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Simulation in first-responders training to improve the decision-making process: chemical, biological and radiological weapons in improvised explosive devices at airports

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Abstract

The aim of the article is to analyse the role of simulation in training first responders to deal with chemical, biological and, radiological weapons in improvised explosive devices. It was assumed that simulation improves decision-making in life threatening situations, especially those related to the use of hazardous substances and explosive devices together. A case study – a specialised exercise conducted in Poland in 2018 involving empirical research data, constitutes evidence concerning the credibility of the hypothesis. A simulated terrorist attack on an airport, where drones carrying IEDs with CBRN agents were used, was enacted. This simulation was carried out during the 3rd National Polon CBRN Workshop on June 26-27, 2018 in Bydgoszcz. Implications for the future concern present and future technologies and equipment for simulating a potential terrorist attacks using IEDs with CBRN agents at an airport.

Keywords: security of airport; improvised explosive device, dirty bomb, simulation-based training;

1. Introduction

The tragic events of 11 September 2001 marked, a turning point in the history of mankind, and the beginning of a new era 'superterrorism'. (Aleksander, Koenig, 2001 & McBride, 2008 & Michailiuk 2015 & Pantucci, 2015 & Rappaport, 2006) However, the role of those events in catalysing the development of technologies to counter terrorist threats is not often highlighted. Modern terrorism has taken on new and dangerous forms, as evidenced by attempts to use chemical, biological and radiological materials in terrorist activities. (Horgan, Bloom, Daymon, Kaczkowski, Tiflati, 2017).

One of the directions in which modern terrorism could developing is the construction and use of improvised explosive devices for the dispersion of chemical, biological and/or radiological materials (Adamski, 2007). Consequently, there is a need to effectively minimize any effects related to such activities. One way to do this is to train first responders using simulation methods. The aim of this article is to analyse the role of simulation in training personnel to combat the use of chemical, biological and radiological weapons in Improvised Explosive Devices.

The analysis relies on a case study from the 3rd National POLON CBRNE Workshop in Bydgoszcz,

which took place on 26- 27 June 2018. The setting for the exercise was the airport in Bydgoszcz. A survey was used to identify and analyse the training needs, which if insufficient, should be improved. The outcomes from the analysis serve as an evidence that, when applied in training on how to deal with chemical, biological and radiological weapons in Improvised Explosive Devices, simulation is a key means of improving decision-making (POLON CBRNE, 2018).

2. Background situation

Airports are facilities that would appears to be particularly vulnerable to terrorist attacks using explosive devices and other hazardous materials (Glen, 2014). An airport is a complex anthropotechnical system, (it consists of many elements associated with numerous internal relationships) where human factor is strongly evident. One of the specific tasks carried out by the airport management bodies is to set up an airport security system to achieve the expected level of confidence in airport security.

To counter security threats to passengers, non-passengers, aircraft and port facilities, airport security is based on the real-time *image and anticipated modus operandi of* a potential adversary. To date, no attacks have been carried out in Europe with an improvised explosive device containing chemical, biological or radiological materials. The possibility of carrying out such attacks is strongly emphasized in terrorist propaganda, where various social media platforms provide tactics for building CBRN (chemical, biological, radiological, nuclear) weapons, and regarding potential targets. The threat of such attacks was noted by the UN Security Council (United Nations Security Council Resolution S/RES/2325 (2016) of 14 December 2016), where concerns were expressed about the increasing proliferation of these weapons, which can be used by non-state actors.
The Action Plan to increase preparedness for *chemical, biological, radiological and* nuclear security threats contained in the Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions COM (2017) 610 final, dated 18.10.2017 issued in Brussels, indicates that the European Union must increase its vigilance and preparedness to deal with CBRN attacks.

The risk of the use of an improvised explosive device containing
a chemical, biological and/or radiological material should
be considered low, but as having serious potential effects.
An attack on airport premises could have serious consequences for the target society and the economy by causing long-term disruptions to air traffic, serious medical consequences, and uncertainty.The human and financial costs of such attacks could be very high (Winterfeldt, Rosoff, 2017 & McBrid, 2008).

Despite the efforts made by various actors to improve safety in air transport there is still a lack of interoperability solutions corresponding to the modern threats that improvised explosive devices containing chemical, biological and radiological materials may constitute.

A terrorist attack on an airport could employ a variety of tactics, from diversion or sabotage by an airport employee
or conventional security services, to explosive devices containing chemical, biological or radiological materials, to "drones" and other aircraft. It should be stressed that port security systems must constantly evolve, given the increasing "creativity" of potential bombers and the new methods they have at their disposal.

Ten years after 11 September 2001 terrorists are still determined to achieve their goals, and this could involve:

a) hijacking a passenger aircraft or other aircraft filled with fuel or explosives with a view to destroying a particular object or attacking civilians;

b) using (manned or unmanned) aircraft as a means of transport for discharging (spraying) poisonous (chemical or biological) agents;

c) using a nuclear-laden aircraft or a 'dirty bomb' to destroy an important object or damage the ground (Lidwa, Krzeszowski, Więcek, 2010);

d) using a CBRN IED

- directly (in person);
- using a vehicle;
- using a drone.

Maintaining airport security on a permanent basis is a demanding task that requires the use of a number of organisational and technical measures, including the introduction of adequate personal, physical and ICT protection. It is also necessary to constantly monitor emerging risks, and to modify solutions that guarantee airport safety. This raises awareness of the need for systemic action to identify and develop appropriate prevention methods and, in the event of a risk, to take the most effective measures to mitigate the impact. The proper preparation of the capabilities of the forces and resources of services within the various ministries and institutions, and their proper cooperation in responding to the threats posed, is of paramount importance. As evidenced in previous crisis situations at airports, how well these various services are prepared and cooperate with other falls far short of the ideal. (Urban, 2018 & Kaszeta, 2012).

3. Terrorist attack using IEDs with CBR

agents at airports

3.1. Definitions of IEDs with CBR

A simulation can involve several different risks associated with the use of a CBR IED. The description of the specific risks involved focuses on detailing their most important aspects so as to assess the complexity of the phenomenon and the features that should be taken into account in the process of building the simulation model.

In order to properly describe a hazard in the form of an improvised explosive device containing chemical, biological
or radiological materials, consideration should be given
to defining what an improvised explosive device is and to analysing the possibility of using chemical, biological
or radiological materials in order to have a direct and indirect impact on human health, life and property (Keelley, 2017).

In order to identify the risks posed by improvised explosive devices, the author analysed the following definitions;

1. The United Nations Mine Action Service (UNMAS) defines an explosive device (IED) as: "[...]a device placed or fabricated in an improvised manner incorporating destructive, lethal, noxious, pyrotechnic, or incendiary chemicals and designed to destroy, incapacitate, harass, or distract. It may incorporate military stores, but is normally devised from nonmilitary components [...]". (https://unmas.org/en/improvised-explosive-device-lexicon
2. the definition of the US Department of Defence reads as follows: "[...] A weapon that is fabricated or emplaced in an unconventional manner incorporating destructive, lethal, noxious, pyrotechnic, or incendiary chemicals designed to kill, destroy, incapacitate, harass, deny mobility, or distract [...]" (Department of Defense Dictionary of Military)
3. the definition in the NATO AAP-6 glossary of terms and definitions, defines improvised explosive devices as "[...] A device placed or fabricated in an improvised manner incorporating destructive, lethal, noxious, pyrotechnic or incendiary chemicals and designed to destroy, incapacitate, harass or distract. It may incorporate military stores, but is normally devised from non-military components [...]" (AAP-6 NATO Glosasary of Terms and Definitions (2012).
4. In another NATO normative document that addresses the issue of improvised explosive devices, is the Doctrine of the North Atlantic Alliance – Allied Joint Doctrine AJP 3.15 (A). It comprehensively characterises the issues related to these devices and the system for counteracting them. An IED is defined as a "[...] device planted or improvised, containing destructive, lethal, poisonous, pyrotechnic or incendiary chemicals and designed to destroy, damage, harass or distract. May contain military materials, but is usually made of non-military components [...]' AJP-3.15.

3.2. Chemical substances in IEDs

An improvised explosive device containing a chemical material can be used in two ways: firstly, to disperse the aforementioned typical chemical munitions by initiating an explosion that will damage the shells of typical ammunition and will continue to release (disperse) the chemical material; secondly, the use of an explosive device containing in its design combat poisonous agents or toxic industrial agents. It is most likely to use chemical materials that are easy to synthesize in basic laboratories, such as: sarin, iperyt. Toxic industrial agents such as fosgen, chlorine and ammonia can also be used. These chemical materials are characterized by high toxicity. The explosive device is used to leak transport containers and release (disperse) chemical material shaving corrosive and irritating vapours and aerosols (Kawka, 2009 & Ellison, 2008 & Górniak, Kalisz, Ostrowska, 2018 & Croddy, Perez-Armendariz, Hart, 2003).

3.3. Biological substances in IEDs

Biological weapons are one class of weapons of mass destruction whose combat materials include pathogenic bacteria, fungi, viruses and biological toxins. Each of these materials can cause a deadly or chronic disease that can lead to epidemics, mass panic and disruptions to public order.
An important factor affecting the high effectiveness and danger of weapons of this kind is the proliferation itself. The a biological material dispersed by an explosive device may continue to be carried over long distances by contaminated persons, wind, animals or any object without losing its properties. The use of an improvised explosive devices containing a biological material can be difficult to identify. This is due to the fact that one of the signs of the use of biological weapons is a sudden simultaneous increase in the morbidity and mortality of a significant number of people in a certain area.
The purpose of an attack using an improvised explosive device containing a biological material will be to induce dispersion in the form of an aerosol,

causing air pollution. This is the most dangerous form of attack, and the form most desirable for perpetrators since inhalation is associated with the greatest risk of extensive dispersion of the disease (Bijak, 2018).

3.4. Radiological material in IEDs

An explosive device containing a radiological material may consist of a tray containing the radiological material and an explosive that will disperse the radiological material. The purpose of the use of an explosive device containing radiological material is to kill injure potential targets, as well as to cause contamination of the area which the radiological material is dispersed.

An improvised explosive device containing a radiological material commonly referred to as a 'dirty bomb' (Meister, Karam, 2005) Isn't a military-type weapon, but a non-military, makeshift weapon. The inhalation of the radioactive material in dispersed form does not necessarily lead to acute radiation syndrome. The intention in detonating an improvised explosive device containing a radiological material is to cause panic as a result of the radiation contamination of persons, facilities and terrain. (Magill, Hamilton, Lützenkirchen, Tufan, Tamborini, Wagner, Berthou, Zweidorf 2007. & Zimermann, Loeb, 2004 & Solarz 2007).

4. Decision-making in emergency situations

Airport security problems are becoming more and more topical and demanding. Decisions taken by first-responders in crisis situations caused by a threat in the form of an improvised explosive device containing a CBR material are a function of the information they are provides with. That information as well as their intuition, reason, experience and intellect, all contribute to the decision-making process in which the first-responder seeks to neutralize the threat by making the best possible decisions in the given circumstances (Maciejewski, Robak, Młynarczyk, 2017).

However, at airports, in crisis situations caused by improvised explosive devices containing a CBR material, which are complex situations for decision-makers, first-responders should have more than their previous experience to guide them. They should also have tools and techniques they can rely on.

The main objective of the first-responder decision-making process in the event of an airport emergency caused by the use of a CBR IED is to create the most favourable conditions for achieving the objective of neutralising the threat.

Given the unique and specific nature of the CBR IED threat, which, when used at an airport, will most often be aimed at achieving the maximum effect, the use of simulation tools is of particular importance in the effective support of first-responders. Firstly, this is due to their ability to: (Heyer, 2006)

- research analytical and theoretical work on the threat of CBR IEDs at airports;
- understand the methods of operation of terrorist groups that can use CBR IEDs;
- analyse the vulnerability of airport to the threat of CBR IEDs, including by simulating variants of attack scenarios;
- illustrate the effects of an attack on airport premises using a CBR IED;
- forecast the occurrence of a CBR IED terrorist attack using at an airport, including on the basis of selected scenarios and historical data;
- make a hazard analysis of CBR IEDs and a risk assessment;
- establish plans and procedures for responding to a threat in the form of a CBR IED;
- support first-responder decisions related to the response to a threat in the form of an CBR IED;
- teach, train and prepare first-responders who are responsible for neutralising CBR IED threats;
- design decision support systems, and use these to generate and evaluate a set of emergency decisions at the airport caused by an IED CBR incident; update the situational picture in real time, evaluate alternative methods and ways of neutralizing the threat (Wiśniewski, Kozioł, Falecki, 2017).

5. Risk in decision-making

The natural aspiration of people – the first-responders who are in a crisis situation - is to strive for certainty, or at least the appearances of certainty, when making decisions. The idea is to make sure that the decision-maker uses the right evaluation and selection criteria, so that appropriate action will be taken as expected (Sienkiewicz, 2013 & Agnusdei, Gnoni, Tornese, 2019).

Decisions are made for the future, but based on historical data. Decisions are predictive in nature, are derived from the diagnosis of the current state, and aimed at effectively neutralising the threat. Decisions concern the prognostic aspects of future crisis developments. So the decision-making process is a process of diagnosis and projection of the past, of the present, and of the future (Ficoń, 2007).

Virtually every real decision-making situation is

uncertain and involves risk. That is why it is so important to provide first-time respondents or decision-makers with the tools to optimise decision-making and minimise risk. Simulation provides the tools that can be used to create potential scenarios for terrorist attacks, including those using CBR IEDs, so that airport security services can minimise their vulnerability to this type of threat.

6. Hazard simulation as a method of education

Learning first-person through experience is one of the most effective ways to learn. The modern model of learning through experience is derived from David Kolb (Kazimierska, Lachowicz, Piotrowska, 2014).

People learn best through experience. Experience is understood as a method of trial and error in the course of action. It provides incentives to change behaviour. This is especially useful in adult learning. Established strong patterns and habits often block mature people from opening up to new forms of behavior, new decision-making strategies and skills. Simulations allow participants to actually act and experience the effects of their actions, to have the opportunity to observe their chosen strategies and improve their performance through trial and error.

Why are simulations so effective?

- Their attractiveness increases energy and motivation for the learning process. Therefore, the acquisition of competences or attitude changes occurs more quickly;
- The dynamic nature of simulations as a learning method provokes participants to make quick and difficult decisions;
- Simulations give reliable and concrete feedback to participants and instructors on whether they have achieved the intended results through their decisions and actions;
- This method is better than others possible for really testing the actions and decisions of first-time participants.

Simulation is training in which all the participants become involved in situations that reflect real conditions as closely as possible. Simulations can be divided into two types: real simulations and constructive simulations (Carlson, 2016).

A real simulation provides an effective test of the skills and endurance of participants, and allows them to practice specific responses to crisis situations, including those involving the use of a CBR IED. In this respect, simulating a dispersion of chemicals can help trainees understand how to respond effectively in a crisis situation.

A constructive simulation is one in which participants make decisions using a computer system in a simulated reality. The purpose of using a constructive simulation is to assess, as reliably as possible, the solutions to the crisis situation chosen by the participant. A constructive simulation employs a virtual environment that is effectively 'real' for the participant and at the same time makes it possible to objectively evaluate the decision-making process. It is important that the simulation time corresponds to real time, since will ensure that the participants stick to the time regime (Kępka, 2015).

The purposes a simulation include testing the procedures adopted during a crisis situation and creating a dynamically changing situation that forces the participant to use both accepted and non-standard solutionis.

Resolving the simulated crisis necessitates communicating the decisions taken, cooperating with peers (in the case of group exercises) and coordinating participants as implementing elements presented in the simulation system (Gudzbeler, 2018).

6.1. 3rd National CBRN POLON Workshop case study

An example of a constructive simulation exercise aimed at implementing the operating procedures adopted at an airport in the event of an emergency caused by the use of IED CBR was the 3rd National POLON CBRNE Workshop in Bydgoszcz, which took place on 26- 27 June 2018. The scenario of the exercise organized by the Border Guard Post in Bydgoszcz. It assumed an episode of an act of unlawful interference consisting of the intrusion into the restricted space of the airport by an unmanned aircraft, 'drone', which leaves a package on the territory of the airport that may contain an improvised explosive device containing chemical, biological material or radiological material (POLON CBRNE 2018 https://www.nadwislanski.strazgraniczna.pl/wis/aktualnosci/28599,III-Ogolnopolskie-Warsztaty-POLON-CBRN.html).

The simulation of the identification and neutralisation of this threat was attended by Border Guard officers, who had to carry out radiometric control activities and conduct mine-pyrotechnic activities, and by officers of the State Fire Brigade from the 2nd Fire Fighting Unit of the Municipal Fire Department in Bydgoszcz and the Fire Fighting Unit of the State Fire Service Sub-Officer School in Bydgoszcz. In addition, soldiers from the Military Preventive Medicine Centre in Bydgoszcz took part in the simulation.

Participants were asked how often simulations take

place in the unit they represent. This was done in order to gain first-hand knowledge from persons representing entities that may participate in the process of protecting international airports in Poland from the threat of CBR IEDs. The questions contained in the survey were prepared by the author in a way that made it possible to analyse how well international airports in Poland are protected against this threat and to outline desirable directions of change for ensuring ensure the safety of people and airport infrastructure.

The survey involved representatives of services from four international airports, selected at random. They included the border guards, airport security services, airport rescue and firefighting services; and representatives of other services which, in the event of an emergency involving the use of a CBR IED in the port area, could be called in to take part in dealing with the crisis namely: the State Fire Brigade, the Police, the Border Sanitary Station, and the Military Centre for Preventive Medicine.

As part of the survey sample, the author posed two questions.
The first concerned training frequency relevant to CBR IEDs; the second was designed to assess participants level of knowledge of the risks of an emergency involving explosive devices containing chemical, biological or radiological materials?

7. Results and Discussion

The first question was: *How often do you train/practice in the organisation you represent to address the risks of improvised explosive devices containing chemical, biological and radiological material?* A numerical and percentage distribution of the results to this part of the survey is shown in Figure 1.

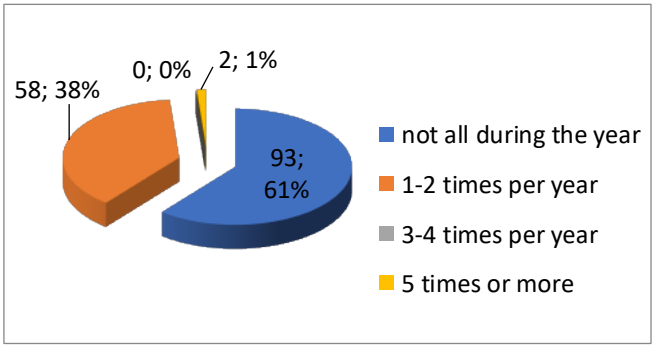

Figure 1.

In the majority cases, no training in this area takes place at all, as evidenced by the worryingly high percentage (61%) of respondents who gave such a response. Only (38%) of respondents replied that their units provide training 1 to 2 times a year, and only 1% said they are given raining 5 or more times a year.

Minimising the risks of improvised explosive devices containing chemical, biological or radiological materials requires operating procedures to be adapted to the risks present in a given situation. Risk awareness is one of the key elements in ensuring that security forces are properly prepared to act. Knowledge plays a particular role in ensuring the effective protection of human life and health and airport infrastructure.
The second question of the survey: *How do you assess the level of knowledge about the risk of using explosive devices containing chemical, biological and radiological material?* Respondents' rating of awareness of these risks is shown in Figure 2.

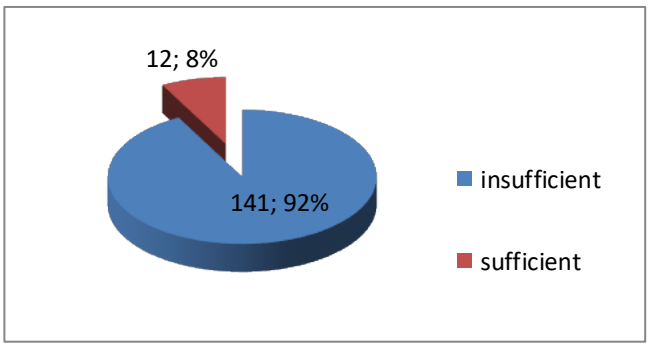

Figure 2.

Almost all of the respondents answered this question in the negative – 92% of those surveyed (141 people). According to the them, the existing shortcoming in this regard is mainly caused by: a lack of reliable sources of knowledge on the nature of the threat that improvised explosive devices containing chemical, biological or radiological materials may pose, a lack of education in this field, and the small number of CBR hazard specialists. This is clear evidence of a lack of awareness of the evolution of the construction of explosive devices, which are still seen as one of the main threats in the area of civil aviation security.
Staff and officers of international airport security organisations, do not have sufficient knowledge of the potential and could have serious consequences in the event of an attempted attack.

In view of the above, the author recommends that simulation training be introduced on the risk of improvised explosive devices containing chemical, biological or radiological materials being used to attack airports. This is a proposed priority direction for changes in the functioning of international airport security organisations. Such simulations should be carried out among

the security services, and then continued in period crisis exercises at the airport. Officers performing mine-pyrotechnic duties at an airport should be trained in the methods, procedures and optimal use of technical equipment for neutralising improvised explosive devices containing chemical, biological or radiological materials.

An analysis of participants' responses to the survey question shows that it is crucial to increase first responders' knowledge of the threat posed by potential attack using explosive devices containing chemical, biological or radiological material that may occur at international airports in Poland (Siadkowski, 2015).

8. Conclusions

On the basis of the studies carried out, the author concludes that the organisational arrangements adopted to protect international airports in Poland are focused mainly on identifying threats in the form of prohibited items brought into the secure area of the airport or on board aircraft. Port security needs to be continuously improved. In view of the specific nature of airports, it is appropriate to also employ solutions that will improve efficiency and effectiveness in addressing the risks posed by explosive devices containing chemical, biological or radiological materials and that will ensure the safety of people and airport infrastructure. In view of the above, the author assumes that, in order to improve the protection of international airports in Poland, it would be appropriate to implement legal, technical and organisational solutions that enable these threats to be dealt with in an effective manner.

The enhancement of international airport security should involve by a team of experts in the field of CBR. It would be composed of experts acting as coordinators in order to develop methods of dealing with CBR events. The team should include persons from the Fire Brigade, Police, Border Guard and other state services and institutions with knowledge and experience. In view of the complexity of the risks involved, the cooperation of all services and entities dealing with such threats should be continuously improved through simulation training and joint exercises, as well through the development of tactics and techniques appropriate for protecting airport infrastructure when responding to improvised explosive devices that contain chemical, biological or radiological materials.

Minimising the risks of explosive devices containing chemical, biological or radiological materials requires operating procedures to be adapted to a given situation. Risk awareness is one of the key elements in ensuring that forces are properly prepared to act. Knowledge plays a particular role in ensuring the effective protection of human life and health, and airport infrastructure.

Simulations of CBR IED threat response processes can address a wide range of issues, including:

- identifying CBR hazard that may be contained in an improvised explosive device;
- studying the impact of first-time respondents equipment on performance;
- acquiring knowledge on information flow, and the coordination and response of security services;
- developing scenarios concerning CBR IEDs (Szulik, Wrzosk, 2013).

An analysis of literature and CBR IED scenarios at airports, suggests that simulation is necessary in order to make first respondents aware of the important role they play in the event of an emergency. Simulation reinforce the need for them to take the initiative towards neutraling the threat posed by CBR IEDs. When supported with new technologies, this can enhance learning (Maciejewski, 2017; Maciejewski et al, 2020; Gawlik-Kobylińska et al. 2019; Gawlik-Kobylińska, 2021).

Understanding the threat is key to successfully preparing to respond to a CBR IED incident. In the author's opinion the possible ways of attacking critical infrastructure, including international airports, using of explosive devices containing chemical, biological or radiological substances are constantly developing. Such threats therefore pose a significant challenge for security specialists.

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References

Adamski J. (2007) Nowe technologie w służbie terrorystów, Wydawnictwo Collegium Civitas, 79.

Agnusdei G.P., Gnini M.G., Tornese F., Modeling and simulation tools fo r integrating farword and reserve logistics: A literaturę review. In: The 31th European Modeling & Simulation Symposium 2019 (Eds.) M. Affenzeller, A. G. Bruzzone, F. Longa, G. Pereira. 317-326.

Aleksander Y., Koenig M., (2001) Superterroryzm biologiczny, chemiczny i nuklearny. Ataki chemiczne, bronie bioterrorystów, zagrożenie nuklearne, dokumenty, Wydawnictwo Bellona.

Bijak M. (2008). Zagrożenia biologiczne, [w:] Podręcznik treningowy. Operacje w środowisku zagrożeń chemicznych, biologicznych lub radiologicznych

Carlson, M. et. al. (2016). CBRN Operator Canadian Joint Incident response Unit Chemical, Biological, Radiological and Nuclear Unit Pre-Selection, Physical Fitness Training Program 1 st Edition P.2.

Croddy E., Perez-Armendariz C., HartJ. (2003). Broń chemiczna i biologiczna, Warszawa. 124-125.

EU. (2017) The Action Plan to increase preparedness for *chemical, biological, radiological and* nuclear security threats contained in the Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions COM (2017) 610 final, dated 18.10.2017 issued in Brussels

Ellison, D.H. (2008) Chemical and Biological Warfare Agents. Second edition. Livestock Pets. p.107.

Ficoń, K. (2007). Inżynieria Zarządzania Kryzysowego. Podejście systemowe.146-176.

Gawlik-Kobylińska, M. (2021). The Proteus effect on security and safety exergamers. Interactive Learning Environments, 1-15.

Gawlik-Kobylińska, M., P. Maciejewski (2019). Experiential Learning with Sansar Platform. A Concept of Military Training. In: IADIS International Conference e-Learning 2019 (part of MCCSIS 2019) (Eds.) M. Baptista Nunes, P. Isaias, 325-328.

Glen, A. (2014). Terroryzm lotniczy. Istota zjawiska, organizacja przeciwdziałania, Akademia Obrony Narodowej, 37-40.

Gudzbeler, G. (2018). Symulatory pojazdów w procesie szkolenia podmiotów odpowiedzialnych za bezpieczeństwo wewnętrzne, Difin 7-19.

Górniak L., Kalisz D., Ostrowska I., (2018) Niebezpieczne substancje chemiczne [w:] Podręcznik treningowy. Operacje w środowisku zagrożeń chemicznych, biologicznych lub radiologicznych.

Horgan. J., Bloom M., Daymon C., Kaczkowski W., Tiflati., H., A New Age of Terror? Older Fighters in the Caliphate May 2017, Vol. 10, Issue 5. A New Age of Terror? Older Fighters in the Caliphate – Combating Terrorism Center at West Point (usma.edu)

Heyer, R.J., (2006) Introduction to CBRNE Terrorism. An Awereness Primer and Preparedness Guide for Emergency Responders, The Disasters Preparedness and Emergency Response Association, Longmont, p. 2

Kazimierska, I., Lachowicz, I., Piotrowska, L., (2014). Uczenie się dorosłych – cykl Kolba. uczenie sie doroslych.pdf (doskonaleniewsieci.pl)

Kaszeta, D. (2012) CBRN and HAZMAT Incident at Major Public Events-Planning and Response Decontamination: planning considerations and tactics triage p. 13 DOI: 10.1002/97811118529713

Keelley R., (2017). Improvised Explosive Devices (IED): A Humanitarian Mine Action Perspective, Journal of Conventional Weapons Destruction Vol. 21. p. 5.

Kawka, W. (2009). Zespoły rozminowania I oczyszczania terenu w operacjach reagowania kryzysowego, Akademia Obrony Narodowej, 42-47, 75-77.

Kępka, P. (2015). Projektowanie systemów bezpieczeństwa,78- 214.

Lidwa, W. Krzeszowski, W. Więcek, P. Kamiński, (2012). *Ochrona Infrastruktury krytycznej*, Akademia Obrony Narodowej, 10.

Maciejewski, P., Robak, W., & Młynarczyk, M. (2015). Protection from CBRN Contamination in the Polish Armed Forces. Bezpieczenstwo i Technika Pozarnicza, 37, 107- 118.

Maciejewski, P. (2017). ICT Tools in CBRN Troops' Education and Training. Journal of Science of the Gen. Tadeusz Kosciuszko Military Academy of Land Forces, 49(4). Retrieved from http://yadda.icm.edu.pl/yadda/element/bwmeta1.elem ent.baztech-e5a7d4dd-1a26-11 4f3d-88ee- d5c33139589b.

Maciejewski, P., Gawlik-Kobylińska, M., Lebiedź, J., Ostant, W., & Aydın, D. (2020, January). To Survive in a CBRN Hostile Environment: Application of CAVE Automatic Virtual Environments in First Responder Training. In Proceedings of the 3rd International Conference on Applications of Intelligent Systems (pp. 1-5), ACM, New York, NY.

Magill, j. Hamilton, D. Lützenkirchen, K. Tufan, M. Tamborini, W, Wagner, W. Berthou, V. Zweidorf A. (2007). Consequences of a radiological dispersal event with nuclear and radioactive sources.

McBride, T.W. (2008) Probable Economic Targets for terrorism by radiological attack, 2-10, 13-16, 28-29.

Meister, K. Karam, P. A. (2005), The Facts About „Dirty Bombs",

Michailiuk, B. (2015). Broń biologiczna jako zagrożenie bezpieczeństwa państwa, Wydawnictwo Akademia Obrony Narodowej, 265-266.

Neffe, Starostin, (2011) *Projekt międzynarodowego programu ICCSS ws. Redukcji zagrożeń związanych z chemicznymi improwizowanymi urządzeniami wybuchowymi,* 1-2.

NATO. (2013). AAP-6 Słownik terminów i definicji NATO zawierający wojskowe terminy i ich definicje stosowane w NATO,

NATO. (2012). AAP-6 NATO Glosasary of Terms and Definitions s.2-I-2, NSA, 2012 Słownik Terminów i Definicji Wojsk Inżynieryjnych NATO

(AAP-19);
NATO. (2008). Allied joint doctrine for countering improvised explosive device (C-IED), AJP-3.15,
NATO. (2008). Allied Joint Doctrine for Countering improvised explosive devices, February 8, 2018 - AJP-3.15 Edition C Version 1. Allied Joint Publication-3.15., AJP 3.15 „Sojusznicza Połączona Doktryna ws. Przeciwdziałania Improwizowanym Urządzeniom Wybuchowym".
Pantucci R.,(2015). „We love death as you love life". Britains's suburban terrorists, Hurst & Co, London.
POLON CBRNE (2018). https://www.bing.com/search?q=III+Ogólnipolskie+warsztaty+CBRNE&cvid=0e366b5781bf4243b9ac11476b18b623&aqs=edge..69i57.11024j0j1&pglt=299&FORM=ANSPA1&PC=LCTS
Rapoport D.C., (2006). The Four Waves of Modern Terrorism in Terrorism: Critical Concept in Political Science, vol. 4. *The Fourth or Regious Wave, Routledge, Abingdon*
Security and Resiliency Guide. Counter-Improvised Explosive Device (C-IED) Security and Resiliency Guide (cisa.gov)
Solarz J., (2007). Broń jądrowa i radiologiczna, czyli o czym „marzą' terroryści, Zeszyty Naukowe AON Nr 1(66) 165-182.
Sienkiewicz, P. (1994). Analiza systemowa. Podstawy i zastosowania, Wydawnictwo Bellona, 349-366.
Szulik, W., Wrzosk, A. (2013). Wspomaganie teleinformatyczne zarządzania kryzysowego [w:] Sobolewski, G., Majchrzak M. Zarządzanie kryzysowe, Akademia Obrony Narodowej 240-261.
Siadkowski, A.K., (2013). Bezpieczeństwo i ochrona w cywilnej komunikacji lotniczej na przykładzie Polski, Stanów Zjednoczonych i Izraela, WSPOL, Szczytno. 316-348.
Urban, M. (2018). Współdziałanie Straży Granicznej z Siłami Zbrojnymi Rzeczypospolitej Polskiej w portach lotniczych w sytuacjach kryzysowych powodowanych przez zagrożenia epidemiczne, *Securitas et Sociates/Wojskowa Akademia Techniczna,* 119-150.
UNMAS. The United Nations Mine Action Service (UNMAS) (https://unmas.org/en/improvised-explosive-device- lexicon
USA. (2001). Department of Defense Dictionary of Military and Associated Term, 12 April 2001, Joint Publication 1-02.
USA. (2010). Department of Defense Dictionary of Military and Associated Term, 8 November 2010, Joint Publication 1-02
Winterfeldt, D. Rosoff, H. (2017) A Risk and Economic Analysis of Dirty Bomb Attack on the Ports of Los Angeeles and Long Beach, *published Articles e-Papers. Paper 39* http://resaerch.create.usc.edu/published_papers/39.
Wiśniewski, Kozioł, Falecki, (2017), Podejmowanie decyzji w sytuacjach kryzysowych, 55 – 177.
Zimmermann, PD Loeb C, (2004). Dirty Bombs: The threat Revisited, Defence Horizons 38: 1-11. http://hps.org/documents/RDD_report.pdf