Army has also been engaged in massive quad-copters in particular for the purpose of exploring the battlefield in recent months. These quadcopters, however, want US Army to use as a support for the solution of various emergencies – Fig. 3.

Fig. 3
Lance Cpl. James R. Fiers Jr., a rifleman with Battalion Landing Team, 2nd Battalion, 6th Marine Regiment, 26th Marine Expeditionary Unit, launches a drone during live-fire training at Camp Lejeune, N.C., Jan. 17, 2018.TOJYEA MATALLY/U.S. MARINE CORPS [9]

Another example of quadcopters deployment can be the use of quadcopters as a continuous floating UAVs in one place anchored on data and power cables – Fig. 4, at the newly-opened Ilan and Assaf Ramon International Airport (beginning of 2019) in Israel.

The development of the quadcopters (although in this case, the quadcopters can not be talked about, but rather the tricopter or the hexacopter is under the conditions of the Czech Republic and the Military Technical Institute.) The developed unmanned rotor universal system can be used not only for the needs of Czech Army missions in missions , but also in fulfilling the difficult tasks of the components of the integrated rescue system, for example, it was deployed as part of the monitoring of the explosion of ammunition in the warehouse in Vrbětice – Fig. 5. [11]

Fig. 4
Drones connected to the power and data cables at the newly opened Ilana and Asafa Ramon International Airport and the Negev Desert near the Isle of Ejlat provide a continuous monitoring of the area. Author David Borek hop source: CT24, CTK [10]

Fig. 5
The site of the Military Technical Institute unmanned device during monitoring in the village of Vrbětice [12]

3.2 Non-Military quadcopters

Over time, quadcopters originally developed for military use began to be used in non-military areas. For decades, this UAV has been generating invaluable helpers in various areas of our lives, including recreation.

The design basis for each quadcopters is frame, propeller, motors, engine regulators, accumulator, flight controller (control unit) and radio receiver (or safety equipment – rescue parachutes). Optional additional devices are the optional quadcopters (optical devices, sensors, etc.) mounted on the gimbal (special frame for attachment of attachments). Quadcopters are known to include Microdrones GmbH, DJI or Robodrone. The use of all quadcopters (especially flight time) is limited by the capacity of the battery used and the terrain, including meteorological conditions, which may interfere with the operator-operator interface. An exception to this are quadcopters, which, as mentioned in subchapter 3.1, may be destined for continuous monitoring of the environment where flight time is not limited as these UAVs are anchored on the power and data cable.

Quadcopters can be divided into several groups, namely:

A. Photographic

The use of quadcopters for these purposes (photography, but mostly shooting) is certainly the most widespread. Their use can be seen, for example, in the field of insurance (verification of the course and consequence of extraordinary events, ie damage to buildings, machines – eg cranes, bridges, consequences after fire, forests, etc.), the real estate market (attractive to advertisements, etc.), control of large real estate to their owners (roofs, building envelopes, etc.) after the occurrence of extraordinary events, checking of aircraft before their take-off – pioneer EasyJet, etc.

For this purpose, commercially available quadcopters (for professional purposes, particularly high quality) can be used with optical instruments – cameras, cameras or thermal cameras or a combination of cameras and thermal cameras.

In the event of extraordinary events or crisis situations, the quadcopters thus equipped will assist rescuers, for example, in reconnaissance of areas affected by fires – see Fig. 6, floods, storms or storms, in search of persons, after hidden fireplaces, in the course of interventions of fire protection units in building complexes for the purpose of exploring premises these rescuers may be at risk or where they can not get quickly, etc. Closer to [13].

Fig. 6
Photographs from quadcopters of fire in Severochem, which broke out on May 29, 2017 shortly after 12 o'clock [13]

Unfortunately, in this area, we can also experience many negative phenomena that could make it harder for these rescuers. These are, for example, broadcasting quadcopters "curious" over emergency sites, which make it difficult to deploy other airborne resources. It is also possible to meet quad-copters broadcasting over closed sites such as road accidents or crime sites, in order to obtain "exclusive footage".

Detailed information about photographic quadcopters can be for example found in [14].

B. Detection

The difference with photographic quadcopters lies in an additional device. These are sensors – thermal, chemical etc., detecting, for example, temperature, smoke, presence of hazardous chemicals in the environment or radiation, etc. In the event of extraordinary events or crisis situations such quadcopters can be used for example in fires, chemical accidents, radioactivity leakage. Additional laser devices can be used for measuring (eg in building) laser scanners – targeting objects or creating 3D models or a variety of multispectral or hyperspectral

cameras whose benefits can be traced to the environment, agriculture, forestry, soil protection – for the purpose of creating a variety of special maps. [1]

One of the top in this area is eg Aerialtronics, which mainly focuses on the production of commercial quadcopters and additional sensors, FLYCAM UAV, etc. Such quadcopters with full equipment are no longer a matter of course, and the price of around € 20,000 is no exception. In particular, the additional sensors increase the price. In the case of this group of quadcopters, the processing of acquired data begins to take place, where the transmissions are mostly provided through the network 4G – Fig. 7.

Fig. 7
Quadcopters Altura Zenith offered by company Aerialtronics capable of detecting organic volatile compounds or radiation with additional sensors [15]

C. Delivery

These quadcopters can be used for the import or logistics support needs. In our state, however, the use of these machines is already hindered by the above-mentioned limitation of the supplement X to the general rules of flying L 2 (see above).

By complying with legal requirements, these facilities can already be used with special additional equipment (especially suspensions or grips) for the transport of smaller material or a variety of supplies – food, water, in difficult-to-reach terrain (eg people who can not get rescuers – stuck in mountain terrain, etc.).

At present, the manufacturers of these machines are particularly interested in the development of quadcopters for the transport of persons and loads with a higher weight (quadcopters with capacity of nearly a quarter of a ton already introduced by Boeing).

A special type of quadcopters with almost unlimited flight times, which is particularly usable in combating fires, may be machines connected to an electrical and data cable and a hose to a water source. He then sets fire to the required height. It can be very cheap to replace eg a helicopter and a bambi bag or to replace some technique of fire protection units.

D. Recreational

These quadcopters, which can be purchased on a regular sales network, have received many supporters in the last decade, not just in the ranks of the youth. Even when operating these quadcopters, their operator must adhere to certain operating rules. For example, he must not operate the quadcopter without losing direct visual contact with him during taxiing or flight.

They must constantly monitor and evaluate visibility, flight traffic in the area, and possible flight obstacles. It is also closer to [16].

Regular recreational quadcopters, as we know them so far, will probably soon retreat to the new generation of these flying machines, namely "Skydio R1". They are quad-copters with full autonomy that can rotate around the chosen object or monitor it without any problems (snowboarders, bikers, etc.). Since in these cases, of course, the operator can not have a non-stop visual contact with this quadcopters, it violates the rules for operating these machines in a supplement X to the general rules of flying L 2. These machines are usually fitted with more than a dozen navigation cameras (these actually consist of autopilot sensors), RAM min. 4 GB and a processor (such as the Nvidia Jetson TX1), however, are no longer a cheap thing, their price is usually over CZK 50,000, while the basic quadcopters can also be purchased with the camera from CZK 1,000. [17]

Quadcopters can also be used for marketing, concert lighting, inventory counting, etc. Their use is constantly expanding. Both in the military and non-military spheres, the so-called "underwater drone" is gradually being promoted. In the military field, it is mainly about the control of hulls, the monitoring of the docks or the performance of special tasks, etc. In the non-military area, underwater drone can be used in the field of construction – inspection of bridge pillars, guides of dams and their facilities, or also for recreational purposes.

3.3 Future and other visions of using quadcopters

So, as you can not stop progress in development in any area, the area of development and use of quadcopters probably has no limits. The use of these machines can be seen not only in the expansion of delivery services, but also in the transport of persons over densely populated areas (eg using the already tested type of quadcopters Ehang 184). Also, the further development of IT technologies, safety features, or longer flight lengths (combined with solar panels, for example) will give the quadcopters a further degree of autonomy in the short term and thus other possibilities to use them.

In connection with this, the European Union is already considering adopting some new rules for the operation of quadcopters (and drone at all), which should enter into force in 2021. This could result in a much more massive deployment of commercially operated quadcopters. This can bring about a considerable number of new jobs (only tens of thousands of jobs in the European Union can be spoken), as well as an increase in turnover in a wide range of industries. These new EU rules should enshrine:

- EU-wide drones for drones;
- division of drones into three categories (Open, Specific, Certified);
- increasing safety and awareness when buying a drone in the EU;
- mandatory registration of all drones users over 80 J impact kinetic energy;
- market development, Droning Traffic Management (UTM), e-identification and classified drones scenarios.

The newly adopted legislation should also embody the Unmanned traffic management system (U-Space / UTM). Closer to [18]. By 2021, however, the use of quadcopters in non-public spaces (in enclosed spaces), ie warehouses, etc. can be expected.

CONCLUSION

Quadcopters are currently an invaluable helper both in the military environment for which they were originally developed and in areas associated with everyday life. An important role has also been played in the past years (and in the future, this role is likely to grow even

more) in dealing with various emergencies or crisis situations, both in the prevention and repression phases. That is wherever these machines can replace the rescue workers whose deployment would be inefficient, impossible or even health or life-threatening in the particular case. They can also be helped by the Police of the Czech Republic in a variety of situations – traffic monitoring, interventions.

However, quadcopters may not only serve as support to address the abovementioned emergencies or crisis situations or support in other areas. They can become a tool to endanger our privacy, disturb the airspace (complicate or completely stop traffic at airports – see, for example, Gatwick International Airport in December 2018 or Václav Havel Airport in Prague in September 2018) or can be an instrument of industrial espionage. Practical examples show that quadcopters themselves can be the cause of a fire or other threat in their crash. They can also be a tool of sabotage, vandalism, or chaos at cultural events.

Quadcopters can also become highly effective weapons in the hands of terrorists. This is confirmed, for example, by the Islamic State, which the quadcopters took advantage of in the fighting in Iraq in the autumn of 2016 in the form of delivery machines. These machines were used initially as a "suicide mission" with the cost of explosives. Then they were remotely guided with fitted hand or mortar grenades. Their use, subsequently, of the Iraqi party (especially in the vicinity of Mosul) has earned the title of "First Dron War" in the press. For this reason, a number of armaments companies are currently focusing on the development and manufacture of Counter Unmanned Aerial Systems (C-UASs) installed on vehicles or buildings that operate as microwave frequency jammers that circulate qadcopters control signals. Initially, the downsizing of qadcopters and shotguns proved to be good. Now, the first attempts are made with quadcopters fitted with weapons or firing nets. Attempts are also being made to eliminate flying quadcopters through birds of prey. [19]

In spite of some of the negatives associated with the operation and use of this type of UAVs, it can be said that their rapid development and use in various areas of our lives will have (as many different visionaries have predicted decades ago through science fiction films) green.

Literature

[1] KARAS, Jakub and Tomáš TICHÝ. *Drones.* Brno: Computer Press, 2016. ISBN 978-80-251-4680-4.

[2] JANOŠEK, Miroslav. Quadcopter Technical Possibilities and their Use in Performing Tasks Aerial Reconnaissance. In: *Tactics 2016*. Brno: University of Defence, p. 45–48. ISBN 978-80-7231-398-3.

[3] KROSSBLADEAEROSPACE. History of Quadcopters and other Multirotors [online]. [view 2019-01-20]. Available from: https://www.krossblade.com/history-of-quadcopters-and-multirotors/

[4] Association of the United States Army. *The Flying Octopus': The Forgotten Beginning of Army Helicopter Aviation* [online]. [view 2019-01-23]. Available from: https://www.ausa.org/articles/%E2%80%98-flying-octopus%E2%80%99-forgotten-beginning-army-helicopter-aviation

[5] Wikipedia. *Quadcopter* [online]. [view 2019-01-24]. Available from: https://en.wikipedia.org/wiki/ Quadcopter

[6] Czech Republic. Act No. 49/1997 Coll., *On Civil Aviation and on Amendment to Act No. 455/1991 Coll., On Trades Licensing (Trades Licensing Act), as amended.*

[7] DRONEWEB. *The UK has decided to register even small drones* [online]. [view 2019-01-25]. Available from: http://droneweb.cz/legislativa-provozu-dronu/item/159-legislativa-velka-britanie

[8] DroneLab. *Types of Military Drones: The Best Technology Today* [online]. [view 2019-01-25]. Available from: http://mydronelab.com/blog/types-of-military-drones.html
[9] STARS and STRIPES. *Marines acquire hundreds of quadcopter drones for infantry squads* [online]. [view 2019-01-24]. Available from: https://www.stripes.com/news/marines-acquire-hundreds-of-quadcopter-drones-for-infantry-squads-1.512055
[10] CT 24. T*he new Israeli airport in Ejlat protects the high fence. In the event of a suppression of the conflict, it may replace Tel Aviv* [online]. [view 2019-01-25]. Available from: https://ct24.ceskatelevize.cz/svet/2711972-nove-israelske-letiste-v-ejlatu-chrani-vysoky-plot-v-pripade-vyostreni-konfliktu-muze
[11] News.CZ. *The Military Technical Institute introduced a new unmanned machine* [online]. [view 2019-01-24]. Available from: https://www.novinky.cz/domaci/361925-vojensky-technicky-ustav-predstavil-novy-bezpilotni-stroj.html
[12] VTÚ. *VTÚ IN THE MEDIA – BRUS: Sharp action of the Czech dron in ammunition warehouse* [online]. [view 2019-01-25]. Available from: http://www.vtusp.cz/news/vtu-v-mediich-brus-ostra-akce-ceskeho-dronu-v-municnim-skladu-www-armadninoviny-cz-30-10-2014
[13] JANOŠEK, Miroslav and Jan KYSELÁK. Quadcopters and their possible use. In: *Conference Safety & Security Conference Prague 2018*. Prague: Václav Havel Airport, p. 53–57. ISBN 978-80-904317-5-1.
[14] Jablonecký deníkCZ. *Liberec – Accident or intention? The Northochem fire investigation took over* [online]. [view 2019-01-26]. Available from: https://jablonecky.denik.cz/pozary/pozar-mohl-byt-zalozeny-umyslne-20170531.html
[15] JURAČKA, Petr Jan. *Drones – Bird Photography: What you need to know about drones and their use for aerial photography and video*. Prague: Grada, 2017. ISBN 978-80-247-5787-2.
[16] AERIALTRONICS. *Aerialtronics' offers widest sensor compatibility* [online]. [view 2019-01-24]. Available from: lhttps://www.aerialtronics.com/2015/11/aerialtronics-altura-zenith-offers-widest-sensor-compatibility-on-the-uas-market
[17] JANOŠEK, Miroslav and Jan KYSELÁK. Quadrocopter Options and their Use when Searching for Crews of Aircraft in Distress in Inaccessible Terrain. *TRILOBIT – scientific journal*. 2017, vol. 2017, no. 2, no pages. ISSN 1804-1795.
[18] Live. *DJI drones are just stupid toys, from Skydio R1 you sit on your butt!* [online]. [view 2019-01-25]. Available from: https://www.zive.cz/clanky/drony-dji-jsou-jen-hloupe-hracky-ze-skydio-r1-si-sednete-na-zadek/sc-3-a-191829/default.aspx
[19] Lupa.CZ. *There is no need to panic or what will bring EU-wide European legislation for drones* [online]. [view 2019-01-24]. Available from: https://www.lupa.cz/clanky/neni-treba-panikarit-aneb-co-prinese-celounijni-evropska-legislativa-pro-drony/
[20] Echo24.CZ. *Terrorist attack by the drones is just a matter of time* [online]. [view 2019-01-24]. Available from: https://echo24.cz/a/w4Adt/teroristicky-utok-dronem-je-jen-otazka-casu
[21] YouTube. E*asyJet testing aircraft inspection by drone* [online]. [view 2019-01-25]. Available from: https://www.youtube.com/watch?v=6vJtyjN8U_M