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COUNTERACTING UNMANNED AERIAL SYSTEMS IN THE OPERATIONAL AREA OF AIRPORTS

Przeciwdziałania bezzałogowym systemom powietrznym w rejonie operacyjnym lotnisk

Abstract: *Unmanned aerial systems (UAS) are treated as an opportunity, a challenge and a threat to airports, but the author decided to focus on the last aspect, in particular on countering UAS in operational area of airports. Due to the above, this article aims to address the characteristics of systems used to counteract and combat (neutralize) UAV in the airport's operational area. There are used the following research methods: analysis, synthesis, inference, comparison, abstracting and expert interview. To achieve the assumed aim, the author performed two research tasks: presentation of the importance of unmanned aerial systems as well as identification and discussion of the selected threats to airports resulting from the use of unmanned aerial systems. The presented material shows that countering unmanned aerial systems is a complex issue which requires the use of a combination of different solutions.*
Keywords: unmanned aerial system, threat, safety, technology, human factor

Streszczenie: *Bezzałogowe systemy powietrzne stanowią jednocześnie szansę, wyzwanie i zagrożenia dla lotnisk, przy czym autor postanowił skupić się na ostatnim aspekcie, głównie na przeciwdziałaniu BSP w rejonie operacyjnym lotnisk. W związku z powyższym, za cel artykułu przyjęto: charakterystykę systemów służących przeciwdziałaniu i zwalczaniu BSP w rejonie operacyjnym lotnisk. Przy opracowywaniu materiału autor posłużył się następującymi metodami badawczymi: analiza, synteza, wnioskowanie, porównanie, abstrahowanie oraz wywiad ekspercki. By zrealizować założony cel pracy, autor wykonał dwa zadania badawcze: przedstawienie istoty bezzałogowych systemów powietrznych oraz identyfikacja i omówienie wybranych zagrożeń dla lotnisk, powstałych w wyniku wykorzystania bezzałogowych systemów powietrznych. Z zaprezentowanego materiału wynika, że przeciwdziałanie bezzałogowym systemom powietrznym to złożony problem, wymagający stosowania kombinacji różnych rozwiązań.*
Słowa kluczowe: bezzałogowy system powietrzny, zagrożenie, bezpieczeństwo, technika, czynnik ludzki

1. Introduction

A flying structure that performs a flight without a pilot onboard and allows multiple uses is called in aviation terminology an unmanned aerial vehicle UAV or unpiloted aerial vehicle. Whereas, a name of the unmanned aerial system (UAS) refers to a complete system, which consists of the proper flying apparatus and control modules, ground station, communication, monitoring devices and an operator. An operator is a person who controls a flying machine and analyzes the obtained data. According to the above definitions, a flight is not only dependent on the device but also the human factor. Instrumentation, communication and control devices are also important. In connection with mentioned factors, it should be stated that in the case of unmanned aerial technology we are dealing with unmanned aerial systems. These type of systems in possession of, for example, a terrorist group, are convenient means to create a threat to airports, infrastructure and persons staying in a terminal and restricted area [6]. Therefore, the author made a brief description of UAVs, discussed justification for the need to implement UAV neutralization systems and characterized systems of neutralizing unmanned aerial systems.

The development of unmanned technology caused a need to create new solutions. Modification of the mission environment was one of the reasons to introduce flight autonomy which reduces the time of direct supervision and flight control by the operator [3]. This solution increases the possible ways to use unmanned systems. There are many types of classification autonomy in the literature, but the author tends to follow:

- zero autonomy: devices are completely man-operated,
- the first degree of autonomy: the operator controls flight most of the time,
- the second degree of autonomy: the operator makes only necessary corrections in accordance with changes in mission environment,
- the third degree of autonomy: devices perform a fully autonomous flight adapting an operating scheme to changes in mission environment, whereas the operator makes corrections if it is necessary.

Unmanned aerial systems are complex connected devices with equipment and the operator. It is important to perceive UAS as a system, not as an isolated aerial vehicle because without human interference the device will not perform any task. Thanks to intensive work on improving and searching for new solutions, it has become possible to dedicate UAS wider spectrum of use in both the civil and military spheres. Next part of this manuscript presents several possibilities for UAS to threaten airports as a justification for the need to implement UAS neutralization systems.

2. Justification for the need to implement UAS neutralization systems

Unmanned aerial systems, despite having many advantages and possibilities to use for national security, include critical infrastructure, such as airports, have a huge negative potential to create threats in formations like terrorist groups [1]. It is possible due to technical properties and an ability to move quickly also at low heights [7]. These systems can carry explosives, chemical, biological, and fire weapons, monitor devices and conduct recognition. An additional advantage is the possibility to cover unmanned flying vehicles by material imitating skin and feathers [2] (fig. 1), which makes them almost indistinguishable from birds.

Fig. 1. Model FALCO ROBOT GBRS in flight [2]

The above short analysis of potential threats to civil airports is done as a result of theoretical research based on available literature and considerations presented at national and international conferences. As a confirmation, empirical research was conducted among employees of the Warsaw Chopin Airport who are specialists in airport safety and security. Eight experts identified the possible threats to airports caused by unauthorized use of UAS. Empirical research was performed by a method called an expert interview and a research tool in the form of an interview questionnaire. Respondents declared the following aviation experience:

- one person: over 30 years old,
- five people: 10-20 years old,
- one person: 5-10 years old,
- one person: 0-5 years old.

In addition, five respondents work as an airport duty officer, one of them has RPAS UAV examiner/instructor license. Among the threats to airports resulting from UAS activity, airport employees indicated:

- UAS flight in inappropriate places (e.g. landing and approach paths) may be a direct cause of an aviation accident,

- unauthorized appearance of UAS in CTR, receiving information during recognition,
- unauthorized intrusion into the restricted area, transfer of prohibited items to the airport area, transfer of hazardous materials to airport area, collision with other aircraft, collision with vehicles moving on the ground movement area, loss of control over UAS and probability of unpredictability of UAS behaviour, the explosion of battery on board of UAS resulting in fire,
- possibility of taking control over UAS by an intruder and using it for threatening,
- lack of UAS operator's awareness of technical problems that may cause uncontrolled entry into the airport operational area,
- loss of control over equipment, unlawful use of collected data on critical infrastructure objects, uncontrolled transfer of pyrotechnic materials by UAS,
- collision with another aircraft, causing air traffic delay as a result of unauthorized enter into CTR area.

The possible threats arising from unauthorized, incorrect or incorrect use of UAS indicate the need to implement specialized equipment enabling for detection and neutralization of UAS, with a focus on aerial vehicles. Examples of detection and neutralization systems were characterized in the next part of this article. It has to be taken into consideration that the above threats are only examples which almost have occurred. Human creativity is unlimited, therefore, it is not possible to list every threat.

3. UAS neutralization systems

The increasing number of threats to airports which result from unauthorized use of UAS has prompted airport management to take protective measures to prevent such situations. Therefore, entities producing military equipment and research institutes began designing and implementing solutions for neutralizing UAS. The author discussed systems that limit research area to Polish solutions. The neutralization systems are very similar. The basic equipment consists of:

- detection subsystem,
- response subsystem.

The first subsystem is based on various types of radiolocation, optical and even acoustic sensors. The second one consists of devices which disrupt electronic systems or mechanically destroy UAS, including combat measures. The basic division of neutralization systems includes:

- non-invasive systems, for example, Jastrząb System, Ctrl + Sky System, Lanca System (fig. 2),
- invasive systems, for example, unmanned systems incapacitated by a net or a water cannon, the anti-drone Skywall 300 system, a neutralizer equipped with a laser cannon (fig. 3), the Stokrotka System.

The Jastrząb system is an advanced security system designed to protect objects and people. It performs real-time monitoring and imaging. The system enables detection, alerting, monitoring and neutralization of UAS. The main advantage is the lack of quantitative restrictions in the detection of unmanned aerial vehicles. The Jastrząb system is available in stationary, mobile and handy versions. The angular range of operation is 360 degrees, the linear range of operation is 3000 m, and the detection rate of unmanned objects is 100% [11].

The Lanca system (basic version 2.0) disrupts the communication between the unmanned aerial vehicle and the control station by sending an electromagnetic wave towards the detected camera. As a result of incapacitation with an electromagnetic beam, the machine stops receiving commands, so it falls to the ground or behaves in accordance with emergency function implemented in its software. The diagonal range of the device is up to 1000 meters [4].

Another solution is the Ctrl + Sky System equipped with a modular and fully configurable radar sensor, an acoustic sensor which allows us to determine the direction of the incoming aerial vehicle and a fully integrated and automated jammer for neutralizing UAS. This solution is available in stationary, mobile and portable versions. The dedicated web application for system monitoring, configuration and control ensures ease of use. It is worth noting that weather conditions do not affect system operation [10]. The above-mentioned applies to Norway airport.

Fig. 2. Neutralization systems: Jastrząb System, Ctrl + Sky System, Lanca System [Source: manufacturers' materials]

The basic invasive solutions are unmanned aerial systems equipped with a net for dropping onto an unauthorized object or a water cannon. These types of anti-drone systems have basic limitations:

– in the case of UAS using a net, it is necessary to be above the enemy object and drop a net to catch it,
– in the case of UAS using a water cannon, it is necessary to be within the range of a plot, track a foreign object and fire it to eliminate it.

A stationary system with a similar operating principle to UAS that ejects a net is Skywall 300. The effectiveness of the system is guaranteed by targeting a foreign object and launching a projectile which explodes over the unmanned aerial vehicle and drops a net onto it.

Another system, more effective according to the opinion of another author, is a neutralizer using a laser cannon. A laser beam is launched, and then, it destroys fuselage or propulsion of unmanned aircraft after locating an unauthorized one.

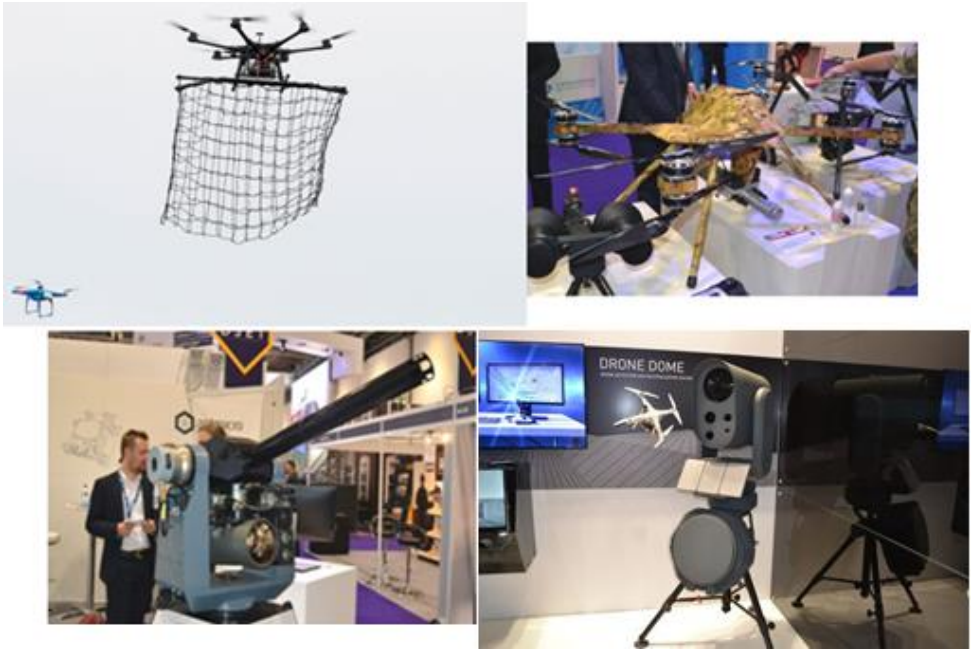

Fig. 3. Neutralization systems: anti-drone system equipped with a net or a water cannon, anti-drone Skywall 300 system, neutralizer equipped with a laser cannon[Source: manufacturers' materials]

Stokrotka ZRN-01 is according to the author the most effective system from the above-mentioned systems for physical neutralization of UAV. Therefore, most attention was paid to this solution. Stokrotka is characterized by the possibility to use in both civil and military areas. It is designed to destroy flying objects. Moreover, it is a mobile system built on the STAR 266M2 platform with a 6x6 drive. The maximum speed is 96 km / h, the range is 760 km. Vehicle parameters allow for fast movement even in difficult (forest, desert or wetland)

terrain. ZRN-01 is equipped with two rocket launchers with the following parameters (fig. 4) [8]:

- 80 mm caliber,
- horizontal operational range 7000 m,
- vertical operational range 4000 m,
- horizontal firing angle 360º,
- vertical firing angle -10º to + 80º,
- the number of people from service: 3.

Discussed construction has a destructive potential which poses a risk of exposing bystanders to loss of life or health and the possibility of property damage in urbanized areas. For this reason, designers created another weapon's variant mounted on the same platform. It is Anti-Aircraft Twin-Barreled Autocannon ZU-23-2 with the following parameters [9]:

- 23 mm caliber,
- horizontal operational range 2000 m,
- vertical operational range 4000 m,
- horizontal firing angle 360º,
- vertical firing angle -10º to + 90º,
- temperature range -30ºC to + 50ºC,
- ability to continuous work 17 hours.

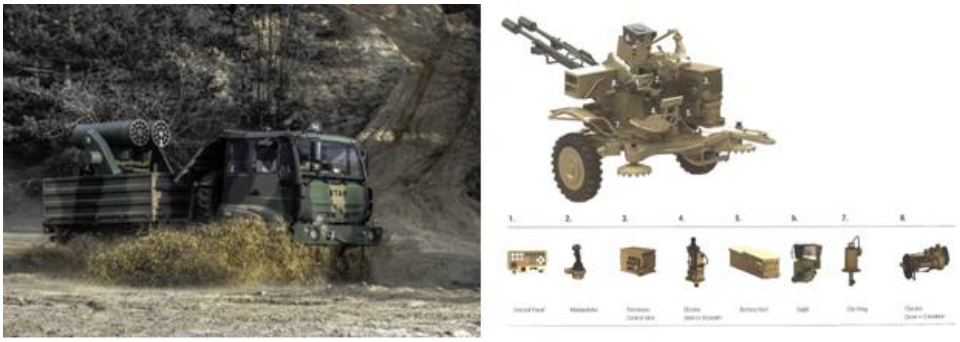

Fig. 4. Stokrotka ZRN-01 (left side) [8] and Anti-Aircraft Twin-Barreled Autocannon ZU-23-2 (right side) [9]

The characterized systems for neutralization of unmanned aerial systems can constitute significant support and complement to the security system of civil airports and military aviation bases. This is even more important due to the constant development of unmanned technology which will result in the occurrence of further methods causing threats. It can be confirmed by the analysis made by W. Leśnikowski in the monograph, which discusses UAS in connection with cyberspace [5]. Consideration related to IT equipment and information sent to aircraft or other facilities and received by airports allows us to perceive the risk of causing disinformation, damaging electronics or taking over airport technical facilities. In that case, the author put forward the following hypothesis: the use of one UAS

neutralization system for the whole airport is not able to provide fully effective protection against such unmanned systems. This hypothesis will be considered in future research due to the thematic scope and quantitative restrictions.

4. Conclusions

The article contains three complementary parts. The introduction presents the essence of unmanned aviation systems. Then, the author analyzes the possible threats to airports caused by UAS as a justification for the need to implement UAS neutralization systems. The analysis was made on the basis of one's own theoretical and empirical research conducted in the form of interview questionnaire. The last part of manuscript consists of the description of non-invasive and invasive UAS neutralization systems. It can be stated that the aim (characteristics of systems used to counteract and combat (neutralize) UAV in the airport's operational area) was achieved.

There are several apparent conclusions, such as UAS are multi-task systems. This kind of systems can be used by almost everyone. UAS used in an inappropriate way can also be the cause of aviation accident or other dangerous situation which occurred many times, for example, at Heathrow airport. There are also threats to aviation safety, especially at airports, which contribute to the production of systems aimed at detection and neutralization of unmanned vehicles. What is more, there are some problems concerning neutralization of UAS. There are also unresolved issues regarding the liability for damages arising after the fall of a rendered or destroyed unmanned aerial vehicle. Unfortunately, operators of most of UAS neutralization systems cannot dispose of machines in autonomous flight without destroying them. Additionally, for the considered systems to be effective, they need to cover an entire airport operational area. Most of UAS neutralization systems are available in a mobile version which significantly increases the possibility of detection and is a threat to security capabilities of the airport.

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