Scientific Journal of the Military University of Land Forces
(ISSN: 2544-7122)
2018, Volume 50, Number 1(187), Pages 5-24
DOI: 10.5604/01.3001.0011.7353

Original article

Aerial detection of contamination with the use of unmanned vehicles – development prospects

Wladyslaw Harmata[1*], Marek Witczak[2], Grzegorz Pietrzak[3]

[1]Department of New Technologies and Chemistry, Military Academy of Technology, Poland, wladyslaw.harmata@wat.edu.pl

[2]Department of New Technologies and Chemistry, Military Academy of Technology, Poland, marek.witczak@wat.edu.pl

[3] Department of New Technologies and Chemistry, Military Academy of Technology, Poland, grzegorz.pietrzak@wat.edu.pl

INFORMATIONS

Article history:

Submited: 26 May 2017

Accepted: 16 August 2017

Published: 15 March 2018

ABSTRACT

Currently, the territory of the Republic of Poland faces a growing threat of contamination with its sources in catastrophes and technical failures in industrial plants (including nuclear power plants) and uncontrolled release of high-toxic chemicals during transport and, which cannot be excluded, terrorism. The increased level of threat resulting from, among others, those factors caused that the National Contamination Detection and Alerting Systems (KSWiA) with the Contamination Detection System of the Polish Armed Forces as the system coordinator was established in the Republic of Poland in 2006.

This paper presents the outline of the aerial system of contamination detection, mainly its technical elements, based on the Unmanned Aerial Vehicle (UAV) carrying on board basic and special-purpose equipment. The elementary way of operating the system while performing tasks as well as requirements for its maintenance and handling have been proposed. Introduction of UAV systems would greatly increase the effectiveness of the Contamination Detection System of the Polish Armed Forces, but also other civilian functional subsystems of KSWSiA. There are many advantages to using them, such as no need to expose personnel to contamination and an enemy impact, high mobility, maneuverability and the capability to operate under difficult terrain conditions.

* Corresponding author

KEYWORDS

contamination detection, unmanned aerial vehicles

1. Introduction

This article concerns the Authors' reflections on the reconstruction of the aerial system of contamination detection in the Polish Armed Forces due to the increasing threat of contamination. The intention of Authors was to take a first step towards a constructive polemics on aerial detection of contamination using pilotless vehicles.

According to the doctrinal document "Defense Strategy for Countering Weapons of Mass Destruction in Joint Operations DD / 3.8 (A)", the primary task of the CBRN defense system is: reconnaissance, identification and monitoring of contamination, which includes detection of CBRN incidents, quantitative and qualitative identification of a toxic agent, designation of contamination areas as well as monitoring changes in a contamination situation [1].

Reconnaissance is an action to identify a CBRN event or presence of CBRN in an environment. It is realized by monitoring, detection and detailed identification of contamination:

- monitoring is the systematic observation of airspace, terrestrial areas, people, animals and materials. For this purpose, devices for visual, auditory, electronic, photographic or other observation are used to identify the presence or absence of CBRN;
- detection is an action aimed to confirm the occurrence of a CBRN event or the presence of a CBRN agent;
- detailed reconnaissance is an action taken to determine the kind and the level of contamination in the area of confirmed contamination, or the projected contamination area. It may also include meteorological measurements and sampling of contaminated materials.

Reconnaissance of contaminants should be prepared and implemented according to the level of threat, and equipment and procedures should provide immediate alerting about the presence of CBRN agents [1].

The effective functioning of the contamination detection system is conditional on the precise performance of the following tasks: detection of contamination, identification of contaminants, designation of contaminated areas, collection of contaminated samples and their analysis, as well as reporting of findings. Carrying out all the tasks of contamination detection will minimize the negative effects of contamination in a short time. The rapid detection is particularly important as it is the first link of defense against contamination.

2. The analysis of contamination threat to the Poland's territory

When analyzing threats, too many phenomena are often perceived, some of which are not so much a threat but a security challenge. They are described as new situations or emerging trends. They require careful investigation in order to formulate responses and take specific actions, since under unfavorable conditions unresolved challenges can generate potential hazards. It is difficult to distinguish challenges from threats at the initial stage of security analysis, because society negatively evaluates both phenomena. An entity's own, specific beliefs and values make the difference between them not clear.

The multidimensional nature of threats makes it possible to find a number of criteria in the literature (e.g. subject, object, range, scale) according to which authors attempt to systematize them. The subject-related criterion is frequently used, which is based on five types of threats: political, military, economic, social (socio-cultural) and ecological [2]. Generally, threats can be divided, among others, into real and potential, military and non-military as well as internal and external.

The Poland's National Security Strategy [3] consistent with the European Security Strategy [4] lists the following major threats to Poland's security in the 21st century: terrorism, proliferation of weapons of mass destruction, organized crime, industrial accidents, natural disasters and catastrophes (Figure 1). The possible occurrence (directly or indirectly) of chemical, biological or radioactive contamination of people and the environment is one of the reasons for which these threats cause the greatest fear and concern among the public.

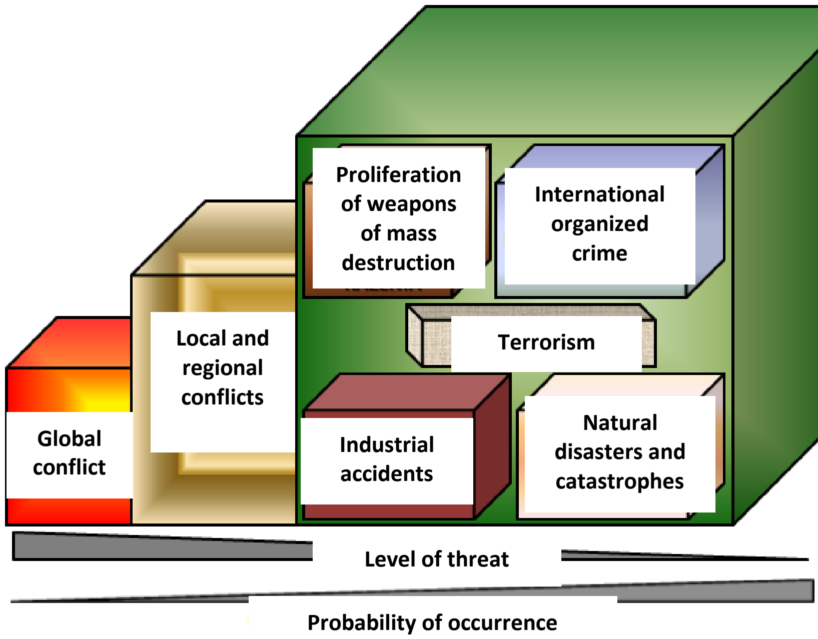

Fig. 1. Security environment of the Republic of Poland [5]

Source: [15]

Productive human activity, though rich in forms and types of human mind and hands, results in less or greater environmental hazards. However, it must be stressed that this problem is very difficult to be solved in an unambiguous way. It cannot but cut like the Gordian knot to prevent hassles. Such a condition arises from the fact that internationalization of many different spheres of social life has been ongoing, since these processes have continually intensified the issues of pollution, which underestimated (!) until recently now have grown to global problems (e.g. smog). In today's industrialized world, paradoxically, even air and water pollution far outweigh risks such as food contamination or threats posed by the use of weapons of mass destruction.

The delay in the detection of contaminants often results in massive losses both in people and in the environment. This necessitates conducting accurate and systematic analysis of real and potential causes of contamination, which will allow for timely preventive action to protect the population from contamination or to minimize its effects. This is a rather complicated issue due to the high complexity of causes of contamination that may result from human activity or the destructive force of nature. It should be noted that both of them are correlated in certain aspects and, affecting each other, additionally complicate the analysis of the risk of contamination.

The vision of a contaminated or severely poisoned environment does not inspire great optimism, the more so that it must be borne in mind that apart from the possible contamination caused by weapons of mass destruction, most of the contamination will come from toxic industrial agents (TSP) released after failures, breakdowns or destruction of industrial plants in Poland and in border areas. Such implications will arise from conducting warfare on a specific territory, i.e. the area of the country. The troops will not usually fight in the areas of their choice but forced by a specific combat situation, including contaminated areas. Therefore, they should be properly trained, prepared and equipped to perform tasks in such extreme and incredibly complicated conditions.

The probability of occurrence of threats related to weapons of mass destruction must be re-evaluated – Figure 2.

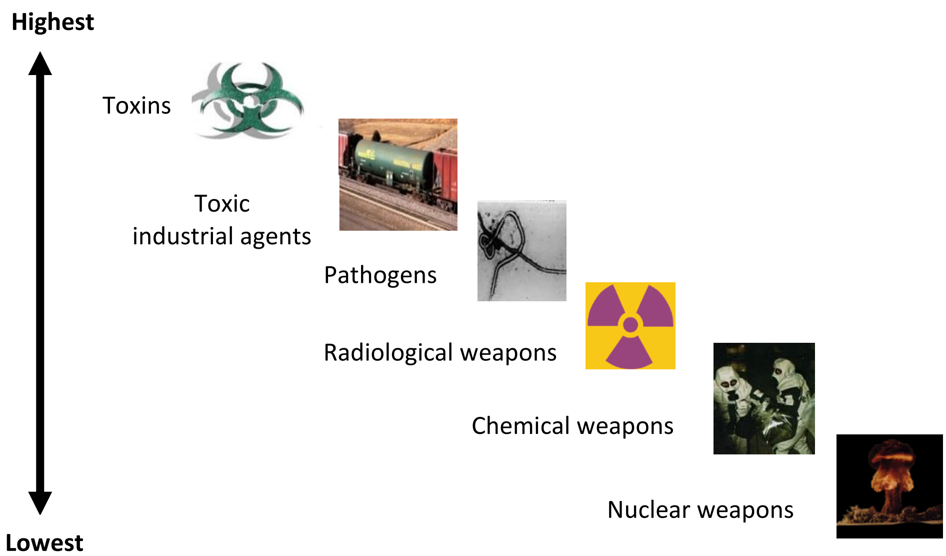

Fig. 2. Probability of the use of components of weapons of mass destruction [6]

Source: Harmata W., Ochrona przed skazeniami, cz. IV Wybrane zagadnienia metodologiczne, organizacyjne i techniczne likwidacji skazen, WAT, Warszawa 2017 (materialy niepublikowane)

In modern times, as mentioned earlier, a threat may come mainly from terrorist activities as part of asymmetric activities (the term "hybrid operation" can be found in the current literature).

The increased level of threat caused by these factors led to, among others, the establishment of the National Contamination Detection and Alerting Systems (KSWSiA) in Poland in 2006. Functional subsystems and organizational units of the military and non-military system designated within the so-called emergency response carry out co-ordinated and interoperable activities within its framework. The Contamination Detection System of the Polish Armed Forces represents the military system in KSWSiA.

It is important to realize that the contamination zones created after uncontrolled release of TSPs or radioactive aerosols after reactor failures at nuclear power plants can have a very large range. National solutions, based mostly on NBC reconnaissance foot patrols will not be able to identify contaminants. In addition, filtering absorbers for masks have a limited protective operation time especially with respect to TSP (in minutes), and the impact of chemical warfare agents (BST) on an unprotected human body is almost instantaneous. Equipping living force with effective and efficient means of protection against contamination is a necessary but insufficient condition. A system for detecting contamination based on individual dosimetry and automated systems should be the second element excluding, wherever possible, human participation in contamination zones and at the same time providing reliable information on contamination.

3. Contamination detection system

In NATO states, the pollution detection system is based mainly on automated systems using the latest technologies, whereas in the Polish Armed Forces on manual systems using technical solutions from the previous epoch - Figure 3. Despite the presence of new solutions that are comparable and often exceed the level of global technologies there is often a lack of will and funds to implement them.

Aerial identification of contamination in the Polish Armed Forces was carried out by stationary NBC reconnaissance subunits. They were formed by Mi-2rs "Padalec" helicopter crews separated from operational formations of the land forces, navy and air force. Since the moment of withdrawal of Mi-2 helicopters (without substitution) from service, the Polish Armed Forces have not possessed appropriate means for conducting aerial reconnaissance of contamination. Hence, despite its numerous virtues, the aerial reconnaissance of contamination in the Polish Armed Forces practically does not exist, and the system of reconnaissance and identification of contamination of the Polish Armed Forces is mainly based on the ground forces and resources held.

The high mobility that allows for the detection of contamination in high-dose-rate areas that are difficult to access (impenetrable for ground-based reconnaissance vehicles) is an important advantage of aerial reconnaissance of contamination. The added values of aerial contamination detection are the ability to adapt to the conditions of land troops' operation as well as little dependence on weather and field conditions.

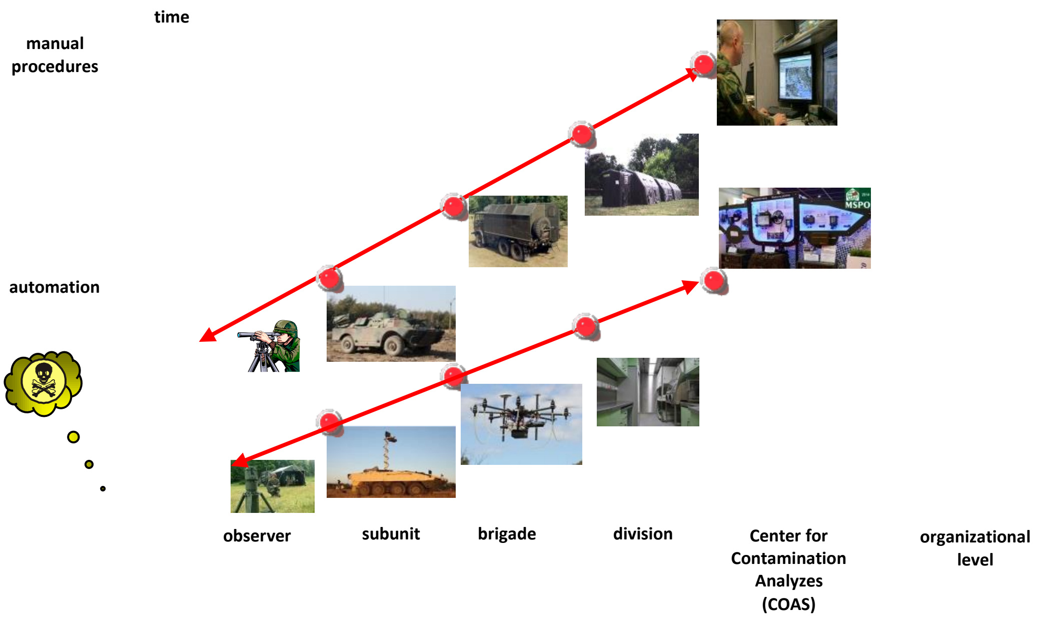

Fig. 3. Graphical visualization of time required to obtain information from the system

Source: own elaboration

NATO armed forces use aerial identification to determine the extent of radioactive contamination (boundaries of contaminated sites, radiation dose rates at fixed points, as well as height, width and direction of radioactive cloud movement) in military areas (present or planned). The main reason is the significant reduction of crews' exposure to radiation while conducting aerial reconnaissance in comparison to ground reconnaissance of the same area. This is accomplishable due to, among others, significantly greater maneuverability and speed when conducting air reconnaissance. The usage of aerial vehicles enables reaching areas inaccessible to ground reconnaissance subunits as well as the reconnaissance of a much larger area, while keeping distance from the source of contamination.

In the US Army, aerial identification of radioactive contamination is carried out using helicopters, e.g. OH-6A (Figure 4a) or UH-60M BLACK HAWK (Figure 4b). A single helicopter, depending on the given degree of detail of reconnaissance, can reconnoiter, within 1 hour, a 130-450 km^2 zone of radioactive contamination. The contamination reconnaissance helicopter crew consists of a pilot and an observer or observers (depending on the requirements of an operation conducted). For instance, soldiers from chemical troops subunits, other types of troops trained for this purpose and those who have experience and regularly perform reconnaissance flights are appointed as observers. Mapping landmark features that can be easily identified by a crew in an area being diagnosed during a helicopter flight constitutes the basis for planning aerial reconnaissance.

a) **b)**

Fig. 4. Helicopters used in the US Army to detect contamination:
a) OH-6A, *b) UH-60M BLACK HAWK [7]*

Source: [19]

Aerial identification of contamination is also carried out in the Russian Armed Forces using Mi-24RKhR helicopters (Figure 5). The Mi-24RKhR, also known as Mi-24RCh, was developed in the 1980s. They took part, among others, in fighting the consequences of the Chernobyl nuclear reactor explosion. About 150 were produced in the years 1983-1989. In addition to detecting contamination, a helicopter crew of 3 soldiers may also take contaminated samples after landing near a designated location.

Fig. 5. Mi-24RKhR (Mi-24RCh) “Hind-G1” reconnaissance helicopter [8]

Source: [20]

2.2. Unmanned Aerial Vehicles (UAV)

The beginning of the 21st century saw the implementation of unmanned aerial vehicles with increasingly new technologies related to miniaturization, development of computer systems, information technology and better reception of GPS signals.

Examples include the US Land Force, which increased the number of unmanned aerial vehicles from 30 to 2000 within ten years after the attacks of September 11, 2001 [9]. In addition to military applications, in the 21st century unmanned aerial systems began to be used extensively in civilian environments (e.g. in research, crisis management and disaster prevention, critical infrastructure and the environment protection).

The varied tactical and technical capabilities of new and old unmanned aerial systems make it possible to classify by a number of different criteria. To this end, the following parameters are often taken into consideration:

- flight altitude;
- operating altitude;
- hover capability;
- flight duration and maximum take-off mass.

The NATO division is one of the most commonly used classifications. It divides unmanned aerial systems in the context of joint operations performed by Member States into 3 classes (Table 1) differing in take-off masses:

- class I – includes UAVs of less than 150 kg which do not require the creation of certification standards in the Alliance. Most of them are hand-launched UAVs, which fall into one of three categories: micro, mini or small. They are mainly used by small subunits for close identification (including base protection). As a rule, they are equipped with optoelectronic and infrared detectors. They are characterized by low logistical requirements, low operating altitudes (<1600 m), as well as limited range and duration of flights;
- class II - consists of tactical UAVs (TUAV) of medium size (take-off masses 150 ÷ 600 kg). They are often catapult launched, however they can perform tasks from logistically unprepared landing sites. They are designed to support brigade operations and lower levels of tactical in terms of identification, monitoring, identification and marking targets. For this purpose they are equipped with optoelectronic and infrared sensors as well as laser rangefinders. Likewise class I unmanned vehicles they do not require much logistical support. Their operating altitude is up to 3000 m.
- class III – includes UAVs with the highest take-off masses (> 600 kg), ranges and times of operation in the air. They are classified into three categories: MALE (Medium Altitude Long Endurance), HALE (High Altitude Long Endurance) and strike (combat) unmanned aerial vehicles. They usually require appropriately prepared aerodromes (landing pads) as well as adequate logistic support so that they can be used in operations. They are equipped with the state-of-the-art navigation and recognition systems (including radars, lasers and high-resolution cameras), as well as armaments (including anti-tank).

The operating radius and the typical (operational) flight altitude are the most important criteria for the current division. Moreover, additional categories of UAVs corresponding to different levels of command are identified in each class.

In the case of non-standard UAV parameters, such as a 20 kg airframe with a ceiling of over 2,000 m and a radius of more than 200 km, the flight mass is the critical criterion – hence the exemplary UAV will be placed in Class I - up to 150 kg.

Table 1. Classes of UAVs [10]

Class	Category	Level of command	Operating radius	Service ceiling
I	Micro (up to 2 kg)	Squad, platoon	5 km	61 m
I	Mini (2-20 kg)	Company	25 km	304 m
I	Small (20-150 kg)	Battalion	50 km	366 m
II	Tactical	Brigade	200 km	914 m
III	Medium Altitude Long Endurance	Operational	Unlimited (retranslation)	12192 m
III	Strike	Operational	Unlimited (retranslation)	19812 m
III	High Altitude Long Endurance	Strategic	Unlimited (retranslation)	19812 m

Source: [16]

2.3. Concept of technical equipment

The system under development will include a single mini-UAV, which will be able to perform vertical take-off and landing at any location. At a further stage of the project implementation it is envisaged to increase the number of UAVs in the developed systems or to combine them into a larger one. Battlefield capabilities, i.e. operational ceiling, flight and reconnaissance speed, flight duration and operating radius were recognized as critical parameters during the selection of appropriate mini-UAVs. Moreover, the mini-UAV is be constructed of materials resistant to weather conditions and mechanical damage and also it will need to be subjected to decontamination processes (without any negative effects on its components) using currently available methods and resources that will be part of the system.

The continuous development of the project is assumed by equipping it with newer, more advanced systems. The purpose of their introduction will be to increase the effectiveness of its operation when implementing tasks. The experience gained from using it during tests and training, and then combat missions, will be systematically covered by analyses aimed at development of new technologies in the field of robotization of the battlefield. The design of an unmanned aerial vehicle that meets a number of specific requirements and is equipped with an appropriate contamination detection system will be one of the critical elements for the successful development of the concept of aerial detection system. The project also foresees a number of strength and resistance tests that a mini-UAV construction will undergo (including decontamination and exposure to electromagnetic field), which is to enable the selection of the most optimal version capable of detecting and monitoring contamination in unfavorable combat conditions. When designing the structure, efforts should be directed at:

- maximum reduction of a mini-UAV's mass while ensuring demands related to the flight distance, operating radius and onboard equipment (basic and special);
- the simplicity of use, including easy launch, flight and landing; manual and automatic control (after a pre-programmed route);
- high resistance to detection by an opponent;
- low operating costs.

2.4. Components of the system

The currently widespread image of an unmanned aerial vehicle is often limited to a pilotless means controlled by appropriate systems communicated with an operator on the ground. In fact, it is an element of an unmanned air system that is more complicated than it is supposed to be. From the very outset its design must take into account all elements of its composition. The proposed aerial system of contamination detection will consist of a mini-UAV with basic equipment: a navigation system, an HD digital camera and thermal imaging camera, as well as special equipment: a sampling system, detection and monitoring systems, a meteorological measurement system. The mini-UAV will communicate via wireless radio with a monitoring and control center, which will be part of the mini-UAV ground control station (Figure 6). Having met the assumptions concerning the minimum weight and size requirements, all elements of the aerial system for detecting contaminants will be transported by two soldiers.

An unmanned aerial vehicle - the mini-UAV's main task will be to carry sensors and systems (included in basic and special equipment) that allow the functioning of the aerial system to detect contamination in a mission area - a contaminated zone. The mini-UAV will include a communication system, flight stabilizer, control system, power source, elements allowing for take-off, flight and its later recovery. The Mini-UAV will be electrically driven, powered by, for example, lithium-ion batteries that enable patrolling for 1 hour and performing 1.5-hour flight (50 km back and forth) without having to charge them. What is more, the mini-UAV will be characterized by high maneuverability, including the capability to conduct reconnaissance, contamination monitoring and meteorological measurements just above the ground, even in difficult terrain conditions. For this purpose, the mini-UAV design will allow for vertical take-off and landing, as well as hovering in the air for sampling or monitoring contamination at a given point. The maximum speed of mini-UAV during observation and flight will be 20-40 m / s. The flight will be conducted along the Lo-Hi-Lo (low-high-low) trajectory.

The high altitude flight will take place along beyond the effective range of small arms (500-600 m), and the low operational altitude will depend on the type of mission and may even be just above the ground. The total mass of the mini-UAV will not exceed 15 kg, while the weight of the equipment being carried is around 30% of this value.

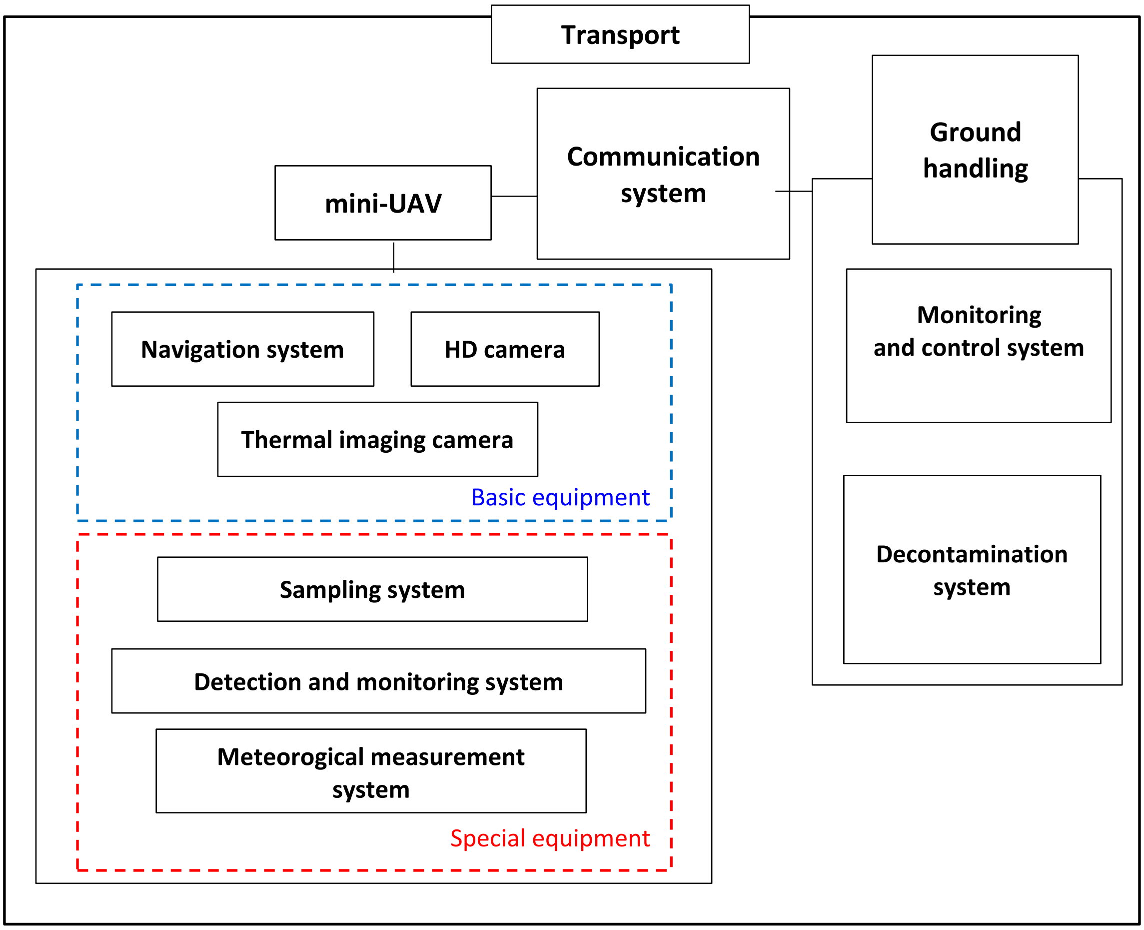

Fig. 6. The aerial system for decontamination detection [11]

Source: [11]

Fig. 7. Unmanned Aerial Vehicle (mini-UAV) – ATRAX take-off mass: 7÷22 kg; lift capacity: 15 kg; operating radius: 5 km; straight-line flight: <35 km; flight ceiling: <1000 m; flight time : 45÷60 min [12]

Source: [7]

Fig. 8. Unmanned Aerial Vehicle - AGH for air pollution control; tests in Bytom; laser dust concentration meters, CO and CO_2 sensors used [13]

Source: [12]

Ground handling - will be set up in two components: the control and monitoring station and the decontamination system. The station will possess a laptop with a monitor, a keypad, an antenna set and batteries. In addition to the control and monitoring station, the ground handling system of the aerial system for contamination detection will include the decontamination system. Due to the fact that the system proposed in the concept will be an open electronic - mechanical system (with optoelectronic elements), the "wet" methods used in the Polish Armed Forces will be useless. Conceptually, the decontamination system will be based on a chamber (e.g. in the form of a tent) and a system to generate active agents. The system can apply the method of decontamination using gaseous (vaporized) hydrogen peroxide (GNW). Preliminary studies indicate the high compatibility of GNW with respect to construction materials, paint coatings, electronic and optoelectronic systems and devices [14].

Basic equipment - In the initial phase of the project, the mini-UAV will have two cameras equipped with image stabilization systems – TV Cam HD for high definition videos and thermal imaging. The cameras will allow the observation of the widest possible field of view and control the mini-UAV both day and night. In addition to the cameras, the mini-UAV will have a navigation system for identifying its position at any time, thus controlling and executing an independent flight to the programmed destination in the event of loss of communication with the ground-based control and monitoring station. Furthermore, multi-spectral cameras, laser rangefinders (for marking targets), and small LIDARs to illustrate the area around the mini-UAV within a few dozen meters will be added to the mini-UAV's equipment at subsequent stages of the project implementation. New mini-UAV's sensors and equipment will be selected or designed in such a way that they do not exceed its allowable mass.

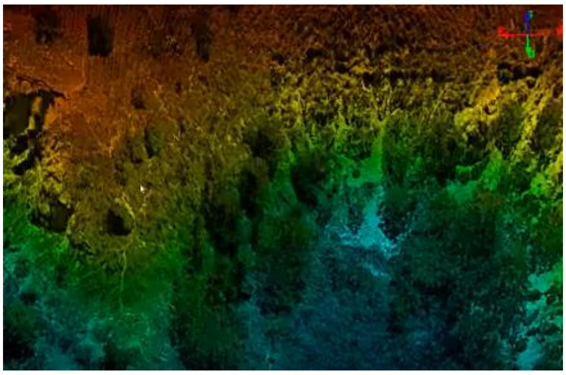

Fig. 9. Phoenix Aerial AL3-16 Velodyne VLP-16 RTK UAV LIDAR system

(lidar's parameters: mass - 1,8 kg; range - 120 m; up to 6 thousand measurement(s) in the field of view up to 30 ° vertically and up to 240 ° horizontally, photogrammetric, multispectral and thermal imaging) [15]

Source: [17]

Special equipment - performing specialist tasks within the framework of the concept under development will be based on 3 systems:

- monitoring and detection of contamination;
- atmospheric measurements;
- sampling.

The contamination monitoring and detection system will consist of a set of 3 detectors for chemical, biological and radioactive contamination respectively. These should be systems (electronic, optoelectronic) that guarantee swift detection, identification (with assumed probability) and determination of concentration of hazardous substance or radiation dose rate. They should be controlled and monitored by the on-board system and connected to the air-sampling probe. The intake system should consist of a control system (e.g. for heating the inlet system), a 50 cm automatic expandable tube and a vacuum generating system. Its purpose is to allow the vapor to be analyzed directly above the soil and to minimize the effect of air movement on the measurement results. The detector system used will also allow for the monitoring of contamination in the area of interest. Elaborations that comply with requirements of standards have been developed [16] in Poland, however they have not been implemented in the Polish Armed Forces for non-substantive reasons, contamination detectors: e.g. automatic PRS-1W gas signaler. This is an example of a device using differential ion mobility spectrometry (DMS) to detect chemical contamination, including explosives, and after disconnecting probes - to detect radioactive contamination. This device is characterized by high resolution (approx. R = 60), high selectivity and a short measurement cycle of about 5 s, high sensitivity (sensitivity below 20 μg / m^3 for paralytic-convulsive chemical warfare agents and less than 200 μg / m^3 for vesicant CWA, below the maximum admissible concentration value for toxic industrial chemicals), and a short response time of approximately 20 seconds or based on the same Portable Chemical

Contamination Signal Detector [17]. Biological Contamination Detector (BIODES) enables the real-time detection of hazardous biological agents in the surrounding air using the laser-induced fluorescence of biological substances. BIODES is the result of joint work of the Institute of Optoelectronics at the Military Academy of Technology and Pimco Sp. z o.o [18]. The instruments can be information providers for the Operational Graphics Package and PROMIEN Information System and may cooperate with the Network Centric Data Communication Platform JASMIN.

The meteorological measurement system will provide real-time data on air temperature (at the set altitudes), velocity and direction of wind as well as relative humidity. Some of the sensors included in the system will be placed on the attachment for collecting samples.

The gas sampling system that will be used to collect and gather 3 different gas samples of a defined volume sucked from the intake into the airtight containers. The samples collected will be subjected to thorough analysis in specialized stationary laboratories. In the further development of the system, the sampling system should be extended for possibility of collecting samples of soil and water.

The integrator with computer software is to enable automated integration of collected data from specialized measurement equipment while creating reports and the creation of reports whose form and content are consistent with NATO standard documents ATP-45 (D) with their broadcasting by radio;

All systems included in the special equipment as well as the basic equipment will be selected and developed in such a way that they are easy to handle and do not exceed the allowable mass of the mini-UAV.

The application and purpose of the system - the mini-UAV's on-board, central monitoring and control system will communicate with a ground station operator through a radio communication system within a radius of approximately 25 km. An operator will be able to set one of two modes of unmanned system operation - manual or automatic - using the appropriate interface. In the automatic mode, the flight parameters (such as a profile, a speed and a route, as well as a landing location in the event of communication loss), and the manner and parameters of carried equipment and special systems during reconnaissance and monitoring of contamination are to be determined in advance. An operator will be able to change operation parameters quickly and easily even during a pre-programmed task, including a total change to new ones. With the further development and implementation of the system in question, it is assumed that its automated monitoring and control systems will be improved with the aim to increase its autonomy while fulfilling tasks with less and less human intervention. However, it is assumed to use mainly the manual mode at the initial stage of the system application. In the initial version - a mini-UAV's flight route and positioning based on GPS data using the appropriate interface and information from sensors and systems carried (camera image, GPS data and special device data), an operator will be able to determine the route and flight parameters as well as operating parameters of the onboard equipment in real time. The introduction of the semi-automatic mode is also considered, in which a mini-UAV will fly automatically along the scheduled route and operation of on-board devices will be controlled manually.

The mini-UAV's operator will be equipped with a portable rugged computer satisfying the requirements of the military, with a pre-loaded digital map of the terrain, displaying information necessary to monitor and control the flight and on-board operation. The basic data available on the laptop screen will be as follows:

- a terrain map;
- a mini- UAV's actual position;
- a mini- UAV's flight route;
- a day / night camera image streamed "online";
- marked points for detailed reconnaissance by mini- UAV;
- information about a mini- UAV's status (e.g. battery charge level, speed, flight height);
- information from the contamination detection and monitoring system about the current mode of operation, status and current measurement results;
- information from the meteorological measurement system with measured weather parameters;
- detected areas of contamination and their coordinates together with the specified type and concentration value (dose rate) of a toxic agent;
- location of other objects in the area of a mini-UAV's mission;
- other terrain data such as terrain obstacles, contours, mini-BSP distance from checkpoints.

The discussed system for aerial contamination detection enjoys widespread interest, starting with the Special Forces through Chemical Forces, civil defense and order services (the Police, the State Fire Service and the Border Guard). At the initial stage of the development and implementation the project under consideration will largely be adapted and developed in terms of requirements and needs of the Chemical Forces, namely NBC reconnaissance subunits. NBC reconnaissance squads are intended to be equipped with single aerial contamination detection systems that will supplement their operation at the initial phase in the scope of inter alia:

- conducting the battlefield observation;
- detection, identification and monitoring of contamination;
- designating bypass routes and crossings through contaminated zones for own troops;
- meteorological measurements in ground-level atmospheric air;
- taking of contaminated samples.

At the further stage the project envisages the complete replacement of the equipment and devices used by NBC reconnaissance squads (vehicles for the detection of contaminants along with their equipment) with unmanned systems for aerial contaminants detection.

Fig. 10. A drone with a lidar contamination detector

Source: [5]

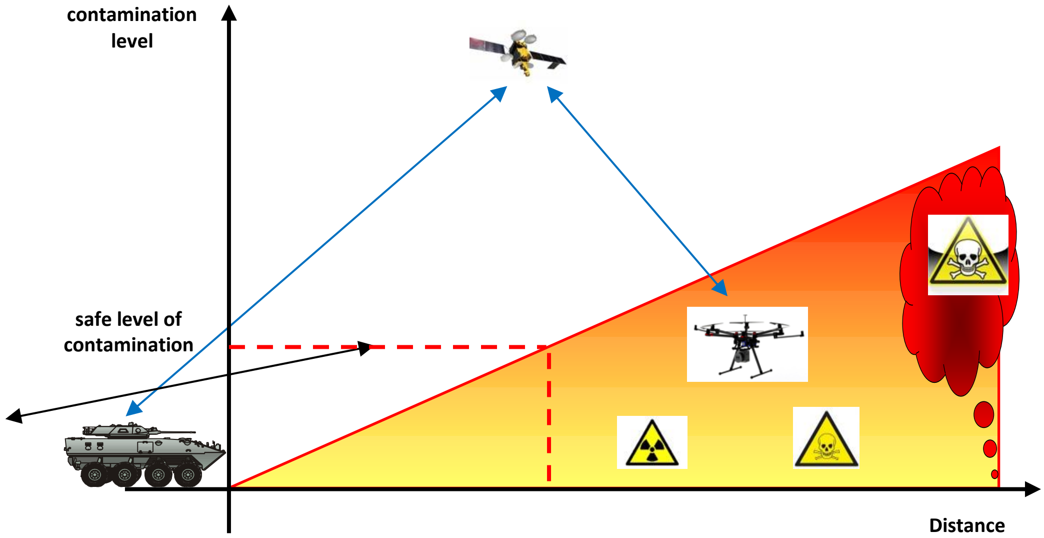

Fig. 11. System capabilities according to the concept - recognize without entering the contaminated area

Source: own elaboration

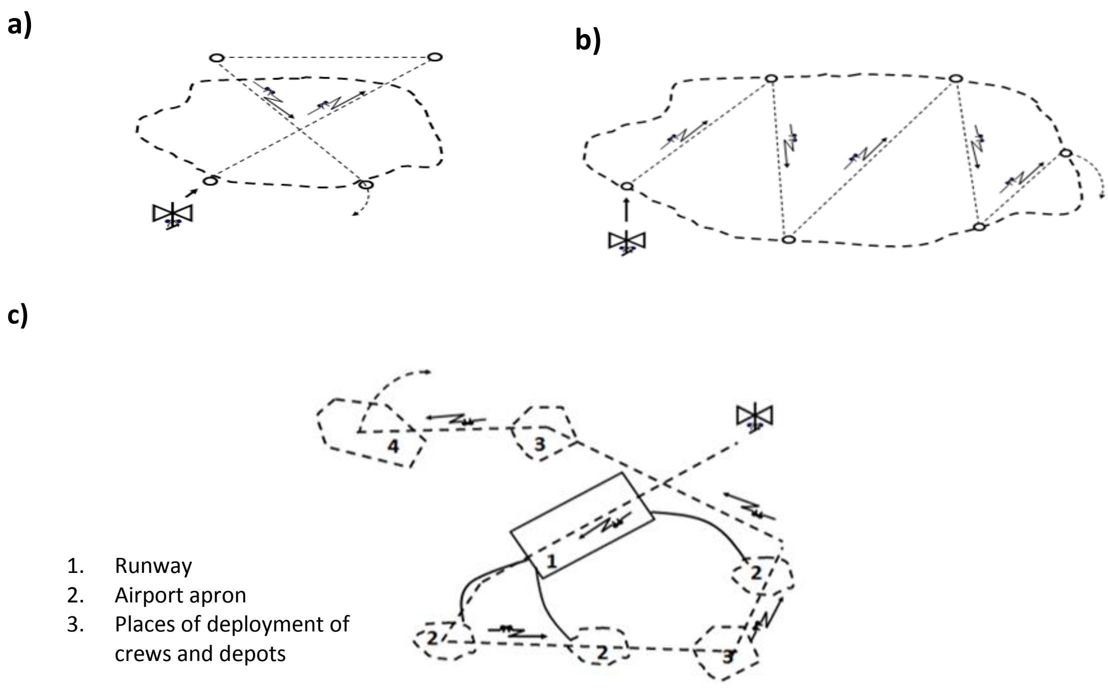

Fig. 12. Aerial identification of radioactive contamination a) small zones, b) large zones, c) airfields [20]

Source: [6]

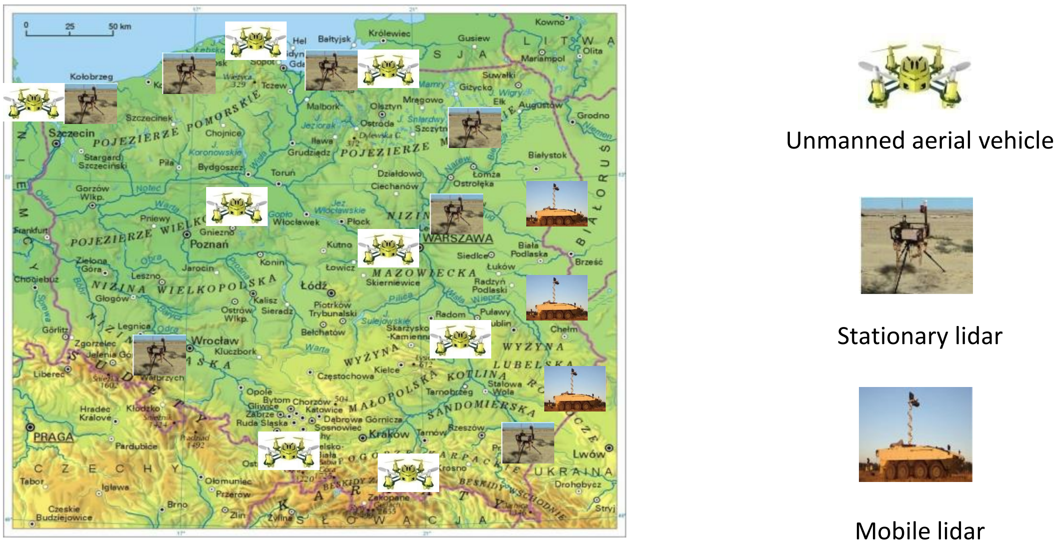

Fig 13. Elements of crisis response and contamination reconnaissance in the Polish Armed Forces with the use of unmanned platforms

Source: own elaboration

Conclusions

- The Contamination Detection System in the Polish Armed Forces is procedurally inconsistent with the analogous solutions existing in NATO. This mainly concerns the operating methodology and technical equipment.

In NATO, automated systems based on the state-of-the-art technology are preferred, while in the Polish Armed Forces - "manual" ones with technical equipment from a bygone era. There are new solutions in the field that are up to or even exceeding world standards, but unfortunately there is no will to implement them.

– The use of Unmanned Aerial Vehicles in conducting aerial reconnaissance and identification of contamination will significantly increase the effectiveness of operation not only of the Polish Armed Forces and other sub-systems of the KSWSiA. UAVs will to a large extent support ground-level contamination reconnaissance subunits, and in the longer term they may even replace them in the performance of most tasks.
– The main advantages of UAV utilization in aerial identification include: no need to expose personnel to contamination and enemy impact, low radar detection, minimal visual and acoustic performance during reconnaissance, reducing the likelihood of enemy detection, high mobility, maneuverability and the ability to operate in difficult terrain conditions.
– At the moment, research and development work on the reconstruction of aerial contamination detection in the Polish Armed Forces has not been conducted.

Acknowledgement

No acknowledgement and potential founding was reported by the authors.

Conflict of interests

The author declared no conflict of interests.

Author contributions

All authors contributed to the interpretation of results and writing of the paper. All authors read and approved the final manuscript.

Ethical statement

The research complies with all national and international ethical requirements.

ORCID

The authors declared that they have no ORCID ID's

References

1. Austin R., *Unmanned Aircraft Systems. UAVS Design, Development and Deployment,* A Joh Wiley and Sons, Ltd., Publication, Chippenham, 2010.

2. Czaputowicz J., *System czy nielad? Bezpieczenstwo europejskie u progu XXI wieku*, PWN, Warszawa, 1998, s. 23.
3. *Europejska Strategia Bezpieczenstwa. Bezpieczna Europa w lepszym swiecie.* Luksemburg, 2009.
4. Harmata W., *Ochrona przed skazeniami, cz. IV Wybrane zagadnienia metodologiczne, organizacyjne i techniczne likwidacji skazen,* WAT, Warszawa 2017 (materialy niepublikowane).
5. Harmata W., Klosowicz, S., Chalupczak M., Witczak M., Pirszel J., *Problemy likwidacji skazen powierzchni „wrazliwych".* Komunikat naukowy na Konferencje naukowa „Ochrona czlowieka i srodowiska naturalnego przed skazeniami. WIChiR, Warszawa 2014.
6. *Instrukcja o powietrznym rozpoznaniu skazen,* MON, Chem. 306/82, Warszawa, 1982.
7. Instytut Techniczny Wojsk Lotniczych, www.itwl.pl (avalible: 06.2016).
8. Jakubowska M., Maziejuk M., Ceremuga M., Siczek J., Gallewicz W., *Ceramic DMS – type detector,* [in:] "International Journal of Ion Mobility Spectrometry", DOI 10.1007/s12127-012-0093-1, 2012.
9. NO-42-A221:2015 Sprzet do wykrywania skazen chemicznych. Automatyczne sygnalizatory skazen chemicznych Wymagania techniczne.
10. *Obrona przed bronia masowego razenia w operacjach polaczonych DD/3.8(A),* Ministerstwo Obrony Narodowej, Centrum Doktryn i Szkolenia Sil Zbrojnych Szkol. 869/2013 s. 14 -32.
11. Pietrzak G., *Koncepcja systemu powietrznego wykrywania skazen z wykorzystaniem srodkow bezpilotowych,* praca dyplomowa, WAT, Warszawa 2016, s. 119.
12. [online]. [available: 15.07.2016]. Available on the Internet: http://fakty.interia.pl/galerie/kraj/zdjecie,iId,2174003,iAId,218218.
13. Strategia Bezpieczenstwa Narodowego Rzeczypospolitej Polskiej, Warszawa, 2014.
14. Witczak M., *Systemy rozpoznania skazen oparte na zaawansowanych systemach detekcyjnych i bezzalogowych platformach*, (ed.) B. Kot., J. Baranski, *Funkcjonowanie krajowego systemu wykrywania skazen i alarmowania w swietle aktualnych zagrozen skazeniami,* Warszawa 2016, s. 28-43.
15. Wojnarowski J., *Teoretyczne podstawy podsystemu bezpieczenstwa militarnego RP,* [in:] "Mysl Wojskowa" 6/2004, Warszawa, 2004, s.35.
16. [online]. [available: 15.07.2016]. Available on the Internet: http://militarium.net/klasyfikacje-i-wymagania-dla-bezzalogowych-statkow-powietrznych-uav-w-polsce/.
17. [online]. [available: 15.06.2016]. Available on the Internet: http://www.phoenix-aerial.com/products/lidar-systems/scout-series/.
18. [online]. [available: 15.06.2017]. Available on the Internet: http://www.pimco.pl/products/detektor-skazen-biologicznych-biodes/.

19. [online]. [available: 15.05.2016]. Available on the Internet: www.military-today.com/helicopters/oh6_cayuse.htm; www.sikorsky.com/Pages/Products/ Military/BlackHawk/UH60M.aspx.

20. [online]. [available: 15.05.2016]. Available on the Internet: https://www.flickr.com /photos/nxgphotos/6609613333.

Biographical notes

Wladyslaw Harmata - DSc. Eng. Associate professor, graduated from the Faculty of Chemistry and Technical Physics of the Military University of Technology in Warsaw in 1978. Professor at the Department of New Technologies and Chemistry of the Military University of Technology. Specialization - ecology, decontamination, protection against contamination. Co-author of 9 national patents and 20 implementations to the Polish Armed Forces. Research results were published in about 340 original scientific works. Author of 6 monographs and academic textbooks.

Marek Witczak - Brigadier General ret., graduated from the Faculty of Chemistry and Technical Physics of the Military University of Technology in Warsaw in 1978. Visiting Professor at the Department of New Technologies and Chemistry of the Military University of Technology. Specialization - protection against contamination. Co-author of a number of papers on Defense against Weapons of Mass Destruction. He specializes in military methods of chemical and radiological contamination reconnaissance, with particular emphasis on the use of unmanned aerial vehicles for reconnaissance and detection of contamination. He also deals with assessment of contamination situations based on information systems for the needs of the Polish Armed Forces.

Grzegorz Pietrzak - Sec. Lt. M.A. Eng., completed the individual military studies at the Department of New Technologies and Chemistry at the Military University of Technology in 2016, at the Faculty of Chemistry, specialization - protection against contamination. Major areas of his interest include unmanned technologies and their use in Armed Forces as well as liquid crystal materials and their practical application, for example, in the detection of contamination.

How to cite this paper

Harmata W., Witczak M., Pietrzak G., (2018) – Aerial detection of contamination with the use of unmanned vehicles – development prospects. *Scientific Journal of the Military University Of Land Forces*, vol. 50, no. 1 (187), p. 5-24, http://dx.doi.org/ 10.5604/01.3001.0011.7353