SAFETY RISK OF UNMANNED AERIAL VEHICLES

A PILÓTA NÉLKÜLI LÉGI JÁRMŰVEK BIZTONSÁGTECHNIKAI KOCKÁZATA

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Abstract

Drones never seen before are present in everyday life, allowing for technological advancement and falling prices. Drones with increasingly precise navigation, longer operating time and video and au-dio recording systems and load-bearing capa-bilities pose a serious safety risk. The lack of registration of equipment and pilots makes it almost impossible to de-tect and prosecute the perpetrator of a damage event or infringement. In 2018, the Council of the European Union adopted updated aviation safety rules, which amend the mandate of the Europe-an Aviation Safety Agency (EASA) and now include, for the first time, EU-level rules for drones of any size used for civil-ian purposes. In 2019, ESA pre-sented a unified European package of laws on the use of drones, and in 2021 Hungary also introduced significant changes in the use of drones.

Keywords

drone, safety risk, prevention, regulation

Absztrakt

A drónok soha nem látott mértékben van-nak jelen a mindennapokban, köszönhetően a technológiai fejlődésnek és a csökkenő áraknak. Az egyre precízebb navigációval, hosszabb üzemidővel és hatótávolság rendelkező drónok a kép-és hangrögzítő rend-szerekkel, teherhordó ké-pességükkel ko-moly biztonságtechnikai kockázatot jelen-tenek. Az eszközök és pilóták regiszt-rációjának hiánya pedig szinte lehetetlen-né teszi egy káresemény, jogsértés elkövetőjének felderítését és fele-lősségre vonását. Az Európai Unió Tanácsa 2018-ban elfogadta az aktualizált repülésbiz-tonsági szabályokat, amelyek módosítják az Európai Repülésbiztonsági Ügynökség (EASA) megbízását, illetve most először uniós szintű szabályokat tar-talmaznak a bármilyen méretű, polgári cé-lokra használt drónokra vonatkozóan. Az ESA 2019-ben bemutatta a drónok használa-tára vonatkozó egységes európai tör-vénycsomagot, 2021-ben pedig hazánk is jelentős változtatásokat vezetett be a drónhasználatra vonatkozólag.

Kulcsszavak

drón, biztonságtechnikai kockázat, elhárítás

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INTRODUCTION

Unmanned aerial vehicles (UAVs), better known as drones, are taking part in everyday life to an unprecedented extent. As a result of technological advances and declining prices, drones are no longer luxury items available only to a few, but tools available to the average person. As a result, drones are no longer operated only by skilled, trained pilots, but even by inexperienced children. Drones with increasingly precise navigation, longer operating times and longer ranges, equipped with growingly advanced image and sound recording systems and their load-bearing capacity, now pose a serious safety risk. And the lack of registration of equipment and pilots makes it almost impossible to detect and prosecute the perpetrator of a damage event or infringement. Integrating safe and reliable UAVs into aviation can only be feasible if the acquisition and operational cost is low enough to be economically viable in recent economy. [1] The seriousness of the situation and the need for regulatory change have also been recognized by the European Union, as the Council of the European Union adopted updated aviation safety rules in 2018, which, among other things, amend the mandate of the European Aviation Safety Agency (EASA), and, for the first time, contain EU-wide rules for drones of any size used for civilian purposes. In 2019, ESA presented a unified European package of laws on the use of drones (Commission Implementing Regulation (EU) 2019/947), and in 2021 Hungary also introduced significant changes in the use of drones. The drone flight safety is the desired optimum state in which drone operations executed in certain circumstances with an acceptable operational risk. [2]

CURRENT REGULATIONS FOR UAVS IN HUNGARY

As mentioned in the introduction, on 12 March 2019, the European Commission accepted EU rules setting out technical requirements for drones. The ESA package presented in 2019 creates uniform regulations throughout the European Union, unmanned aerial vehicles can be used in all countries belong to European Union under the same conditions, and the transport, proper operation and cross-border use of business drones within the European Union can be facilitated. The aim is to lay down the principles that guarantee security, safety, protection of privacy and personal data, and to encourage innovation. [3] The uniform European package on the use of drones is Commission Implementing Regulation (EU) 2019/947, the package is available: [4] Hungary requested and received a postponement of the introduction of EU legislation in order to develop amendments to its local regulations. According to the European Union's regulatory standard, member states may accept stricter rules than those of the European Union, but not the opposite. The provisions contained in the European Union system of rules no longer need to be repeated in domestic legislation. Hungarian laws and regulations, as well as the rules formulated by the European Union, must be interpreted together. The basic concepts and statutes related to drones are defined in Act XCVII of 1995 on aviation. law. In December 2020, this law was amended to include the relevant rules, and as early as 2019, European Union regulations were issued that provided a framework for the development of drone regulation. Based on the risk level criteria and other criteria, the European Union regulation defines three categories of operations: "open", "special" and "licensed". "Open" category UAS operations are not subject to either a prior operating license or a UAS operator's statement of operation issued prior to the operation. The condition for belonging to the “open” category is the take-off mass of less than 25 kg, the unmanned aircraft must be kept at a safe distance from people and the pilot must be able to always see the drone with the naked eye. The UAS must not transport or scatter any material and must not be more than 120 meters from the ground. The "special" category should include other, higher risk types of operations, for which a thorough risk assessment should be performed to determine what requirements are required for the safe execution of the operation. For low-risk operations in the "special" category for which a standard scenario and detailed risk mitigation measures have been defined, the implementation of this regulation should be facilitated by an operator declaration system. Operations in the "licensed" category should be subject to operator certification, remote pilot licensing and signature of aircraft in accordance with the certification requirements under delegated regulation (EU) 2019/945. For the "licensed" category, the certificate issued by the competent authorities for the operation of the unmanned aircraft and for the persons concerned is mandatory, and aircraft certification in accordance with delegated regulation (EU) 2019/945. The regulation addresses the issue of marking and identification of unmanned aircraft. It recommends, but does not make obligatory, the registration of unmanned aircraft operators and certified unmanned aerial vehicles. It is recommended to registrate the operator of a drone that is capable of delivering more than 80 joules of kinetic energy in the event of a collision and poses a risk to privacy, personal data protection, safety and the environment. For drones weighing 250 grams or more, it is also recommended to register the operator, even if an operation in the “open” category is performed.

The Hungarian regulations apply the three categories proposed by the European Union regulation and the requirements for them furthermore the “toy” category. A drone is considered to be a toy if it weighs less than 120 grams and is not equipped with a data recorder, such as a camera, and can only move up to 100 meters from the remote pilot, or if it can be classified as a toy under EU directives. Although the European Union regulation recommends a maximum take-off weight of 250 grams for toy” category, this has been set at 120 grams in Hungary. Registration of the drone and pilot has become mandatory, except for unmanned devices in the “toy” category. Even in the case of the “open” category, an online course and exam is obligatory, which is conducted by the Institute of Transport Science Nonprofit Ltd. In addition, as before, all drone pilots must have compulsory liability insurance except for drones with a maximum take-off mass of less than 250 grams. It is now mandatory to use the Mydronespace mobile app in flight to see the current use of airspace. Require a Temporary Designated Airspace, which must be submitted to the State Aviation Department of the Ministry of Defense at least thirty days before the scheduled flight, remains mandatory. The change, however, is that, unlike before, the permit can be applied for not for thirty days but for seven days. [5]

	Before Feruary 2021	After February 2021
drone and operator registration	not obligatory	obligatory
categories	no defined categories	"open", "special" "licensed"
pilot exam	not obligatory	obligatory
liability insurance	obligatory	obligatory (exept drones under 250 gram)
MyDronespace application	not obligatory	obligatory
Temporary Designated Airspace	obligatory in-and outside built-up area, valid for 30 days	obligatory in built-up areas, valid for 7 days

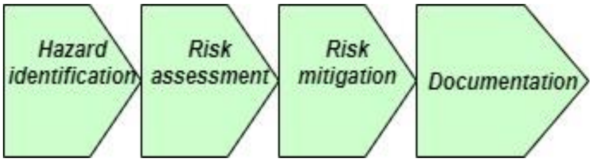
1. Table Hungarian drone regulation before and after 2021

The Hungarian drone community was pleased that Hungarian rules do not require a Temporary Designated Airspace outside in built-up area, but the general opinion is that applying for a Temporary Designated Airspace 30 days before a flight makes it very difficult to comply with the law. Droning is a highly weather-dependent activity, so it is difficult to determine which days will be suitable for this operation, and in the case of leisure activity, the joy of spontaneity is lost. And if the goal is to conduct research, scientific activity, or monitor industrial operations, it may be difficult for participants to arrange such a remote date. Logistically, therefore, problems may arise. his is compounded by the fact that instead of the previous 30 days, Temporary Designated Airspace can be requested for a maximum of seven days and the previous fee of HUF 3,000 has now been increased to HUF 9,000. Another critical point is that the regulation of the “toy” category is limited to a maximum take-off weight of 120 grams. This is stricter than the European Union limit of 250 grams and excludes many popular, popular drones (DJI Mavic Mini, DJI Mavic Mini 2) from the category.

DRONES AND THEIR SIGNIFICANT PROPERTIES FOR SAFETY RISK

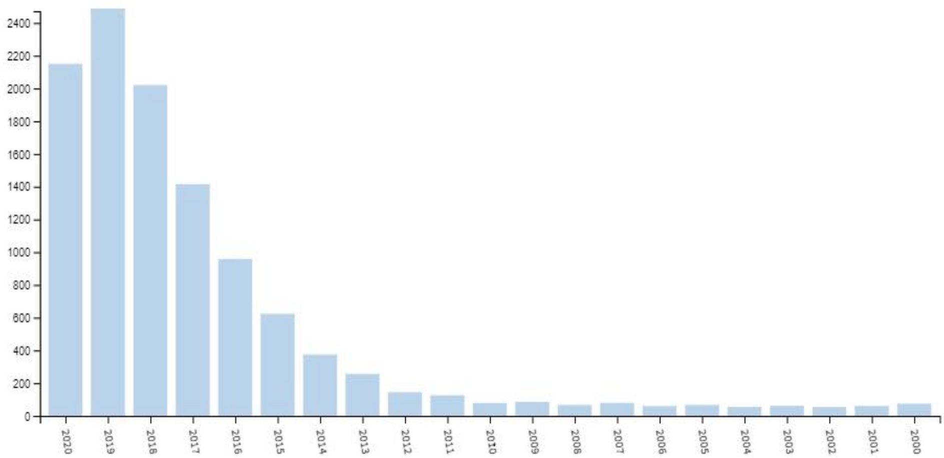
The safety risk of drones is determined by a combination of factors. Two general scenarios can be distinguished. UAVs operating over civilians and infrastructures, and UAVs flying in unpopulated areas.

According to Wackwitz and Boedecker, 2015 [6] an UAV safety risk assessment makes safety risks measurable so that risks can be better controlled. It is recommended to separate the UAV safety risk assessment into the following four phases which can be seen in Figure 1.



1. figure UAV safety risk assessment

Since drones have been released for non-military usages, drone incidents in the unarmed population are gradually increasing, according to a study from 2021. [6] The mechanical force, damage to health or property due to impact is important. A serious risk is the drone's load-bearing capacity and its ability to release the load above the specified target. The third significant factor is their data recording system, such as the camera, which can be used to support the preparation of a terrorist act, industrial espionage, and the violation of personal rights. Taking into account the above, it can be stated why the European Union considered the presence of data recording devices, transport and weight to be critical in the regulation, which principle also applies in the Hungarian regulations, as these principles are decisive in the "game" and "open" categories, for example. The need to regulate drones is justified by the fact that they have now become a mass-produce article that is accessible to everyone. It has gone from being a luxury item to an affordable product for the average person. The popularity and unbroken momentum of the technology is well illustrated by the fact that by 2025 HungaroControll expects twenty-five thousand registered flights per day. (Currently, that's all in one day all over Europe today) and expects $ 72 billion in revenue from drone flights in Hungary. Their current use rates are: military use (70%), consumer use (13%), business and corporate use (17%). These data were presented at the 2018 Drone Conference and Expo of HungaroControll. The safety risk of drones is increased by the significant, rapid growth in their popularity. This increase can also be well measured in the number of scientific publications related to drones, which can be seen in Figure. 2.



***2**. figure Results for the keyword "drone" by the Web of Science science search between 2000-2020*

The figure shows that, especially since 2015, the number of scientific publications on drones has skyrocketed, from 1,510 in 2010-2015 to 9,563 in 2015-2020. The range of the drones, as opposed to the initial few tens of meters, is now as high as 5-7 kilometres for mid-range drones. Their maximum achievable speed is constantly increasing, the typical maximum speed of currently commercially available drones is 70-80 km / h, while the speed range of drones specifically designed for competition is between 150-250 km / h. (In 2017, RacerX set the world record for "Fastest Cordless, Remote-Controlled Drone" at 263 km / h. [7]) The typical size is 322x242x84 mm and weighs about 800-1500 g. Thanks to the continuous development of cameras, better and better quality images can be taken from further afield. As an example, the DJI Mavic 2 Zoom with a 12 megapixel camera, the optics allow four times magnification, 2x optical zoom (24-48mm) and 2x digital zoom.[8]) Even if not sharing location, UAV photos may still reveal privacy information. Photos taken by DJI products are saved in JPEG format, containing invisible information, image information (manufacturer, resolution), camera recording (ISO, white balance, saturation, sharpness), and GPS data (shooting longitude, latitude, altitude). GPS and shooting time reveals when and where the photo is taken. Invisible information will be saved in accordance with the JPEG file standard in the image file header.[9]

Drones with a thermal camera are also capable of flying at night or in bad atmospheric conditions (fog, smoke). Positioning can be as accurate as centimetres, thanks to RTK (real-time kinematic) support, for example. [10] For some drones, a trigger is already available, which is also suitable for dropping an object over a target. The true potential of drones actually lies in their diversity, so anyone can find or build the right tool for their purpose. It can be seen from the above that drones are very serious factors to consider from a protection point of view. Potential hazards include waterborne and hybrid drones. Hybrid drones are able to travel in the air, underwater or on the water. An example of such a hybrid drone is the drone called Spry, released in 2019. This can be particularly important in the operation of water-bound facilities such as nuclear power plants. [11] It is also possible to fly with the drones in swarm, during which the drones are able to communicate with each other and work on their own. In 2014, the drone-based research results of the Department of Biological Physics of Eötvös Loránd University and the Research Group of Biology and Statistical Physics of the Hungarian Academy of Sciences and Eötvös Loránd University entered the world for the first time. The research team led by Tamás Vicsek created a swarm of the world's first outdoor self-organizing quadrocopters, consist of 10 drones. In thirty realistic simulations in the field, researchers have been able to make drones work closely together in a barrier-free environment with up to a thousand high-speed drones. These so-called intelligent drone swarms require a whole new way of defending for which there is currently no accepted protocol.[12] There are also drones measuring a few grams and disguised (e.g., insect, bird-shaped) that are even harder to detect and thus suitable for supporting illegal operations. One such mini drone is the RoboBee X-Wing, developed at Harvard Microrobotics Laboratory, which weighs only 90 milligrams and is 3.5 centimetres. [13] In particular, this data is open information, so the technologies and tools mentioned above are accessible to anyone, not state-of-the-art military developments. Damage with a drone can occur intentionally or accidentally. Ignorance can also lead to serious accidents as a result of incompetence. That is why the newly introduced compulsory course and exam is of paramount importance, where the correct operation and maintenance learnable, the legislation and information about safety can be known. However, in most countries strict training is not required to fly a UAV, human error often becomes the main cause for UAV disasters, according to a study from 2018.

CURRENT ANTI-DRONE SYSTEMS

The goal of anti-drone technologies is to detect drones at the proper time, to force them to the ground and destroy them if necessary. The role of anti-drone is to prevent possible terrorist acts or industrial espionage. Detection of drones is difficult for many reasons. As a relatively new technology that is only widespread in the present, detection-response technology is still immature. A key factor in removing drones is device detection. Existing airspace surveillance radar systems have been developed for high-speed and high-performance aircraft and are therefore ineffective against small drones. Due to the small size of the drones and the small number of metal parts, its position cannot be detected by the radar, it remains hidden from the air traffic services, posing a general source of danger. The visibility of the flight profiles of drones is highly dependent on weather conditions, time of day, terrain features and pilot training, as well as the instrumentation of the drone. Visibility is also affected by the time of day. Vision to the day (east) is very limited in the morning, the same is true to the west in the evening. Weather is an important factor. Foggy, rainy, or cloudy weather can even make visual identification impossible from any direction, which is a very important consideration in the final phase of a possible terrorist attack. It should be added that there are already waterproof drones, when the operation is not hindered by moisture and rain. In case of drone with a thermal camera, it may be possible to deliver the device in poor visibility conditions. with an accuracy of up to centimetres. In addition, certain types of drones are capable of performing so-called autonomous flight. The operator of the device designates the route to be flown before take-off, which is then followed by the drone without any further guidance. As mentioned earlier, most commercially available drones weigh around 800-1500 grams, so they cannot physically cause significant damage in a protected facility. The potential dangers are the acquisition of information by drones, the support of live terrorist movements, the ingest of prohibited articles within the line of defence, and the fitting of drones with weapons and explosives. Detection is further complicated by the mini and camouflaged drones already mentioned.

Table 2 provides an overview of the basic types of drone detection technologies according to their operating principle. [14]

Detection method	Example
radar	Blighter
acustic	DroneShield
radio frequency	DJI Aeroscope
optical	Dedrone
disturbing signs	DroneDefender
complex detection and response systems	Henshold Xpeller

2. Table Possibilities of drone detection

One group of today's anti-drone systems is the so-called anti-drone drones. When an intruding drone is detected, the drone sent to repel, it is able to fire a net and thus capture and disarm the other device. It is possible to avoid the helpless drone falling on people and to extract from the captured drone the data fed into it and collected so far during its flight, which can be of great use to intelligence. Such is the DroneHunter, an intelligent flying robot that can detect and classify an intruder and then decide, based on the degree of danger, whether to throw its net at it.[14], [15] However, practice shows that due to the speed of the drones, the flights and attacks take place in seconds. An average open object enclosed by a fence ranges from a fence lengths of 10 meters to a length of a few kilometers. It is easy to calculate that if our drone is traveling at a speed of 40 km / h and the target is 100 meters from the fence line, then barely 10 seconds is enough to reach the finish line.

During this time, it is impossible to make substantial action with a manually controlled drone capture system.[16] However, newer systems, such as the Skylock developed in Israel, have the ability to take control of the drone, allowing the device to be taken to a nearby landing site where it can be safely landed. The drone can be returned to the sender and its armament can be turned against the attacker. [17] The problem of radar detection was mentioned earlier, but the Blighter system developed by Plextek, for example, is able to measure small objects flying below 30 meters (including drones) and then identify them with the help of a camera or thermal imager.[18] Acoustic sensor systems operate by identifying noise from motors and propellers. The characteristic buzzing drone sound entering the microphone is compared to the sound sample stored in its database. The DroneShield system, for example, works on this principle. There are two sources of noise generated by drones: engine system and aerodynamic noise, such as airflow around the airplane fuselage.[19] Mark Ayers, DroneShield's sales director, also spoke about the system in his 2019 presentation. The disadvantages of this system are that it cannot be used in large, noisy environments, it does not detect rigid wing drones and due to their short range it is necessary to install several sensors. [20] Radio frequency technologies include, for example, the DJI Aeroscope, which can identify the most popular commercially available drones by tracking and analysing the radio frequency signals they emit. In this way, they can obtain extremely important information about drones invading forbidden places and ensure the integrity of our flight-sensitive airspace. The device is able to determine the identification number, speed, direction of the drone, the position of the controlling person, the take-off position of the drone, the flight altitude, the type of the drone and its current position.[21], [22] Optical detectors include, for example, a multi-camera networked system developed by Dedrone. DroneTracker software has intelligent video analysis capability that detects and finds drones in real time. The automated tracking feature continuously monitors the drone so security personnel know where they are flying in protected airspace.[23]

Another possibility is disturbing the communication between the drone and the operator by interfering with radio frequency communication. It can be done up to 3-4 different frequency bands, the problem is to find the frequency you are using in a timely manner. It would be a solution to interfere with all frequencies, but on the one hand it is very energy intensive and on the other hand it hinders all communication, including your own. The knowledge of the jammers lies in the fact that on the one hand he knows the ISM channels used by the drone manufacturers, and on the other hand he analyses the radio frequency signals measured from the space. It only starts to interfere with suspicious frequencies, not its own frequencies. It is possible to create two zone circles around the object to be protected. If the aircraft flies into the first zone, the connection between the drone and the drone pilot is lost. Only the communication channels are disturbed, not the signals needed for orientation. If the drone reaches the second zone as well, all GPS signals will be blocked, the drone will land or crash. There are drone weapons with a range of 2 kilometres. The response device knows the communication frequency range of each commercially available drone. This technology is not effective in all cases either. Radio frequency controllers from drone manufacturers able to monitor the interfering effects and then switch to another channel on the so-called frequency hopping principle. In this case, the interferer devices are not or only less effective. [24,][25] Devices that use signal interference include the Dronedefender, which has a range of up to two kilometres. [26] In 2019, the II. Drone Conference and Expo, organized by HungaroControl Zrt., introduced a complex anti-drone system, which is installed in a car, a special Hensoldt Xpeller type Mercedes G-Class SUV. Xpeller consists of infrared and conventional cameras, radars, laser sensors, electronic jamming devices and unique software packages. It can be fixed or car mounted, but can even be available in backpack form. Sensors, cameras and radars are located on top of the car shown, and a smaller control centre is located inside. Even the basic version of the system is able to detect and radar all existing drones larger than tablet size. If a drone is within 2.5 km, the customer will be notified on the radar screen. If necessary, the operator can also reach into their control. In this case, it is only possible to send them out of the controlled zone or force them to land, but it is also possible for the operator sitting in the car to take all the drones flying here at the touch of a button. [27]

SUMMARY

Drone technology is one of the most dynamically developing industries, offering countless opportunities, whether hobby, economic or professional. However, these positive changes are accompanied by an increase in security risk. Today, all strategically important facilities must anticipate this new phenomenon and take responses. As is typical in all areas, in the drone industry, the response follows the development of the device one step behind. It must be borne in mind that a drone attack can even have a crowd destroying effect, a risk to national security. As can be seen from the above, the anti-drone technology is still immature and needs to be developed. The changes in the Hungarian legislation of 2020 represent a serious step forward from a security aspect. However, it would be worth considering that, as in the case of cars, drones should be subjected to a technical inspection at regular intervals in order to prevent an accident due to the improper condition of the device. As drone technology is constantly evolving, it is also necessary to continuously examine and improve the efficiency of the protection system. The goal is to develop complex detection and response systems that can detect and neutralize malicious drone attacks with the highest possible hit rate. According to a study on anti-drone concept, the two main challenges is to build a structure to accommodate industries and persons operating small UAS, furthermore ensure the compliance to regulation.[28] In conclusion, it should be emphasized that the usefulness of drones is indisputable, but their integration into aviation is essential.

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