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History, Current State, and Prospects of Development of Unmanned Aerial Vehicles as a Technical and Forensic Tool and Object of Forensic Research

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■ **Abstract**. The relevance of the study is conditioned by the scientific originality and practical significance of using modern capabilities of unmanned aerial vehicles by law enforcement agencies. The purpose of the study is to investigate the history, current state, and prospects of development of the unmanned aerial vehicle as a technical and forensic tool and object of forensic science. The study is based on the dialectical method of cognition of social and legal phenomena and concepts. Along with it, such general scientific and special research methods as historical, comparative legal, system and structural, sociological, statistical, logical, and other modern approaches were used, allowing the study to formulate assumptions and draw conclusions. Based on the findings, an analysis of the history of the development of an unmanned aerial vehicle was carried out, where the author identifies five main stages, namely: the period of the late 19th – early 20th century, the period of the First World War and the post-war period, the period of the Second World War, the period of the Cold War and local military conflicts of that time, and the modern period, which was characterised by the involvement of modern unmanned aerial systems not only in the military sphere, but also in various spheres of human life, including criminal activities, and in the activities of law enforcement agencies to disclose, investigate, and prevent criminal offences. Based on the intended purpose, technical characteristics and parameters, the classification of unmanned aerial vehicles is given, depending on their types, size, weight, power plant, and control method. In this regard, attention is focused on unmanned aircraft systems related to multicopters, as the most promising unmanned aerial vehicles that can be implemented in the work of law enforcement agencies. Certain aspects and features of using an unmanned aerial vehicle as a technical and forensic tool and an object of forensic research are considered. In this regard, problematic issues related to definition of a unified legal terminology for systems and elements of an unmanned aviation complex. Priority areas of introduction of unmanned aerial vehicles in the activities of law enforcement agencies are highlighted. Considering international standards in the aviation sector, the main areas are proposed for improving Ukrainian legislation on registration, licensing, and certification of unmanned aerial vehicles, and the grounds and procedure for its use by relevant law enforcement agencies in the detection, investigation, and prevention of criminal offences. The practical significance of the study is conditioned by the fact that it examines topical issues of the history of development, the current state, and prospects for improving Ukrainian legislation on issues related to the practical use of an unmanned aerial vehicle as a technical and forensic tool and the object of forensic research

■ **Keywords**: drone; quadcopter; unmanned aviation system; unmanned aircraft; statutory regulation

■ Introduction

Over the past few decades, man has conquered more natural forces than in the entire previous history of mankind. Nowadays, the use of modern information and digital technologies is no longer considered something unusual. Moreover, due to their accessibility and capabilities, they have found their wide application not only in the military sphere, but also in law enforcement, civil, economic, and administrative activities [1-3].

Admittedly, most technological developments, to one degree or another, are closely related to the military-industrial complex. Unmanned aerial vehicles (hereinafter – UAVs, drones) are no exception to

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this rule, the main purpose of creating which was to implement and perform certain combat and reconnaissance tasks on enemy territory [4].

To date, unmanned aerial systems are one of the most promising areas of development of modern military aviation. Even today, the use of drones has led to significant changes in the tactics of conducting combat operations. It is believed that modern warfare is a war of drones and howitzers, where drones are the eyes of artillery. Their value is expected to increase even more in the near future. Now the market for combat drones is on the rise. According to some estimates, in the period from 2020 to 2029, the volume of its turnover will be at least UAH 38.7 billion [5]. Progress in their creation is probably the most important achievement of modern aviation over the past few decades.

At the same time, UAVs have become the subject of public discussion, in particular, regarding their irresponsible use in military intelligence operations and law enforcement activities. The incident that occurred in 2020 in Libya, as a result of which, the drone-kamikaze Kargu 2, without a specially given order, using artificial intelligence, independently tracked down and attacked an innocent person (a live target) [6].

It is also impossible to ignore the fact that today there is a need for proper legal regulation of Ukrainian legislation on the use of UAVs over private property, critical infrastructure facilities, and other protected objects. A separate study requires legislative regulation of the grounds for the use of drones by authorised law enforcement agencies and their officials, including during the detection, investigation, and prevention of criminal offences, etc.

In this regard, the discussion of problematic issues of scientific and technical support for the activities of law enforcement agencies is not new for legal science. They have been the subject of many scientific discussions of researchers and practitioners in the fields of criminal procedure, criminalistics, and intelligence-gathering activities not only in Ukraine. At the same time, the issue of using UAVs as a technical and forensic tool and object of forensic research, in contrast to military exercises, is relatively new areas of scientific study. However, some of their aspects, in particular, concerning the regulation of legislation on the use of drones in the activities of bodies and divisions of the National Police, are reflected in scientific discussions by Ye. Bakutin [1], V. Bilous [7], V. Korshenko [8], Ye. Kuzmenko [9], A. Movchan [10] and others. The scientific and theoretical developments of these authors are important for solving the problem of using UAVs by law enforcement agencies when performing their assigned tasks. With this in mind, this paper will investigate in more detail the history, current state, and prospects of drone development in the context of their use as a technical and forensic tool and object of forensic research.

Purpose of the study: the main purpose of the study is to investigate topical issues related to the history of UAV development, features of their classification, and the current state and prospects for improving the statutory regulation of the use of unmanned aerial systems in the detection, investigation, and prevention of criminal offences.

Materials and Methods

The methodological basis of the research was general laws and categories of cognition. To achieve the goal of the study, general scientific and special methods were used, which allowed formulating assumptions and drawing conclusions. Formal and logical methods allowed for studying laws and regulations, analytical materials, concepts, and authors' opinions on certain issues related to the subject of research. Based on the descriptive and analytical, dogmatic method, the interpretation of legal categories, the formulation of definitions and clarifications of the terminology, the development and formulation of proposals for improving legislation on the research topic were carried out. Using the comparative legal and formal legal method, the analysis of international and Ukrainian laws and regulations defining the concept and legal grounds for using UAVs was carried out. Using the modelling method – general conclusions and proposals were formed to improve the current legislation regulating public and legal relations in the aviation industry and law enforcement activities.

The study is based on the norms and provisions of the Air Code of Ukraine No. 3393-VI of 05/15/2011 [11], Convention on International Civil Aviation of 07/12/1944 [12], Aviation Regulations of Ukraine "Regulations for the use of Ukrainian airspace" approved by a joint order of State Aviation Service of Ukraine and the Ministry of Defence of Ukraine dated 05/11/2018 No. 430/210 [13], Rules for the use of flights by unmanned aircraft complexes of the State Aviation of Ukraine, approved by Order No. 661 of the Ministry of Defence of Ukraine dated 12/08/2016 [14], Instructions for the use by police bodies and divisions of technical devices and technical means that have the functions of photo and film shooting, video recording, approved by order of the Ministry of Internal Affairs of Ukraine No. 1026 dated 12/18/2018 [15], Rules of registration of state aircraft of Ukraine and rules of certification of a copy of a state aircraft of Ukraine: approved by Order of the Ministry of Defence of Ukraine No. 63 dated 02/07/2012 [16], Regulations on the use of Ukrainian airspace approved by resolution of the Cabinet of Ministers of Ukraine No. 945 of 12/06/2017 [17], Aviation Regulations of Ukraine, part 47 "Rules for

registration of civil aircraft in Ukraine", approved by order of the State Aviation Service of Ukraine No. 153 dated 02/05/2019 [18], Aviation Regulations of Ukraine "Technical requirements and administrative procedures for flight operation in civil aviation", approved by order of the State Aviation Service of Ukraine No. 682 dated 07/05/2018 [19].

■ Results and Discussion

History of UAV development. The development of UAVs can be divided into five historical stages, each of which was marked by its own important dates and events, which as a result contributed to their spread and improvement.

Stage I (early period). Unmanned piloting systems are inextricably linked to the beginning of the 20th century. It was during this period that radio waves were first used to transmit information wirelessly. With the development of radio technology, the frequency range of waves that can be generated and perceived by radio equipment has also expanded. This circumstance in 1903 allowed the Spanish engineer and inventor, Leonard Torez de Quevero, to invent a radio control system called "Telekin". The principle of its operation was a robotic device capable of executing simple commands, and its main purpose was to remotely control airships, boats, and torpedoes. Subsequently, due to lack of funding, the inventor was forced to abandon these projects [20].

Notably, "Telekin" was the second device, the operation of which was controlled by radio communication. Nikola Tesla is considered the inventor of the world's first patent for a radio-controlled device; his invention was called "Teleautomat" [21].

Stage II (the First World War and post-war period). The war of 1914-1918 gave an impetus to the development and introduction of unmanned radio-controlled devices in the military sphere. For example, the squadron of unmanned aerial combat vehicles described by N. Tesla as early as 1915 inspired English physicist and inventor Archibald Montgomery Lowe in 1916 to make the first attempt at unmanned aerial targets with an internal combustion engine [22, p. 120-186].

Around the same time, the prominent inventor and entrepreneur Elmer Ambrose Sperry, together with the company's designers "Hewitt-Sperry", developed by and they tested a bomber aircraft known as the "Flying Bomb" or "Hewitt-Sperry automatic airplane", which had the ability to deliver explosives to specified targets without a crew [23].

At the beginning of 1918, the chairman of the French Senate Committee on the Army, Georges Clemenceau, announced the launch of a state project to introduce "unmanned aircraft" into the French armed forces. The first French UAV was designed, manufactured and tested in 1923 by engineer Maurice Percheron [24].

In 1935, aircraft modelling enthusiast Reginald Leigh Dugmore (Denny) developed the first large-scale production model of a remote-controlled target "OQ-2 Radioplane" [25].

During the same period UAVs received their second name – *a drone.* The word *drone* refers to males in the honey bee family. In the 1930s, this word, in a joking form, began to be informally referred to English automated versions of aircraft "DH.82 *Queen Bee*". Due to the fact that these UAVs had a low speed and noisy flight more similar to a bumblebee (rather than a bee), they received the unofficial nickname "drone". Subsequently, in 1941, this name took on an official form and was adopted by the US Army [26, p. 67-81].

Stage III (the Second World War period). In 1940, Reginald Denny founded the company for the production of UAVs "Radioplane Company", which during the Second World War increased the model range of drones, not only for performing combat tasks, but also for training pilots [25].

In Germany, developments on the creation of radio-controlled drones began in 1938. As a result, a target drone of the "V1" model was created. *Vergeltungswaffe* – weapons of revenge), which was powered by a pulsed rocket engine. Today, the V1 is considered the first cruise missile in the history of Aeronautics [26, p. 96-101].

The use of UAVs during World War II was also reflected in intelligence purposes. For this purpose, the Luftwaffe was armed with aircraft-type drones of the Argus as-292 model, which also had the name Flakzielgerät 43, they were equipped with a camera for aerial photography and a parachute to prevent damage to the film during the landing of the drone [27].

Stage IV (post-war period and the Cold War). The post-war period was marked not only by the Cold War, but also by a number of local military conflicts, including the Korean War, the Tonkin incident, the Vietnam War, the Egyptian-Israeli war (War of Attrition), the Doomsday War (Arab-Israeli war), the 1982 Lebanon War, the Afghan War, etc.

All these armed conflicts have become an impetus for the production and testing of UAVs in the conditions of real military operations. One of the reasons for their rapid development and widespread use in military aviation was announced in 1972 by the US Air Force Command as a doctrine of *"zero deaths"*, the main purpose of which was that the use of drones allows performing military tasks without sacrificing the life and health of military personnel [28; 29, p. 65-72].

This was confirmed by Israel's development of the world's first drone IAI Scout, which was equipped with equipment that allowed to conduct real-time surveillance. The images and radar false targets provided by these UAVs helped Israel completely neutralise the Syrian air defence system at the beginning

of the Lebanese war in 1982, as a result of which none of the Israeli pilots were shot down [29, p. 14-20].

In the 1950s, for the first time, American company Ryan Aeronautical, developed a series of UAVs "Fairby" capable of launching from an airplane or ground launcher using a single rocket accelerator. Subsequently, in 1966, the Lockheed D-21 supersonic reconnaissance drone was developed [29, p. 25-30].

In the Soviet Union, since the 1950s, developments were also carried out to create military drones. The first such drone was a reconnaissance UAV model La-17 designed by the Lavochkin Design Bureau. The next UAV developed in the USSR was the Tu-123 supersonic long-range unmanned reconnaissance aircraft, which was designed and manufactured by the Tupolev Design Bureau in 1961. But the greatest success was the Tu-143 "Reys" reconnaissance UAV of 1970, designed for conducting tactical low-altitude reconnaissance in the frontline zone by photo and television reconnaissance of objects and individual routes, and monitoring the radiation situation along the flight route [30].

Stage V (modern period). The current stage of UAV development, first of all, was marked by high-tech innovations, the introduction of which took place in the development and improvement of unmanned aircraft systems. This circumstance gave an impetus to the introduction of unmanned aircraft in the commercial and civilian industries. Thus, in order to use UAVs for civilian purposes, in 2002 the European Union initiated the CERESON project, for which EUR 2.8 million were allocated and which attracted more than 20 international organisations, educational and scientific institutions, and leading manufacturers and developers in the aerospace industry [29, p. 44-49].

In 2014, the first commercial UAV flight to Alaska was made in the United States. Already today, issues related to the use of drones for domestic purposes are being publicly discussed, for example, during the delivery of food, medicine, mail, etc. In addition, the development of intelligent technologies and power supply systems has led to the use of drones not only for consumer purposes, but also in general aviation. As of 2022, drones show a wide demand among the population, they are used not only as entertainment and hobbies, but also in sports competitions. As a result, this circumstance created prerequisites for the emergence of new manufacturers of UAVs for entertainment and civilian needs in the start-up market.

The main market for the production and operation of drones belongs to the United States, Israel, China, India, Iran, Turkey, Great Britain, and the European Union (Germany, Italy, France, Spain, the Netherlands). Some of the most famous military UAVs in the world are MQ-1 Predator manufactured by General Atomics Aeronautical Systems equipped with air-to-ground missiles. It is the main combat drone in service with the United States [29, p. 4-6].

The smallest UAV is considered to be a helicopter-type micro drone Black Hornet 3, which belongs to the personal intelligence system used by the armed forces and law enforcement agencies. The system includes two drones controlled by a ground control station. The drone has a rotor diameter of 12.3 cm, a body length of 16.8 cm and a weight of about 33 g. At these sizes the Black Hornet 3 has a best-in-class audio and visual surveillance signature. In addition, the drone produces very little noise, which allows it to be used in secret operations. It is capable of operating at wind speeds from 7.5 to 10 m/s and air temperatures from -10 to 43°C [29, p. 15-18].

With the beginning of the military operation in the East, the Armed Forces of Ukraine, the National Guard and Border Guards also began to need UAVs, which gave an impetus to the development of domestic industries for their production. Leaders in this field are a number of state and private enterprises, including the Oleg Antonov Aviation research complex, LLC NPP "Athlon Avia", "Aerotekhnika-MLT", JSC "Meridian' named after S.P. Koroliov, etc.

It is impossible not to mention the Ukrainian enterprise "Motor Sich" whose engines are installed on UAVs not only Ukrainian companies, but also leading foreign UAV manufacturers [31].

Classification of UAVs. Classification of UAVs is carried out based on its intended purpose, technical characteristics and parameters, depending on its type, size and weight, flight altitude and range, engine installation and control method, etc.

Thus, depending on the type, drones are divided into:

– aircraft-type UAVs. That is aircraft with fixed wings like an airplane;

– helicopter-type UAVs (single-rotor), having a rotating wing on the helicopter shaft;

– glider-type UAV, which also has the name "skimmer" or "multicopter" [7, p. 170-175; 32, p. 44-49].

Unlike aircraft and helicopter-type drones, which use a complex system of blades with a variable angle of inclination, the multicopter has three or more propellers corresponding to the total number of its rotors, and relatively simple flight control.

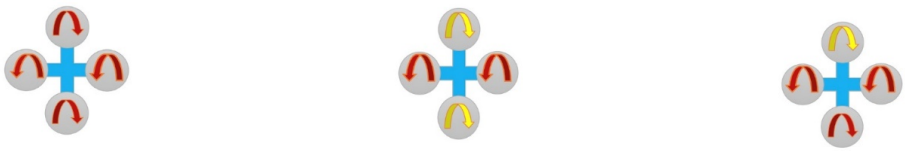
Depending on the number of rotors, skimmers are distinguished by:

– tricopters – equipped with three motors;
– quadrocopters – equipped with four motors;
– hexocopters – equipped with six motors;
– octocopters – equipped with eight motors.

The most common type of multicopter is a quadcopter. In terms of external parameters, its body usually has a cross-shaped appearance, and the rotors that it is equipped with are usually located at its ends. To direct the movement and flight of the quadcopter, a

mechanism is provided that causes the first pair of propellers to rotate in one direction, and the other in the opposite direction. Thus, by changing the relative speed of diametrically located one-from-one propellers, control of the flight and movement of the glider is achieved.

This configuration of the propellers allows you to reduce the net torque around the angle of movement of the aircraft to zero and by creating the opposite torque – to fly without the tail rotor, which is utilised by helicopters (Fig. 1).



a) b) c)

Figure 1. The figure shows the direction of movement of rotating quadcopter robots in which the following actions are performed

Note: *a – hover or adjust the height (applying equal traction to all four screws); b – roll, pitch, and yaw adjustment (by increasing the thrust of diametrically located rotors rotating in one direction); c – quadcopter roll adjustment (by increasing the thrust of one or two adjacent rotors, which leads to its horizontal movement)*

Given its small size, simple control system, and relatively low price, the quadcopter has become one of the most popular UAVs on the private market, which as a result allowed its widespread use not only in entertainment, commercial, military or law enforcement purposes, but also during the commission of torts, including its use as a tool for committing a criminal offence.

The literature describes other types of motorised and non-motorised UAVs, which differ in design features in paragliders, aerial sleds, blimps, drones based on the bionic principle of a flapping wing (flywheel, ornithopter), copying the movements of birds or insects, etc., but all of them have not found their wide application in practice [2; 4].

Depending on the size and maximum take-off weight, drones can be divided into three groups, namely:

– UAVs with a maximum take-off weight of no more than 50 kg (ultralight – with a take-off weight of up to 5 kg; light – with a take-off weight of up to 50 kg);

– UAVs with a maximum take-off weight of 50 to 300 kg (small – take-off weight of up to 100 kg; medium – off weight of up to 300 kg);

– UAVs with a maximum take-off weight of 300 kg (heavy – with a take-off mass of up to 1.000 kg; super-heavy – with a take-off weight of more than 1.000 kg) [3, p. 44-49].

Depending on the flight altitude and range, according to NATO standards, drones are divided into three classes, namely:

– UAVs whose range does not exceed 40 km (nano – range up to 1 km and flight altitude up to 100 m; micro – range up to 10 km and flight altitude up to 3 km; mini – range up to 40 km and flight altitude up to 3 km);

– UAVs whose range does not exceed 500 km (short-range – range up to 150 km and flight altitude up to 4 km; medium-range – range up to 500 km and flight altitude from 5 to 8 km);

– long-range UAVs (LALE – range of more than 500 km and a flight altitude of up to 4 km; MALE – range of more than 1,000 km and a flight altitude of up to 8 km; HALE – range of more than 4,000 km and a flight altitude of up to 20 km) [3, p. 44-49].

Depending on the type of engine, drones are divided into electric and those that run on an internal combustion engine, including hydrogen or solid fuel (piston, rotary, gas turbine (turboprop, turbofan, propeller-driven), jet).

The power plant system, along with the electronic computer control system, communication system and navigation system, is part of the main systems of the unmanned aviation complex.

Depending on the list of tasks set, additional systems and devices can be installed, such as:

– intelligence system (optoelectronic, thermal imaging, radar, radio engineering, radiation, chemical, bacteriological, and other types of intelligence);

– means for electronic warfare or electronic interference devices; devices for guidance and correction of guided weapons;

– means of hitting various types of targets;

– means of control and communication with the ground control point;

– automatic piloting and landing equipment;

– transport cassettes, compartments, fasteners, etc. [8, p. 12-24; 33, p. 7-17; 17].

Depending on the period of use, unmanned vehicles are divided into multiple-use UAVs (reconnaissance,

reconnaissance and strike, transport, weapons carriers, with advanced carrier functionality, with possible separation, interceptors) and single-use UAVs (false targets, barrage kamikazes, reconnaissance and strike kamikazes, interceptors) [34, p. 139-146].

The above classification is not exhaustive, and therefore UAVs are also divided depending on their intended purpose and scope of use (military, civil, commercial, industrial), according to the method of control (remote, automatic, and combined), according to the nature of the tasks performed (strategic, operational-tactical, and tactical, can perform such tasks as observation, collection of intelligence data of the area and objects, cargo transportation, electronic strikes, patrolling and monitoring of the area and objects, aerial photo and video shooting, striking air and ground targets of a potential enemy), etc. [28].

The International Civil Aviation Organisation of the United Nations, which is responsible for the organisation of world aviation, does not refer flight models (models of aircraft of reduced or miniature size) used for entertainment or air sports to UAVs. In turn, US legislation refers to drones as any aircraft without a crew, regardless of its size [29]. In Ukraine, the attitude to remote-controlled aircraft models is not clearly defined and remains open.

III. Statutory regulation. In accordance with international and national legislation, UAVs refer to aircraft whose use is regulated by specific laws and regulations. In Ukraine, one of the main codified legal acts regulating legal relations in the aviation industry is and remains the Air Code of Ukraine [11]. Thus, according to its norms, "*unmanned aircraft* – is an aircraft that is part of the *unmanned aviation system*, and is intended for performing a flight without a pilot on board, whose flight control and control is carried out *remote pilot (operator)* using a special control station located outside the aircraft" (paragraph 23 of Part 1 of Article 1 of the Tax Code of Ukraine).

A similar definition is found in the provisions of the Aviation Regulations of Ukraine, approved by the Joint Order of the State Aviation Service of Ukraine and the Ministry of Defence of Ukraine dated 05/11/2018 No. 430/210 [13], according to which, "*unmanned aircraft* – is an aircraft designed to perform flights without a pilot on board, whose flights are controlled by a special control station located outside the aircraft" (paragraph 6 of Section 1).

A similar concept is contained in the norms of the Chicago Convention on International Civil Aviation of 1944 [12], where "*an unmanned aerial vehicle* (*pilotless aircraft)* includes any aircraft capable of flying without a pilot on board" (Article 8).

In turn, to the elements *unmanned aviation system,* according to the Rules for the use of flights by unmanned aircraft complexes of state aviation, approved by the Order of the Ministry of Defence of Ukraine dated 12/08/2016 No. 661 [14], it was assigned "an unmanned aircraft, associated remote piloting points, necessary control lines, and other equipment, including, but not limited to any device, mechanism, appliance, software, or accessory necessary for the safe operation of an unmanned aircraft".

With this in mind, when formulating the definition of the concept *"unmanned aerial vehicle"*, the provisions of the above-mentioned regulations focus on the phrase *"aircraft"*. One of the reasons that contributed to this was that in Ukraine the term "*unmanned aerial vehicle"* appeared relatively recently. Having a virtually foreign-language origin (from English *an unmanned aerial vehicle* – UAV), this phrase is mostly reflected in international regulations and recently adopted Ukrainian bylaws, including by the Ministry of Internal Affairs of Ukraine.

These may include, for example, the Annex and Regulation of the Council of the European Union No. 428/2009 of 05/05/2009[1], or paragraph 2 of Section 1 of the Instructions for the use by police bodies and divisions of technical devices and technical means that have the functions of photo and film shooting, video recording, approved by the Order of the Ministry of Internal Affairs of Ukraine dated 12/18/2018 No. 1026 [15], where under the concept of *"unmanned aerial vehicle",* it was defined as an aircraft designed to perform a flight without a pilot on board, the control of which is carried out using a special control station located outside the aircraft – which actually literally repeats the definition given in paragraph 6 of Section 1 of the Aviation Regulations of Ukraine [13].

Given the above, it can be concluded that *"unmanned aerial vehicle"* refers to *"unmanned aircraft"* in the same way as *"unmanned aerial system'* refers to *"unmanned aviation complex"*. That is, these terms are absolutely identical and lexically synonymous, and therefore, their definition should not be misinterpreted and perceived differently.

This is also emphasised by the Rules for performing flights by unmanned aircraft complexes of the state aviation of Ukraine, approved by Order No. 661 of the Ministry of Defence of Ukraine dated 12/08/2016 [14] according to which, "an unmanned aerial vehicle (UAV) is an aircraft whose flight control is carried out remotely, using a remote piloting point located outside the aircraft, or an aircraft that flies autonomously under the appropriate programme".

In turn, "an unmanned aviation complex (unmanned aviation system) is an unmanned aircraft, its associated remote piloting points (ground control stations), necessary control and control lines, and other elements specified in the approved project of the type of unmanned aviation complex. An unmanned aviation complex can include several UAVs".

[1] According to Annex I of the EU Council Regulation No. 428/2009 of 05.05.2009, a UAV is any aircraft capable of starting and maintaining a controlled flight and its navigation without the presence of a pilot on board.

According to the norms of Ukrainian legislation, all aircraft of Ukraine by scope of use are divided into:

– *state-owned aircraft* – aircraft used in the military, border guard, civil protection service, National Police and customs authorities – paragraph 31 of Part 1 of Article 1 of the Tax Code of Ukraine);

– *civil aircraft* – all other aircraft that do not belong to state-owned aircraft (Paragraph 103 of Part 1 of Article 1 of the Tax Code of Ukraine) [11].

Registration and certification procedure of *state-owned aircraft of Ukraine* defined by the Rules of registration of state aircraft of Ukraine and the Rules of certification of a copy of the state aircraft of Ukraine, approved by the Order of the Ministry of Defence of Ukraine No. 63 dated 12/07/2012 [16]. In accordance with these rules, UAVs that relate to state aircraft of Ukraine, including those used by the National Police, without exception are subject to mandatory registration in the Register of state aircraft of Ukraine, the introduction of which is entrusted to the Department for regulating the activities of state aviation of Ukraine of the Ministry of Defence of Ukraine (Section II of the Rules for registration of state aircraft of Ukraine). At the same time, flights of state-owned aircraft of Ukraine that are not registered in the relevant register are strictly prohibited, since they violate a certain procedure for using Ukrainian airspace in accordance with the Regulation on the use of Ukrainian airspace approved by resolution of the Cabinet of Ministers of Ukraine No. 945 of 12/06/2017 [17].

In turn, the procedure for registration and certification of *civil aircraft of Ukraine* is regulated by the relevant Regulations for registration of civil aircraft of Ukraine [18] approved by the Order of the State Aviation Service of Ukraine of 02/05/2019 No. 153, and the Aviation Regulations of Ukraine "Technical requirements and administrative procedures for flight operation in civil aviation", approved by the Order of the State Aviation Service of Ukraine of 07/05/2018 No. 682 [19].

According to the above-mentioned bylaws, UAVs are subject to state registration of civil aircraft of Ukraine, the introduction of which is entrusted to the authorised body for Civil Aviation (State Aviation Service of Ukraine) or an institution authorised by it, except for those, *maximum take-off weight* which do not exceed 20 kg, and which are used for entertainment or sports activities (Section II of the Rules for registration of civil aircraft of Ukraine, Article 39 of the Tax Code of Ukraine) [18]. In this case, the registration procedure for UAVs classified as civil aircraft that are not subject to registration is regulated by the relevant provisions (part 9 of Article 4 of the Tax Code of Ukraine) [11].

The complexity of this issue lies in the fact that referring to such an indicator as "maximum take-off weight", it was not taken into account that most UAVs that are freely available do not contain this information in the operating documentation. At best, the technical documentation provides data on the mass of the UAV itself, taking into account its battery and rotors. This circumstance, first of all, is explained by the fact that most UAVs that are freely available for sale do not technically provide any fasteners for lifting additional cargo. However, ignoring the provision of indicators for the maximum take-off weight, the manufacturer created conditions under which a person would be able to deliberately avoid the registration procedure for registering a UAV. When solving this issue, it is also necessary to consider the fact that today a wide range of parts and spare parts is available for free sale, allowing for independent assembly of a UAV at home, which would require registration according to its technical characteristics.

Unregistered UAVs, along with legal nihilism and a low level of legal culture of citizens, pose a real threat to aviation security, the interests of the state and national security in general. This refers to the use of UAVs for the purpose of committing criminal offences related to smuggling, terrorist activities, collaboration, sabotage, espionage, etc.

Special attention should also be paid to the issue of unauthorised filming that violates the right to privacy and privacy of citizens. Thus, for example, with the help of UAVs, it is possible to conduct aerial photography of the private (personal) life of citizens, and property belonging to them, in order to further publish provocative photos and videos on the Internet that can negatively affect the business reputation of an individual or humiliate their honour and dignity [1, p. 314-327].

During the violation of the use of Ukrainian airspace, there is also a threat to people's lives and health. The possibility of accidents caused, for example, by a UAV falling on passers-by citizens, their vehicles, houses, and other property located in localities is not excluded. In addition, the use of UAVs over critical infrastructure facilities or within air routes can lead to particularly serious consequences or even disasters. This, first of all, indicates that the UAV as an aircraft is a source of increased danger, since its unauthorised use by an incompetent person can lead to irreparable consequences for people, society, and the state as a whole.

Conclusions

Thus, it is possible to conclude that today, in Ukraine, a number of issues related to the definition of a single terminology for an unmanned aviation complex, its systems and elements, the procedure for its registration, licensing, and certification need to be clearly regulated. When resolving these issues, it is advisable to consider the possibility of legal liability for non-registration or late registration of the UAV by its owner.

This is a confirmation of the relevance and need to develop common international approaches to the legal regulation of the Ukrainian aviation sector by implementing international standards in national legislation. In order to remove the Soviet influence from the legislation of Ukraine and bring its norms to international standards, it is advisable to consider the provisions of legal acts regulating legal relations in the aviation industry:

– establishment of uniform rules for registration (certification) of UAVs, mandatory for all copyright holders, including individuals;

– determination of the main restrictions and prohibitions on unauthorised use of UAVs related to ensuring flight safety, protecting the private life of citizens, and compensation for damage caused during the use of UAVs;

– establishment of general rules and prohibitions on the use of UAVs by civilians, including in areas where military facilities, penitentiary institutions, power lines are located, in crowded places, in rural areas during aviation processing of fields, etc.;

– granting the right to the relevant law enforcement agencies to stop the operation of unauthorised UAVs in the airspace in order to protect the life, health, and property of citizens, during mass events, investigative (search) actions and operational search measures, by damaging them, destroying them or suppressing them with firearms or special electronic counteraction devices;

– separate regulation of the provisions of the CPC of Ukraine and the law of Ukraine "On intelligence-gathering activities" regarding the use of UAVs as an independent technical and forensic means during investigative (search) actions, secret investigative (search) actions, and operational search measures;

– development of a unified certified register of technical and forensic means that can be used by law enforcement agencies in the performance of their functions, and would allow their use in the course of pre-trial investigation and intelligence-gathering activities;

– development of an interdepartmental Instruction "On the Procedure for Using UAVs and Applying Their Results for Forensic Purposes in the Detection, Investigation, and Prevention of Criminal Offences";

– establishment of a ban on posting photos and videos about the private life of citizens obtained by aerial photography on the Internet without their consent;

– establishment of administrative and criminal liability for violation of the established rules and prohibitions on the use of UAVs.

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Історія, сучасний стан і перспективи використання безпілотних літальних апаратів як техніко-криміналістичного засобу та об’єкта криміналістичного дослідження

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■ **Анотація**. Актуальність теми дослідження зумовлена науковою новизною та практичною значущістю використання сучасних можливостей безпілотних літальних апаратів органами правопорядку. Метою статті є дослідження історії, сучасного стану та перспектив розвитку використання безпілотного літального апарату як техніко-криміналістичного засобу та об’єкта криміналістичного дослідження. Основою методологічного інструментарію слугував діалектичний метод пізнання соціальних і правових явищ та понять. Поряд з ним застосовано такі загальнонаукові та спеціальні методи дослідження, як історичний, порівняльно-правовий, системно-структурний, соціологічний, статистичний, логічний та інші сучасні методи дослідження. На підставі вивчення історії розвитку безпілотного літального апарата виокремлено п’ять основних етапів: період кінця XIX – початку XX століття; період Першої світової війни та післявоєнний період; період Другої світової війни; період Холодної війни та локальних воєнних конфліктів того часу; сучасний період, означений впровадженням сучасних безпілотних літальних систем не лише у військову сферу, а й в різні сфери життєдіяльності людини, зокрема в злочинну діяльність, а також у діяльність правоохоронних органів з розкриття, розслідування та попередження кримінальних правопорушень. З огляду на цільове призначення, технічні характеристики та параметри наведено класифікацію безпілотних літальних апаратів, що залежить від їх типів, розмірів, ваги, силової установки та способу керування. Безпілотні авіаційні системи, які належать до мультикоптерів,

визнано найбільш перспективними безпілотними літальними апаратами для впровадження в роботу правоохоронних органів. Досліджено особливості використання безпілотного літального апарата як техніко-криміналістичного засобу та об'єкта криміналістичних досліджень. Окреслено пріоритетні напрями впровадження безпілотних літальних апаратів у діяльність правоохоронних органів. На підставі міжнародних стандартів в авіаційній сфері запропоновано напрями вдосконалення українського законодавства з питань реєстрації, ліцензування та сертифікації безпілотних літальних апаратів, а також підстав і порядку їх використання відповідними правоохоронними органами. Практична значущість статті полягає у висвітлені актуальних питань історії розвитку, сучасного стану й перспектив удосконалення національного законодавства з питань, що стосуються практичного застосування безпілотного літального апарата як техніко-криміналістичного засобу та об'єкта криміналістичного дослідження

■ **Ключові слова**: дрон; квадрокоптер; безпілотна авіаційна система; безпілотне повітряне судно; нормативно-правове регулювання