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Impact of the New Technologies on CBRN Terrorist Threats: General Perspective and Perspective of Republic of Croatia

Vliv nových technologií na teroristické hrozby v oblasti CBRN: obecná perspektiva a pohled Chorvatské republiky

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Abstract: Although the level of the overall CBRN threat in the world is currently considered to be low, there is a trend of a growing concern about CBRN terrorism. Various terrorist groups have shown interest in using CBRN materials to disrupt the global order and economy. The motivation and factors that influence the potential use of CBRN agents in terrorist attacks arise from the fact that CBRN agents have potentially high mortality and can cause serious consequences. A large number of potential dual-use (military and civilian) items as well as the introduction of new technologies in use can be utilized for the CBRN attacks and create a wide range of new possible terrorist (and military) threats.

Abstrakt: Ačkoli je v současné době úroveň celkové chemické biologické, radiologické a jaderné hrozby (CBRN) ve světě považována za nízkou, je patrný trend rostoucích obav z CBRN terorismu. Různé teroristické skupiny projevují zájem o použití materiálů CBRN k narušení globálního řádu a ekonomiky. Motivace a faktory, které ovlivňují potenciální využití prostředků CBRN při teroristických útocích, vyplývají ze skutečnosti, že prostředky CBRN potenciálně způsobují vysokou úmrtnost a mohou mít vážné následky. Velké množství potenciálních materiálů dvojího užití (vojenského a civilního) společně se zaváděním nových technologií do užívání umožňuje jejich využití pro útoky s využitím prostředků CBRN a vytváří širokou škálu nových potenciálních teroristických (a vojenských) hrozeb..

Key words: Terrorism; CBRN; Weapons of Mass Destruction; New Technologies.

Klíčová slova: terorismus; CBRN; zbraně hromadného ničení; nové technologie.

INTRODUCTION

The shaping of the present and future security environment is significantly affected by factors as political, ecological, demographic, geographic, globalized economy, a permanent rise of the needs for resources, as well as development and availability of the new technologies. Constant technological progress accelerates changes and makes security environment even more complex through increased availability of the new technologies, facilitating development and possible proliferation of the weapons of mass destruction.[1] CBRN weapons are the most inhuman of all existing weapons, created to intimidate and to destroy. In hands of the states or non-state actors like terrorist organizations it can cause far greater destructions as compared to conventional weapons, with long-term consequences.[2]

Constant technological progress also brings about an increased number and complexity of the human networks that represent a gathering of persons who communicate among them, exchange knowledge and experiences generate ideas and solutions and act together.[3] These networks comprise people, processes, places, and resources and are connected through interests like personal, social, political, religious, or monetary. Extremist and radicalist groups, movements and organizations use advantages of the new technologies for advancement of the destructive ideologies, to win new members and to encourage violence. An increasingly important role of such non-state actors of power and mighty individuals is a security challenge both on domestic and international plan.

Important instruments in combat against CBRN threats at international level are various international treaties, conventions or initiatives that restrain or completely ban their use. However, accelerated technological advancement still surpasses capability of the international community to develop in due time appropriate strategies, legal and political frameworks for their control. At the same time, weak states slip away from the existing international treaties, as well as state and non-state actors of power, states that have not signed and ratified treaties and states with secret programs. Therefore, some state and non-state actors of power as extremist and radicalist groups may have facilitated access to knowledge and technologies for manufacture of the CBRN weapons, particularly those of dual-use. International treaties, as well as the existence and operation of the global institutions like UN, IAEA and OPCW are consequently of great importance for control of the CBRN weapons.

Cooperation of the state actors of power has an important role in prevention of the weapons of mass destruction (WMD) proliferation and terrorism. Changes in the area of global structure of power leads to the process of establishing new balance of military

1 Strategic Foresight Analysis, NATO HQ SACT, 2017, pp. 21, URL: https://www.act.nato.int/images/stories/media/doclibrary/171004_sfa_2017_report_hr.pdf, (14.4.2022.).

2 Blix, Hans, Weapons of Mass Destruction Commission (WMDC) – Weapons of Terror, Freeing the World of Nuclear, Biological, and Chemical Arms, United Nations, 2006, pp. 21-152.

3 M. O. Jackson, The Human Network, How Your Social Position Determines Your Power, Beliefs and Behaviors, Pantheon Books, New York, 2019, pp. 275.

power at world's level and with that leads to greater potential for outbreak of conflicts in various regions of the world.[4] Example for that are global geopolitical ambitions of the Russian Federation and its military aggression on Ukraine that has a potential to endanger world's peace. Such security situation does not favor cooperation of the global actors of power as the USA, Russian Federation and China and this cooperation is of key importance for control of the weapons of mass destruction. At the same time diffusion of power from the state towards non-state actors of power, as one of the basic changes in international security environment after the end of the Cold War has resulted in instability of the world's order.[5]

In this paper we will show how quick development and introduction of new technologies affect the area of CBRN regards to previous assessments of the CBRN risk and probability for terrorist and military attacks. For each CBRN segment we will show challenges regarding new technologies and their application as potential weapon for terrorist attack. We will also demonstrate how introduction of new (publicly available) technologies affect occurrence of the possible CBRN terrorist (and military) threats and efficiency of the existing protective measures.

1 METHODS AND DATA

This paper provides an overview of the potential CBRN threats from terrorist attacks through the analysis of some current new technologies that can be utilized for CBRN terrorist attacks. Regarding impact of the new technologies on CBRN terrorist threats these are some of the main questions that are discussed:

Question No. 1: Why a potential use of the CBRN agents in terrorist attacks presents great threat?

Question No. 2: What are the most probable new technologies that can be used for terrorist attacks with CBRN agents or with dual-use items?

Question No. 3: What are the limitations of new technologies and what are the limitations in availability of CBRN agents to the terrorist groups?

Limitations of the research:

This article focuses only on new technologies that are commercially available and are possibly accessible to the terrorist groups.

Methods used in this article include: description, classification, comparison, analysis, and deduction. Data was used from: scientific articles, professional articles, books, and open sources.

4 Z. Fareed, Svijet nakon Amerike, Fraktura, Zaprešić, 2009, pp. 60-61.

5 Ref. 1

2 TERRORISM AND IMPACT OF THE NEW TECHNOLOGIES ON CBRN THREATS

Given that it can be perceived from various viewpoints, definition of terrorism is very complex and there is no universal definition.[6] In the European Union as well as in the rest of the world, there is a problem regarding consensus and betterment of the existing legal definition of terrorism that would conform to all its aspects.[7] Although it has not been accepted, the most general definition was established in 1995 by the *UN General Assembly Resolution 49/60* according to which terrorism is "criminal offenses intended to provoke a state of terror in public, among certain persons or groups of persons, with justification that is of political, philosophical, ideological, racial, ethnical, religious or of any other nature".[8] The extended definition was established in the year 2004 by the *UN Security Council Resolution 1566* according to which terrorism is "criminal offenses, including against civilian population, committed with intention to cause death, serious bodily harm or to take hostages, with aim to create a state of terror in public, among individual persons or groups of persons, to intimidate population or to force a government or an international organization to do or refrain from undertaking any action".[9] The latest trends have shown that terrorist attacks are primarily directed towards random civilians.[10]

In general, terrorist threat is posed by extremist operation of an individual or groups, and chemical-biological-radiological and nuclear (CBRN) terrorism is only one of the possible forms. CBRN terrorist attacks do not necessarily have to be carried out by confirmed terrorist groups but would most probably be carried out by some small group of individuals or even by an individual, the so-called "lone wolf" and by using simple materials. A rising concern regarding CBRN terrorism occurred in the 1990s when the so-called "new terrorism" characterized by extremist ideologies significantly manifested itself.[11] This threat is not posed only by religious terrorist groups and organizations (most often Islamist, but there are also examples of the Christian, Buddhist and of other cults), but also by various groups with extremist ideologies and some radical ultra-right wing, ultra-left wing and anarchist groups.[12] In the past, some of these groups came into possession of the CBRN materials or they manufactured them by themselves with

6 T. Shanahan, The Definition of Terrorism, in R. Jackson (ed.), Routledge Handbook of Critical terrorism studies, Routledge, London, 2016, pp. 103-113.

7 E. Dumitriu, The E.U.'s Definition of Terrorism: The Council Framework Decision on Combating Terrorism, German Law Journal **5** (2004) 585-602.

8 UN General Assembly, Resolution 49/60, New York, 1995, pp. 4.

9 UN Security Council, Resolution 1566, New York, 2004, pp. 2.

10 Ref. 7

11 Mauro Lubrano, Emerging technologies: Implications for CBRN terrorism, URL: https://globalriskinsights.com/2018/02/emerging-technologies-cbrn-terrorism/, (10.1.2022.)

12 Europol, European Union Terrorism Situation and Trend Report 2021, Publications Office of the European Union, Luxembourg, 2021, pp. 1-109.

intention to use them. Motivation and factors that have impact on potential use of the CBRN agents in terrorist attacks are:[13]

1. CBRN agents have potentially high mortality rate and are silent killers,
1. It is harder to discover CBRN agents and to prevent their dissemination,
2. CBRN materials can cause serious consequences (contamination of the environment and impact on health of the people and animals) and collateral economic damage,
3. CBRN attacks cause fear and panic among population,
4. Attack with CBRN agents would capture great attention of the public and media,
5. CBRN materials represent a potential means for blackmail or exerting pressure on a government,
6. Possession and use of the CBRN weapons would temporarily place perpetrators in the position of power with regard to national authorities.

Despite several cases of successful terrorist CBRN attacks, of relatively bigger proportions and attacks on individual persons (mostly from intelligence sector or political life) that occurred in recent decades, it is currently considered that level of the total CBRN threat (especially a threat of greater proportion), both in the world and in Europe, is still low.[14] SWOT (Strength, Weakness, Opportunity, and Threat) analysis of the threat from CBRN terrorism in the Republic of Croatia has also confirmed a low level of the threat.[15] According to assessments, probability for a large-scale conventional conflict that would include CBRN operations is low because of the potentially disastrous consequences.[16] The biggest CBRN threat is in fact posed by terrorist and not by military actions, although from example of the civil war in Syria it is visible that such military actions were carried out in recent past. However, probability for CBRN terrorist attacks continues to be low because of the obstacles in obtaining or procurement of the CBRN agents and of arming them. Factors of risk consist of the CBRN materials that are out of control of the government in the zones of conflict, abuse of the poor inventory systems in problem areas and possibility of unauthorized access to sensitive facilities that is enabled by blackmail or corruption of individuals.[17] There is also the fact of the existence of a great number of potential materials that can be used for CBRN attack and have a dual-use (military and civilian) and are legitimately used, e.g. in medicine, industry and agriculture. Even if it would be of smaller proportions and would cause only a restricted number of victims, CBRN terrorist attack could have an important psychological (creating fear and panic in target and surrounding population), political and economic influence. Psychological

13 E. Dinu, Reassessing CBRN terrorism threats, in F. Su and I. Anthony (ed.), Reassessing CBRN Threats in a Changing Global Environment, SIPRI, Stockholm, 2019, pp. 8-13.

14 A. Rimpler-Schmid, R. Trapp, S. Leonard, C. Kaunert, Y. Dubucq, C. Lefebvre, H. Mohneu, EU preparedness and responses to Chemical, Biological, Radiological and Nuclear (CBRN) threats, European Union, Brussels, 2021, pp. 1-108.

15 D. Tušek, SWOT analiza opasnosti od KBRN terorizma u Republici Hrvatskoj, Polemos, **23** (2020) 37-60.

16 Strategija nacionalne sigurnosti Republike Hrvatske, URL: https://narodne-novine.nn.hr/clanci/sluzbeni/2017_07_73_1772.html, (13.1.2022.).

17 Ref. 13

segment is very important given that no other conventional weapon would have such big impact. Crisis management and suppression of the consequences of the CBRN attack in case of the CBRN attack in densely settled places would be very complex because of many factors, especially regards to dissemination of contamination, establishing the area of contamination and its removal. Implementation of the protection and decontamination countermeasures would include many state elements (emergency services – first responders, army, agencies). This would require forming large multidisciplinary teams what would raise questions regarding leadership and coordination. As an integral part, expert and scientific resources are required for the process of proper collection and analysis of the evidence (CBRN materials) gathered at the scene of the event. For all stated actions and measures a question is brought up about availability of the resources that include great human resources, material and financial assets.[18] Potential CBRN attacks can additionally be maliciously used in order to spread misinformation that can additionally complicate a response on attack because part of the population might not trust information provided by the authorities and will refuse to follow instructions.[19] Historically, the number of planned terrorist attacks to include use of the CBRN agents was relatively small, whereas the number of successfully executed CBRN attacks was even smaller. However, it was noticed that in closed forums (of probable or potential terrorist circles) on Internet still exist ongoing numerous discussions about CBRN agents and use of the CBRN weapons. Technological information is also exchanged online but without adequate scientific background, whereas extremist propaganda provides incentive for execution of the attack by using CBRN agents (especially chemical and biological warfare agents). *Dark Web* is the main tool that provides a possibility for anonymous and safe communication, exchange of information regarding manufacture and procurement of the CBRN agents and weapons or procurement of the items of dual-use, or rather in general it provides possibilities for planning CBRN terrorist attacks.[20] Various free of charge communication platforms, given that they use encryption, also provide safe communication and anonymity. Besides the exchange of information and procurement of the resources Internet has also become the main means of the terrorist and extremist groups for propaganda, dissemination of their ideologies and recruitment. Terrorists and extremists approach young persons on various platforms (mostly gaming online platforms) where they gradually radicalize them through communication (and play).[21]

Terrorists also utilized COVID-19 pandemics by using a method of dissemination of misinformation and theories of conspiracy on Internet and in media. Discussions were noticed on forums among members of Jihad, about possibilities of arming SARS-CoV-2 virus and proposals for execution of indirect attacks by distribution of infected masks on streets. Beside members of Jihad, discussions were also noticed in circles of the ultra-right-wing extremists about methods of using SARS-CoV-2 virus as a weapon. They considered spreading the virus in circles of the specific minorities, politicians, policemen

18 Ref. 13

19 Ref. 14

20 Ref. 13

21 Ref. 13

and medical staff, by transmission of the virus through air and contaminated objects, by delivery of contaminated packages and through close contacts. Apart from using biological warfare agents, on forums of the ultra-right-wing extremists recently was also noticed a proposal for attacks on critical infrastructure and governmental facilities by using cyanide for contamination of the drinking products.[22]

New technologies entail technologies and means that have new elements, that are (often) still being developed, have a significant potential that has not been completely developed yet and have significant impact on social and economic effects.[23] Most of the terrorist attacks that took place in Europe in the recent years were not carried out by using new technologies but by using low-technology means (bombs, (personal) fire arms, cold weapons, motor vehicles) where most of the Jihad terrorist organizations as Al-Qaeda and ISIS adhere to the principle "make it as simple as possible".[24] In general, it is more probable that terrorist groups will use already tested traditional and conservative methods. However, in the future, terrorists could use advantages of the new technologies, and this could increase the risk from CBRN threats. Therefore, all possibilities should be taken into consideration and perceive what are motivations of the terrorist groups for using unconventional weapons. Some of the recently developed existing and new technologies that can have the greatest influence on a potential CBRN threat include chemical microreactors, bioengineering, 3D printing, cyber-attacks, *Dark web,* and UAVs.[25] In order to be a step-ahead of the potential terrorist threats, state actors also benefit from new technologies. State actors need to keep up with new technologies and introduce them in operational use as soon as possible to develop the capabilities for effective response to current CBRN threats.

Although terrorism poses a constant threat to international and national security, as it was already stated, currently, a probability for successful terrorist attack that would include CBRN agents is still relatively small.[26] After disintegration or civil wars in some states that possessed CBRN weapons it cannot be confirmed with certainty that part of those weapons were not stolen and made available on the "black market" and to terrorist groups as well. Likewise, terrorist groups often have at their disposal sufficient funds and experts who monitor scientific research and development of the existing and new technologies from all fields. That opens possibilities of their malicious use for the purpose of a CBRN attack that could potentially provoke massive casualties and a large-scale destruction. Abuse of the individuals from scientific community and industry who possess specific knowledge that is necessary for manufacture of the CBRN agents and weapons is also possible. One segment of the terrorist threats is also represented by use of the cyber-space in order to cause casualties and damage in material world through, e.g. intentional causing of disasters in risky industrial plants that use or manufacture

22 Ref. 12

23 D. Rotolo, D. Hicks, B. Martin, What Is an Emerging Technology?, Research Policy 44 (2015) 1827-1843.

24 R. Veer, Terrorism in the age of technology, URL: https://www.clingendael.org/pub/2019/strategic-monitor-2019-2020/terrorism-in-the-age-of-technology/, (27.1.2022.).

25 Ref. 11

26 Ref. 16

hazardous substances. Release of such hazardous substances can cause very serious health, material, ecological and security consequences.[27], [28] From that perspective, terrorist organizations do not have to possess CBRN agents or weapons in order to carry out a successful CBRN attack. Cyber-attacks on network computers can be directed towards facilities like chemical and pharmaceutical industry and nuclear power plants. Cyber sabotage of the control mechanism as flow regulation, temperature, equipment and similar, with aim to disrupt their normal operation can cause unstable operation of the plant at unsafe levels. If, in the worst-case scenario, contamination is released, the facility can become a "weapon of mass destruction".[29]

Although according to an assessment, probability for terrorist attack in the Republic of Croatia is low, all states and the European Union as well have recognized proliferation of the WMD and terrorism within their security and defense policy, as one of the greatest security threats given they can potentially cause mass and long-term consequences.[30] The Republic of Croatia adopted: *National Security Strategy of the Republic of Croatia* (*Official Gazette* 73/2017)[31], *National Strategy for Prevention and Combating Terrorism* (*Official Gazette* 108/2015)[32] and *National Strategy of Cyber-Security and Action Plan for Implementation of the National Strategy of Cyber-Security* (*Official Gazette* 108/2015)[33]. Within all modern security strategies, including those of the Republic of Croatia, CBRN threats are listed as one segment. On basis of the stated documents and international agreements and conventions *National Strategy and Action Plan for Combatting WMD Proliferation* was adopted and it has defined: "Protection, from a threat of the WMDs and their proliferation, is obligation of the state in its basic function of ensuring conditions for a peaceful and safe life of its citizens, free from violence and fear, democratic, tolerant, creative, prosperous, in which order and law are respected."[34] In conformity with this national strategy, the main activities of the combat against weapons of mass destruction are primarily represented by prevention and detection, followed by response to threats.

27 Ref. 16

28 Nacionalna strategija kibernetičke sigurnosti i akcijski plan za provedbu nacionalne strategije kibernetičke sigurnosti, URL: https://narodne-novine.nn.hr/clanci/sluzbeni/2015_10_108_2106.html, (13.1.2022.).

29 Ref. 11

30 Ref. 16

31 Ref. 16

32 Nacionalna strategija za prevenciju i suzbijanje terorizma, URL: https://narodne-novine.nn.hr/clanci/sluzbeni/2015_10_108_2105.html, (13.1.2022.).

33 Ref. 28

34 Nacionalna strategija i akcijski plan za suzbijanje širenja oružja za masovno uništenje, URL: https://vlada.gov.hr/UserDocsImages//2016/Sjednice/Arhiva//71.%20-%206.pdf, (13.1.2022.).

2.1 Chemical hazards

Chemical segment consists of the chemical warfare agents and toxic industrial chemicals. Of all weapons of mass destruction, it is precisely this segment that provides a means that is sufficiently effective and can be obtained in the easiest manner. It is directly available, or it can be relatively easily manufactured in an improvised laboratory, and it represents the most probable terrorist weapon. Manufacture, hiding and transportation of smaller quantities of the chemical warfare agents are relatively easily achievable. It is known that in improvised laboratories certain terrorist groups managed to synthesize certain quantities of chemical warfare agents (most often nerve and blister agents), but they were of low quality and had a lot of impurities that significantly reduced effectiveness of their toxicity. The most famous example is of the Japanese cult *Aum Shinrikyo* that in the 1990s synthesized and carried out ten attacks in which they once used a choking agent fozgen, once the blood agent hydrogen cyanide, four times nerve agent sarin and four times VX.[35] Although it had certain deficiencies, as sarin was not sufficiently pure and the manner of its dissemination was not very efficient, the attack with sarin carried out in 1995 in the subway of Tokyo is considered to be the most successful terrorist attack that included use of the chemical warfare agents. Although there were only 13 fatalities, the number of people who suffered consequences of poisoning was over 1000.[36] In recent history, except confirmed use of the chemical warfare weapons on Iranian and Kurdish targets by Sadam Hussein and use in Syrian civil war, after terrorist attack with sarin that was carried out by a sect *Aum Shinrikyo,* there were no other large-scale attacks that included chemical weapons.[37] Most of the recent small-scale attacks were carried out in public places, in states without active conflicts, on targeted individuals with use of sophisticated new nerve agents of the fourth generation as *novichok*. The means that was mostly used in CBRN attacks on individuals were nerve agents (sarin, VX and novichok), but there were also examples of using radioactive isotopes (e.g., alpha emitter ^{210}Po), toxins (e.g., ricin) and other toxic chemicals (e.g., dioxin). However, simple chemical warfare agents of the first generation are still used, as chlorine which is a widely available toxic industrial chemical. In addition to chlorine, a relatively complex nerve agent of the third generation, sarin, was used in civil war in Syria.[38] Organisation for the Prohibition of Chemical Weapons, OPCW also confirmed that in 2017 ISIL, the *Islamic*

35 C. W. Hughes, Japan's Aum Shinrikyo, the Changing Nature of Terrorism, and the Post-Cold War Security Agenda, Global Change, Peace & Security **10** (1998) 39-60.

36 Chronology of Aum Shinrikyo's CBW Activities, Center for Nonproliferation Studies, Monterey Institute of International Studies, 2001, URL: https://www.nonproliferation.org/wp-content/uploads/2016/06/aum_chrn.pdf, (20.1.2022.).

37 J. Ballard, Reassessing chemical weapon threats, in F. Su and I. Anthony (ed.), Reassessing CBRN Threats in a Changing Global Environment, SIPRI, Stockholm, 2019, pp. 14-19.

38 S. Toprak, Trends in recent CBRN incidents, in F. Su and I. Anthony (ed.), Reassessing CBRN Threats in a Changing Global Environment, SIPRI, Stockholm, 2019, pp. 3-7.

State of Iraq and the Levant carried out attacks in Syria and also used sulfur mustard, a warfare agent of the second generation.[39]

A significant step forward in technology of the synthesis of the chemical warfare agents was made by development of microreactors that enable conduction of the chemical reactions that were very demanding or even impossible. Microreactors provide greater control of the pressure, temperature, and flow, thus reducing possible unwanted consequence like exothermal or explosive reactions. If terrorist groups come in possession of such microreactor, it would allow them an easy and undiscovered manufacture of the various toxic chemicals, precursors, and chemical warfare agents.[40] Table 1 contains a list of the most probable chemical warfare agents that could be used for a terrorist attack.

Table 1: List of some chemical warfare agents that are most suitable for terrorist use.[41], [42], [43]

Chemical warfare agent	Military designation
nerve	
sarin	GB
VX	VX
novichok	A
carbamates	EA
blister	
sulfur and nitrogen mustard	H, HD, HN
blood	
hydrogen cyanide	AC
carbon monoxide	-
choking	
chlorine	CL
ammonia	-
hydrogen chloride	-
phosgene	CG
incapacitating	
fentanyl	-
BZ	BZ
other potential warfare agents	
dioxins	-

39 Ref. 13

40 Ref. 11

41 J. Clancy, A. McVicar, Handbook of Chemical and Biological Warfare Warfare agents, 2nd ed., CRC Press, Boca Raton, pp. 3-492.

42 R. C. Gupta, Handbook of Toxicology of Chemical Warfare Warfare agents, 3rd ed., Academic Press, 2020, pp. 97-478.

43 T. C. C. Franca, D. A. S. Kitagawa, S. F. A. Cavalcante, J. A. V. da Silva, E. Nepovimova, K. Kuca, Novichoks: The Dangerous Fourth Generation of Chemical Weapons, Int. J. Mol. Sci. **20** (2019) 1222.

The main international document relating to the chemical segment of CBRN is *Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on their Destruction, Chemical Weapons Convention* (CWC). On 13 January 1993, under CWC Convention, agreement was reached about destruction of the chemical weapons and the Convention came into effect on 29 April 1997. Its implementation has been controlled by OPCW with seat in The Hague in the Netherlands. Over 96 % of the reported chemical weapons have been destroyed so far, and destruction of the remaining weapons is underway.[44] Most of the precursors from which chemical warfare agents are obtained have dual-use where they are used commercially in industry or for research. That provides their availability and conduction of the hidden synthesis of the chemical warfare agents. Therefore, CWC Convention contains three lists of chemicals that, beside chemical warfare agents and toxins, also contain precursors with aim to control their quantities. Example of the widely available chemical that is controlled because of the possible misuse is the fertilizer ammonium nitrate (NH_4NO_3) from which a very efficient bomb can be made. However, in practice, given that a large number of toxic industrial chemicals are freely available on the market and are in everyday use, it is not possible to completely control all the chemicals and precursors that could potentially be used for terrorist attacks.[45] CWC Convention was accepted by 193 states and the exceptions are Israel that signed the Convention but it has not ratified it and Northern Korea, Egypt and Southern Sudan that neither signed nor ratified the Convention.[46], [47] It is precisely because of these states that did not sign and/or ratify CWC Convention and consequently did not adjoin destruction of the chemical weapons that there is a possibility they possess the chemical weapons which can then be also available to terrorist groups. Moreover, it is questionable whether all the signatory states of the CWC Convention abide by this Convention and do not have secret programs in which they are improving the existing or developing new generations of chemical agents and weapons. Likewise, after World War I and World War II and during Cold War, large quantities of the chemical weapons (that mostly contain nerve agent sarin, GB or blister agent sulfur mustard, H and HD) have been left behind throughout the world, buried or thrown in lakes, sea, and ocean. Given that most often, these are easily accessible public places, these discarded chemical weapons, in addition to representing a real hazard for ecological system and people, also represent a potential threat if terrorist groups come in their possession.

44 Ref. 37

45 Ref. 13

46 Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on their Destruction, Technical Secretariat of the Organisation for Prohibition of Chemical Weapons, Hag, 1997.

47 Arms Control Association, Chemical Weapons Convention Signatories and States-Parties, URL: https://www.armscontrol.org/factsheets/cwcsig, (12.1.2022.).

2.2 Biological hazards

The main international document relating to biological segment of CBRN is the *Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction* (BTWC) that took effect on 26 March 1975. It was accepted by 183 states but BTWC Convention was neither signed nor ratified by the following ten states: Chad, Komori, Djibouti, Eritrea, Israel, Kiribati, Micronesia, Namibia, Southern Sudan and Tuvalu.[48], [49] As with CWC Convention, here it is also questionable whether all signatory states of the BTWC Convention abide by it and do not have secret programs in which existing pathogens are modified or capabilities of the new pathogens are explored. An example is SARS-CoV-2 virus for which it has not been yet clarified in what manner it has spread and caused a pandemic, whether it is a consequence of the natural vector transmission from animals to men or it is a result of the research (and modification) of this family of Corona virus and its accidental (or intentional) release. However, an investigation conducted by the World Health Organization (WHO) indicates that the potential source of the spread of the virus was the Wuhan Institute of Virology.

Biological segment of the CBRN represents a big challenge for its use so the number of cases where individuals or terrorist groups successfully used biological warfare agents is relatively small. For example, Japanese cult *Aum Shinrikyo* carried out seven unsuccessful attacks with biological agents (four with anthrax and three with botulin toxin). Fortunately, this was because of the reason that the biological agents were not virulent. It is known that members of this cult were also in Africa, in DR Congo (ex Republic Zaire) with objective to establish contacts with ill people and to come in possession of the Ebola virus. Again, fortunately, they did not succeed.[50] There is another example of the cult Rajneesh that in 1984 carried out attack with political intentions in the USA, in the city of Dalles, Oregon. They contaminated food and water supply system with Salmonella. Moreover, primarily in the USA, there were registered cases of letters that contained anthrax spores or powdery ricin and were sent mostly to politicians and government officials.

As in the case of the chemical agents, it is relatively simple to come into possession of the biological pathogens. Table 2 contains a list of biological warfare agents that would be the most suitable for terrorist attack. The simplicity of the manufacture and handling of the biological warfare agents is also enabled by commercial availability of the equipment and dual-use items. However, with potential use of the biological weapons, the main challenge is arming a biological warfare agent which is very complex.[51] The greatest

48 United Nations, Biological Weapons Convention, URL: https://www.un.org/disarmament/biological-weapons/, (12.1.2022.).

49 Arms Control Association, Biological Weapons Convention Signatories and States-Parties, URL: https://www.armscontrol.org/factsheets/bwcsig, (12.1.2022.).

50 Ref. 36

51 Ref. 14

challenge with explosive devices and various methods of dispersion is protection of the biological warfare agents so that they are not destroyed immediately or quickly during explosion or because of the environmental conditions.

Table 2: List of some of the high-mortality biological warfare agents that are most suitable for terrorist use.[52]

Bacteria	Toxins
Plague	Botulinum toxin – bacteria Tetanus toxin – bacteria Staphyilococcus enterotoxin B - bacteria Trychotecen - fungi Aflatoxin - fungi Anatoxin - algae Microcystin - algae Brevetoxin - algae Saxitoxin - algae Ricin - plants Abrin - plants Batrachotoxin - animals Palytoxin - animals Sneak venom - animals
Antrax	
Tularemia	
Diphtheria	
Q-fever (proteobacteria)	
Brucellosis	
Salmonella	
Dysentery	
Cholera	
Viruses	
Hemorrhagic fevers	
Corona viruses	
Rabies	
Adenoviruses	

Of all categories of the biological warfare agents, the most probable means of terrorist use is currently represented by toxins. Toxins are widely available in nature and can be easily obtained by simple extraction from various plants and animals. It is known that terrorist groups possess various "cookbooks" and video instructions and have knowledge on how to obtain and use toxins. The most famous is the case of the toxin ricin that is obtained from seeds of the plant Ricinus (Lat. *Ricinus communis*).[53] The most famous cases are the one from USA where letters containing ricin arrived to Pentagon, and the case from Federal Republic of Germany where construction of the explosive device with ricin was stopped in the last minute.

However, to come in possession of one of the "worst" pathogens is not easy and simple, as it is not simple to handle and use genetic engineering over certain pathogens because they require special equipment and laboratories, with special conditions of work or rather conditions of the biosafety level 3 and 4 (BSL-3 and BSL-4) and require highly professional scientists. Of the recent biotechnologies, the greatest potential concern is presented by CRISPR technology. Its full name is CRISPR-Cas9 (*Clustered Regularly Interspaced Short Palindromic Repeats*) technology, and this is a method of manipulation genetic material that changes parts of the DNA. This method was developed during the 1980s and 1990s and was introduced in wider (commercial) use as late as in 2012. Nowadays, CRISPR is a very efficient, affordable, and relatively cheap biotechnology for

52 S. Bokan, A. Čižmek, B. Ilijaš, I. Jukić, Z. Orehovec, Ž. Radalj, Oružja za masovno uništavanje: nuklearno-kemijsko-biološko i toksinsko oružje, Pučko otvoreno učilište Zagreb, Zagreb, 2004, pp. 695-966.

53 Ref. 12

implementation of the genetic engineering with all organisms (microorganisms, plants, animals, human beings) and consequently with bacteria and viruses. This allows terrorists to create modified versions of bacteria and viruses that can lead to a potentially very destructive epidemics or pandemics. The virus of Smallpox (Lat. *Variola major*) is an example and although it was eradicated in late 1970s and nowadays it is only stored in some laboratories, it is possible to carry out genetic engineering over similar animal versions of the virus and, in this process, it is possible to create new pathogens similar to Smallpox.[54] However, CRISPR technology also has its restrictions in the form of unwanted mutations that could lead to unpredictable consequences, particularly when dealing with modifications of the viruses and bacteria.[55] In addition to the stated, expansion of the unknown and new biological pathogens, as it is visible from the current COVID-19 pandemics, is still not predictive and it is not possible to control it, thus putting potential attackers at risk and questioning their final goals. However, current capabilities of the terrorist groups (at least for the time being) do not allow this option. Regardless that this type of the CBRN threat is presently (still) not actual, it must be taken into account that an ever-increasing availability of knowledge and technologies from the field of biotechnology will become a serious security problem very soon.[56]

2.3 Radiological and nuclear hazards

Prevalence and use of the nuclear and radioactive material for peacetime purposes has been growing throughout the world. It is anticipated that the biggest rise of the use of nuclear energy will be in the states that do not have a long, even no history of the use of nuclear energy. Those states also have a limited or no knowledge and experience in storing and safekeeping of the nuclear material. Additional problem is also posed by the fact that some of those states are placed in politically and security-unstable regions. The stated raises a question of potential loss or theft, because without implementation of the adequate security measures such material can become a relatively easy target to terrorists.[57] Besides radiological and nuclear material, nuclear reactors represent potential targets or rather means to obtain benefit or to accomplish an objective through cyber-attacks, sabotage or other forms of attack that include terrorist and military attacks. Examples are attacks and seizing of the nuclear plants, warehouses that contain nuclear waste and nuclear research institutions in Ukraine. These attacks and seizing didn't have negative consequences in the form of dissemination of radiological contamination but were used to realize strategic goals. Such attacks are not a novelty. Since the 1960s attacks have been made on facilities with nuclear reactors (research and commercial),

54 Ref. 52

55 X. Chen, M. A. F. V. Gonçalves, DNA, RNA, and Protein Tools for Editing the Genetic Information in Human Cells, iScience 6 (2018) 247-263.

56 Ref. 11

57 Ref. 14

with objective to cause damage or to destroy them. These attacks were carried out by state and non-state actors, and they included sabotage by internal elements, cyber and kinetic attacks.[58] Despite many multilateral efforts during the past several decades, there are still no formal legal frameworks that would ban attacks on operational and non-operational nuclear plants. However, *International Atomic Energy Agency* (IAEA) through implementation of the meetings, conferences, and summits on the topic of nuclear and radiological security and terrorism, foster efforts of capability development and raising the level of security.

Various terrorist groups showed interest in using radioactive and nuclear material to cause mass casualties and to disrupt global order and economy. Successful terrorist attack that would include nuclear or radioactive material could potentially destabilize not only a city in which such attack would be made, but an entire state and could affect the global economic system. With aim to cause damage, the most destructive terrorist attack would be most certainly caused using nuclear weapons. However, the risk from such attacks is exceptionally low given that there are very good security mechanisms of protecting such weapons. The probability of a terrorist attack in which radiological materials would be used is far bigger as terrorists can come considerably easily into possession of such materials (hospitals, scientific and educational institutions, industry), and manufacture of such weapons ("dirty bombs") is relatively simple. As regards nuclear power plants and their security, after terrorist attacks on 11 September 2001 in the USA, a possibility of a terrorist attack on them using big airplanes was also considered. However, an assessment showed that with a big airplane it would be very difficult to precisely aim the most critical facility of a nuclear power plant where a reactor is placed which is low in height and small in size.[59] Greater probability for successful attack would be by using Unmanned Aerial Vehicle (UAV) and this will be explained in detail later. In addition to stated physical forms of possible attacks, a risk is also posed by previously mentioned potential cyber-attack on a nuclear power plant. Apart from nuclear power plants, a question is also raised about security of the warehouses with highly radioactive material (used reactor fuel). In this case, beside theft, great security risk is also posed by attack with explosive that could cause possible wide scale dissemination of radioactive contamination.

The main international documents relating to a nuclear segment are *Nuclear Non-proliferation Treaty* (NPT) and *Convention on the Physical Protection of Nuclear Material* (CPPNM). NPT Treaty came into effect on 5 March 1970, and it is the only multilateral treaty aimed to create the obligation to disarm states that possess nuclear weapons. This treaty attempts to foster peacetime use of the nuclear technology and to prevent proliferation of the nuclear weapons and of the technology of nuclear weapons manufacture. Its implementation is controlled by IAEA with seat in Vienna in the Republic of

58 William Potter, The fallout from Russia's attack on Ukrainian nuclear facilities, URL: https://warontherocks.com/2022/03/fallout-from-russias-attack-on-ukrainian-nuclear-facilities-military-environmental-legal-and-normative/, (11.3.2022.).

59 Ref. 14

Austria.[60] CPPNM Convention that came into force on 8 February 1987 and its Amendment came into force on 8 May 2016 have made the signatory states legally binding to protect nuclear facilities and materials for peacetime use, their storage and transportation. This Convention and its Amendment also ensure cooperation among signatory states with respect to implementation of the rapid measures for discovery, location, and recovery of the stolen or smuggled nuclear material, response, and mitigation of all radiological consequences of a sabotage and prevention and combatting crimes connected with them. CPPNM and its Amendment represent an important segment of the global efforts in combatting nuclear terrorism.[61] Likewise, *Global Initiative to Combat Nuclear Terrorism* (GICNT) was launched in 2006 by the USA and Russia in order to develop capabilities and to prevent nuclear terrorism through improvement of the:[62]

1. Control of nuclear materials,
2. Security of the civilian nuclear facilities,
3. Discovery of illegal trade with nuclear materials,
4. Strengthening of the legal frameworks for processing acts of the nuclear terrorism,
5. Upgrading the capability for reaction on acts of nuclear terrorism,
6. Mitigation of the consequences and implementation of the investigation (nuclear forensics).

In practice, in 1995, IAEA established a system *Incident and Trafficking Database* (ITDB) with a purpose of recording incidents that include illegal trade with nuclear materials and other radioactive sources (natural and artificially manufactured radioisotopes and radioactive contaminated material as waste metal). Since the year 1993 almost 4000 cases that included theft, loss of control, unauthorized possession or illegal trade with nuclear and other radioactive materials have been recorded so far.[63] Although not even one successfully carried out radiological or nuclear terrorist attack has been reported, as stated before, cases are known of disappearance (theft) of the radioactive or nuclear material. These materials will most certainly appear somewhere in foreseeable future, with great possibility and probability of terrorist use.[64] There are numerous radioactive isotopes that have relatively high values of half-life times (the time necessary for an isotope's activity to be reduced to one-half), and that are used for commercial, educational or research purposes. Also, many detectors and instruments that use new technologies contain a certain radioactive isotope that has a relatively high half-life time value. Table 3 contains radioactive isotopes of some of the elements that are, in most cases,

60 Arms Control Association, Nuclear Nonproliferation Treaty (NPT), URL: https://www.armscontrol.org/treaties/nuclear-nonproliferation-treaty, (11.1.2022).

61 International Atomic Energy Agency, Convention on the Physical Protection of Nuclear Material (CPPNM) and its Amendment, URL: https://www.iaea.org/publications/documents/conventions/convention-physical-protection-nuclear-material-and-its-amendment, (11.1.2022.).

62 Arms Control Association, The Global Initiative to Combat Nuclear Terrorism, URL: https://www.armscontrol.org/specialprojects/nnpm/GICNT, (13.1.2022.).

63 International Atomic Energy Agency, Incident and Trafficking Database, URL: https://www.iaea.org/resources/databases/itdb, (13.1.2022.).

64 Ref. 14

relatively easily available and represent an ideal choice for manufacture of the radiological weapons ("dirty bombs"). These isotopes even after many years of being safe kept (after theft) still have high or almost the same activity. There are also other radioactive isotopes that are largely used in medicine, industry and for scientific research. However, their half-life times are very short (several hours to several days), and this does not make them suitable candidates for terrorist use because they would have to be used immediately and would have a very short time of effectiveness.

Table 3: List of some of radioactive isotopes that are the most suitable for terrorist use.[65], [66], [67]

Element	Isotope	Type of radiation	Half-life (years)	Commercial application
Cobalt	^{60}Co	β, γ	5,27	medicine, sterilization, industry, research
Strontium	^{90}Sr	β	29,12	industrial instruments, medicine
Cesium	^{137}Cs	β	30	medicine, detector calibration, industry
Nickel	^{63}Ni	β	96	detectors
Americium	^{241}Am	α	432	smoke detectors, instruments
Radium	^{226}Ra	α, γ	1600	measuring instruments, industry
Technetium	^{99}Tc	β	213000	industry
Plutonium	^{239}Pu	α, γ	24110	fission material: nuclear reactors and nuclear weapons
Uranium	^{235}U ^{238}U		$7{,}1 \cdot 10^{8}$ $4{,}5 \cdot 10^{9}$	
Thorium	^{232}Th	α	$14{,}05 \cdot 10^{9}$	aircraft and missile parts (Mg-THz alloys)

2.4. Other new technologies

3D printers can produce almost any product by using material as plastics, metals, ceramics, glass, carbon fibers and other. This technology also makes possible manufacture of the products that consist of several layers made of various materials. As the quality of 3D printing expands and technology is becoming increasingly available, the risk of efficient malicious use of this technology will probably be greater.[68] Since even very sophisticated and industrial 3D printers are commercially available, it is possible to manufacture target products quickly, cheaply, easily, and undetected. 3D printers can be used even by technological laymen since free manuals with detailed instructions can be found on Internet. Theoretically, with good knowledge of the 3D modeling this technology could be possibly used to manufacture detonators for explosives which could be used for making

65 C. Grupen, Introduction to Radiation Protection: Practical Knowledge for Handling Radioactive Sources, Springer, 2010, pp. 323-325.

66 J. M. Chesnutt, Defeating the United States with Radiological Weapons in Fourth Generation Warfare, Air Command and Staff College, 2003, pp. 1-51.

67 Iowa Department of Public Health: Bureau of Radiological Health, Major Uses of Radioisotopes, URL: https://idph.iowa.gov/Portals/1/userfiles/124/MajorUsesofRadioisotopes_IDPH_Rad_Health.pdf, (19.1.2022.).

68 Ref. 24

improvised explosive devices as "dirty bombs" (*Radiological Dispersal Device*, RDD), to manufacture small arms, parts of the rocket, various parts of the (micro)reactors for manufacture of toxic chemicals, precursors and chemical warfare agents, parts of the bioreactors for cultivation of microorganisms and similar products. Knowledge of the 3D modeling is not even a limiting factor since modeling can also be done by using artificial intelligence (AI) with generative design technique. This will become even easier with announced imminent introduction of the commercial quantum computers. Likewise, 3D printers will also enable terrorists to obtain nanotechnologies for manufacture of the various sensors and electronics. The example are Micro Electro-Mechanical Systems (MEMS) and Nano Electro-Mechanical Systems (NEMS) that contain mechanical, electrical and/or magnetic parts integrated on a microchip and serve for activation of particular systems and components respectively.[69]

Unmanned Aerial Vehicles (UAVs) have also been commercially available for a long time. UAVs are a potential means that can be misused in order to carry out terrorist attacks, as well as those that include CBRN agents.[70] The best example is incident (of the accidental?) crash of a relatively big military reconnaissance drone in Zagreb on 10 March 2022. Its intended purpose has not been officially confirmed yet but from all appearances, this drone did not have malicious intentions towards the Republic of Croatia. This event showed that such aircraft was able to fly unnoticed over several NATO member states and reach its objective, and that constitutes a big security oversight and problem. Of the four main categories of the UAVs that are used for terrorist purposes, the most available and suitable are mini-UAV aircrafts of the dimension between 50 centimeters and 2 meters. Technical capabilities of mini-UAVs include flight altitude of up to 300 meters, flight duration of up to two hours and capability of remote control from a distance of up to 10 kilometers. In addition to their task of gathering information, the main aspect of the CBRN terrorist use of the UAVs is possible use as a means for dispersing CBRN agents, use for their delivery to the target, use as a "dirty bomb", as well as for the purpose of delivery and activation of the explosive device on a target facility (chemical and nuclear plants, biological laboratories), where explosion could cause physical damage and release of the contamination.[71], [72] Use of the *"killer drones"* was confirmed during Syrian civil war that began in 2011 in which ISIS used small commercial drones armed with bombshells.[73] It is well known that terrorist groups have already taken in consideration use of the UAVs for CBRN attacks as well, yet not a single successful attempt has been recorded so far. Some of the examples that point to problematic aspects of this technology, as to security threats, are also uncontrolled overflights of the UAVs (drones) with unknown intention above nuclear power plants in France and in the USA. Given

69 Ref. 11

70 Ref. 11

71 D. Sathyamoorthy, A review of security threats of unmanned aerial vehicles and mitigation steps, The Journal of Defence and Security 6 (2015) 81-97.

72 A. Solodov, A. Williams, S. Al Hanaei, B. Goddard, Analyzing the threat of unmanned aerial vehicles (UAV) to nuclear facilities, Security Journal 31 (2018) 305-324.

73 Ref. 24

that UAVs can very easily bypass traditional security mechanisms, attention has recently been widely oriented towards establishing and introducing protection measures against them over critical facilities or areas.

There are many other new technologies that can cause security threats, but they are still in the phase of research and development. If and when they will be released in commercial use, a possibility of their misuse for CBRN terrorist purposes will also have to be taken in consideration.

CONCLUSION

The shaping of the present and future security environment is significantly affected by factors as political, ecological, demographic, geographic, globalized economy, permanent rise of the needs for resources, as well as development and availability of new technologies. Accelerated development and introducing new technologies that also significantly affect CBRN area surely question former assessments of the CBRN risk and probability of the CBRN terrorist and military attacks. New technologies have changed all aspects of life and besides becoming a means of the potential CBRN threat they are also of key importance for implementation of the prevention, detection, and response to the same CBRN threats. The existing equipment and capabilities of the CBRN defense (protection, detection and identification, decontamination) perhaps meet requirements of the current situation, however, introduction of the new (publicly available) technologies opens a whole series of new possible terrorist (and military) threats where the existing equipment will probably not be sufficiently efficient. However, development of the new or upgraded existing technologies of the CBRN defense equipment also has its challenges like providing funds for the research and development that may have uncertain result of the research and questionable possibility of practical use of the newly developed technology, as well as challenges during introduction of the new technologies in operational use. Notwithstanding the stated challenges regarding CBRN defense, it is necessary to be “a step ahead of the time” by keeping up with the most recent scientific research, by introduction of new equipment in use and by continuously adapting to the most recent (or improved existing) technologies to meet the demands of the most recent and anticipated CBRN threats.

LIST OF ABBREVIATIONS

AI	Artificial Intelligence
BSL	BioSafety Level
BTWC	Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction
CBRN	Chemical, Biological, Radiological and Nuclear
CPPNM	Convention on the Physical Protection of Nuclear Material
CRISPR	Clustered Regularly Interspaced Short Palindromic Repeats
CWC	Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on their Destruction, Chemical Weapons Convention
EU	European Union
GICNT	Global Initiative to Combat Nuclear Terrorism
IAEA	International Atomic Energy Agency
ISIL	Islamic State of Iraq and the Levant
ITDB	Incident and Trafficking Database
MEMS	Micro Electro-Mechanical Systems
NATO	North Atlantic Treaty Organization
NEMS	Nano Electro-Mechanical Systems
NPT	Nuclear Nonproliferation Treaty
WHO	World Health Organization
WMD	Weapons of Mass Destruction
OPCW	Organization for the Prohibition of Chemical Weapons
RDD	Radiological Dispersal Device
SWOT	Strength, Weakness, Opportunity, and Threat
TIC	Toxic Industrial Chemicals
UAV	Unmanned Aerial Vehicles
UN	United Nations

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