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The "Evolution" of Improvised Explosive Devices (IED) in the Light of Technical Development

In today's conflicts of war, the various bombings, which are perpetrated against military or civilian targets, have been directed against members of the regular armies considered to be "occupying", as well as against the locals who collaborated with them or assisted them. In the military, such acts are mentioned as an element of asymmetric warfare, and on various interpretations, they are sometimes classified as a terrorist acts. In case of "peaceful" countries, it can only be interpreted according to the latter concept, which can be aimed at a specific person, political orientation, intimidation, revenge or other criminal activity. The explosive devices used fall into the so-called "home-made" category in terms of their design. The assassin's primary purpose is to achieve a devastating effect. In this article I deal primarily with improvised explosive devices appearing in so-called "civilian" life.

Keywords: *improvised explosive devices, IED trigger, imitations*

1. Introduction

To define the IED[2] concept, I use the definition in military terminology, which summarises well the characteristics of explosive devices for criminal purposes.[3] Based on this, improvised explosive devices are any device that is "home-made" for a specific criminal purpose and that contains a chemical, pyrotechnic or explosive substance, and is suitable for achieving the

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[2] Improvised Explosive Device.

[3] Zoltán Kovács, 'Az improvizált robbanóeszközök főbb típusai' [Main types of the improvised explosive devices], *Műszaki Katonai Közlöny* 22, no 2 (2012), 37–52.

desired destructive effect. The definition allows, in addition to the use of purely home-made structures, the partial use of munitions supplemented by a separate actuator.[4]

The Hungarian word *hell machine* (pokolgép) can rightly be considered synonymous with IED, as the Hungarian Interpretive Dictionary puts it this way: "A hidden explosive device made and used mainly by assassins, terrorists; delayed-action bombs or externally operated (camouflaged) bombs." From a technical point of view, the definition may be a little inaccurate, but it contains the essence and is very similar to the wording of an improvised explosive device.

Examining the development of IEDs, it can be concluded that following the development of explosives, they appeared after a relatively short time. The legend about the first application of this kind, mentioned during the Jin Dynasty, explains the method of a certain fox hunter named Iron Li, in which the hard cover (porcelain) already appears, specifically to increase the effectiveness of the attack.[5] Throughout history, they have been repeatedly reported, typically during bombings against rulers.

The first versions, also called technically modern, appeared in World War II. Subsequently, various terrorist organisations began to use it efficiently because of its adequate effectiveness to achieve their own goals. In most cases, bombings were carried out against the occupying military forces or under the influence of the ruling political power or government in their country.

In the context of terrorist organisations, we must not forget the sharing of experience resulting from their international relations, which has taken the form primarily of training activities or even specific assassinations.

2. IED principle structure

In terms of the general construction of improvised explosive devices, they, in any case, contain some type of explosive or pyrotechnic mixture and a component capable of initiating it that may be mechanical, electrical or chemical in function. In many cases, in order to increase the destructive effect, various fragmentation materials are placed next to the explosive and, due to the correct concealment or even deception, are provided with the most varied coatings.

The following figure shows a schematic drawing of an electrically operated IED illustrating the main units: I. Charge; II. Trigger unit; III. Power source.

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[4] Zoltán Kovács, 'Explosion of Improvised Explosive Device Effects on Structures', *Hadmérnök* 11, no 1 (2016), 56–63.

[5] Tonio Andrade, *The Gunpowder Age: China, Military Innovation, and the Rise of the West in World History* (Princeton: Princeton University Press, 2016).

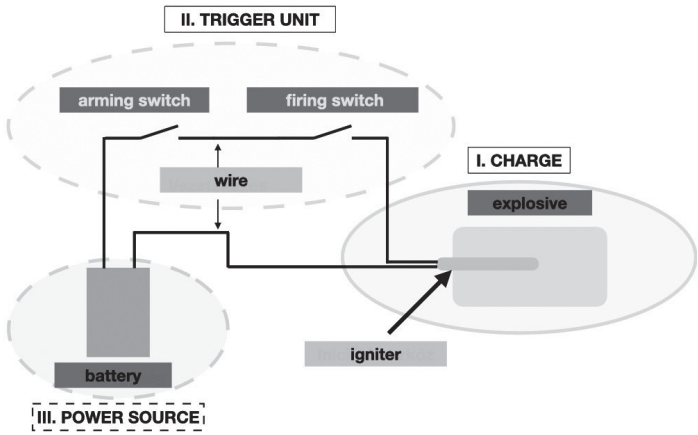

Figure 1: Schematic structure of an electrically operated IED
Source: Compiled by the author based on United Nations Mine Action Service, Improvised Explosive Device Lexicon, 4.

By analysing and classifying the main units separately, we can define certain categories primarily in relation to their operation.

1. Charge

Unlike in war zones, the actual homework is dominated by the explosives used in the IED in normal civilian life, as access to military explosives, structures and agents is more difficult. Occasionally, however, a standard military explosive is used in the perpetration, usually associated with organised criminal circles. In today's wars, local terrorist organisations prefer to use high-powered military explosives packaged from UXO.[6] In case of Hungary, this "acquisition" of modern military explosives can only be linked to the recent South Slavic wars, but the air bombs and artillery shells that did not explode in World War II could still be an opportunity.

Among the home-made explosives, I would highlight the TATP[7] called "Satan's Mother" in the international literature. It is an extremely unstable, sensitive, and therefore dangerous substance, and many of their experimenters are still damaged during production or transport. It is preferred for use in civilian areas primarily for assassination of filament of persons due to its easy initiation. A small light bulb or an electrical spark generated by a separate circuit may be sufficient to induce detonation. The size of the charge may vary depending on the target of the assassination and the experience of the bomb maker, but due to the mechanism of the explosion, it is quite difficult to accurately calculate the extent of the destruction in advance. In "civilian" life, black powder is typically used as a charge for tube bombs, which is popular for its relatively easy availability and production.

6 Unexploded ordnance.
7 Triacetone triperoxide.

2. Trigger unit

The main task of the launching or actuating part is to initiate the detonation of the explosive. The installer of the hell machine at the destination is protected by a so-called arming switch, which prevents accidental operation, after which the charge explodes due to the control signal. Improvised explosive devices can be categorised based on the mechanism of action of the trigger unit.

There is a long way to go from the initial Chinese, so-called "drum" explosive devices, to the advent of technical advances in electronic devices controlled by electronic devices, which are in many cases nowadays used in our everyday devices.

With the spread of semiconductor technology, unlike the single-switch start-up methods, the design of control circuits has expanded with additional possibilities, and on the one hand, there has been a significant reduction in terms of size. As semiconductor components continue to evolve and their integrity increases, operational variations provide new ways of activating sinful structures. Microcontrollers are emerging that further reduce the number of additional components and allow for more complex and accurate start-up solutions. The preparation, qualification and, finally, the practice of the creator of the IED can determine the complexity and technical structure of the completed hell machine. The availability of parts and raw materials in the given environment greatly contributes to this process.[8]

The following figure describes a possible grouping method, of which I primarily examine the basic operation of electronic devices.

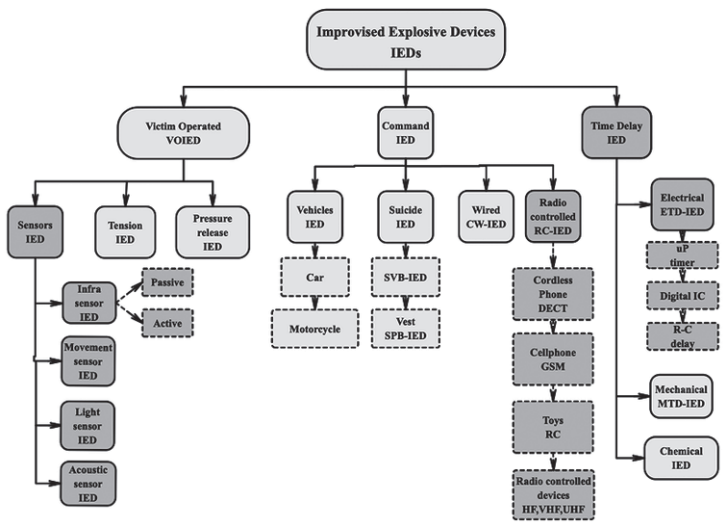

Figure 2: Grouping of IEDs according to their operation

Source: Compiled by the author based on United Nations Mine Action Service, Improvised Explosive Device Lexicon, 20–22.

[8] Norbert Daruka, 'Bombers, Wires and Explosives Part I. – Death Within a Reach', *Műszaki Katonai Közlöny* 23, no 2 (2003), 73–80.

Electrical equipment is required to operate the devices marked in dark grey, and the type of electronic circuitry determines the actual effect from which the IED explodes.

The first column of the triple articulation shows the IED solutions with different sensors, the middle column shows the devices suitable for the implementation of devices controlled directly by the perpetrator, and the last part shows the designs suitable for the implementation of blasts performed at a pre-set time.

2.1. Sensors

Typically, sensors may be those that can generate a trigger signal in the immediate vicinity of the victim or target. Examples are passive or active infrared sensors, which are usually activated by motion, various light sensors (operating in the visible and invisible range), motion and sound sensors. The ones just listed come into play primarily for the presence of the victim, under its direct influence. In war zones, thanks to C–IED[9] activity, structural solutions directly against deactivating bomb disposal, such as hell machines "equipped" with X-ray or radiofrequency detectors, have become more prevalent. Due to the integration of sensor technology, increasingly reliable controls can be assembled, and the available documentation guarantees the construction of fault-free circuits even for the less qualified manufacturer.

2.2. Remotely controlled

From the named category, I primarily describe the so-called wireless boot modes. Of these, I typically highlight radio frequency controls as the most widely used methods. Remote controls based on optical connections, such as devices for remote control of various infrared games or the TV itself, can also be included in the remote-control category. However, it is not widespread among improvised explosive devices, probably due to the range of IR control, which can bridge optical vision and a maximum distance of a few 10 m as a condition for proper operation. Nevertheless, it should not be overlooked as a possible solution.

All equipment based on radio frequency communication may be part of the starter unit. Walkie-talkies in the VHF[10] and UHF[11] ranges are the same as cordless desk phones (DECT[12]), doorbells or garage door openers, and car alarms. Remotely controlled relay panels have been introduced, guaranteeing ready-made start-up solutions.

Public networks (macro environment of mobile phone system) should be mentioned in connection with the design of the remote boot. Their deployment, the implementation of coverage, the technologies used, the ability to access the network as subscriber rules greatly influence the use of the mobile network to launch IEDs. The mode of launch implemented in this way makes it possible to carry out an assassination even monitored and carried out via the Internet.

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9 Counter-Improvised Explosive Device.
10 Very high frequency (30–300MHz).
11 Ultra-high frequency (300MHz – 3GHz).
12 Digital Enhanced Cordless Telephony.

2.3. Timed

Of the triggers described above, the time delay can be considered the "most inaccurate" execution in some respects because adequate proximity to the target is required at the moment of detonation to achieve the desired goal. According to the embodiment, the timing circuit can be of various designs, from the analogue solved with simpler so-called short-delay R-C members to the long-term versions assembled with counters known from digital technology or implemented with microcontrollers used today. Here we can talk about days, maybe weeks or even months in terms of the planned start time. I would also like to mention the possibilities offered by everyday objects, such as the use of digital alarm clocks, timers for household appliances or even the start-up signal generated by the alarm function of a mobile phone, supplemented with some components, to operate an improvised explosive device.[13]

3. Power source

For an electrically operated IED, electricity is provided by the power supply. It can be any solution, from a grid-connected version to equipment with different electrical charge storage capacities. The most important criterion for power supplies is adequate energy storage capacity, from arming the IED to delivering the pulse required for initialisation. The components used may be:

3.1. Batteries

From standard batteries in vehicles to industrial or household versions, all types are available, depending on local conditions. In many cases, the variety used is determined by the nature of the intended use, its ability to hide, and its ability to retain its charge.

3.2. Cells

Normal dry cells can be of the semi-permanent or permanent type, connected in series or in parallel depending on the terminal voltage. Thanks to the latest developments, lithium and silver-oxide have emerged as a capacity storage material, resulting in batteries or long-life variant with much higher capacity.

During World War II, a device called the electric stakes (Elcö[14]) was developed and systematised in the Hungarian army for the technical closing battle. The interesting thing about this electric – ball-star-spring – igniter is that it operated on a 1.45 V terminal voltage dry cell and already had an arming system (short-circuit wire).[15]

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[13] Norbert Daruka, 'Bombers, Wires and Explosives Part II. – Death Arrives With Us', *Műszaki Katonai Közlöny* 23, no 2 (2013), 64–72.

[14] ELCÖ – Elektromos cövek.

[15] Elemér Damó, 'Utász harctéri tapasztalatok' [A sapper's battlefield experiences], *Műszaki Katonai Közlöny* 18, no 1–4 (2008), 207–208.

3.3. High-capacity capacitors

Due to the retention time of the electric charge, the possibility of using the capacitors alone is rather limited. In World War II, however, the Germans already used air bombs based on this principle, and so did the Hungarians (El. AZ-50-5, 36M, 40M).[16] To provide the electrical power required for an IED, the extra-large capacities used in photographic technology today could be considered for application.

3.4. Inductive devices

A common feature of induction igniters is that some kinetic energy, possibly a movement, is required to produce electricity. In World War II, some of the opposing parties used magnetic induction igniters in air bombs (38M, AV-524M, e. AZ-66).[17] These structures based on flux change have retained their functionality to this day, as the "aging" of the ferromagnetic materials in them is a rather long process.

In the case of IEDs used in civilian areas, it is not a preferred technique due to the complexity of the system, but its home-made nature does not preclude its appearance.

4. Fracture-enhancing "effect enhancer"

The appearance of fragmentation material in improvised explosive devices can occur and is highly dependent on the intent, preparedness and manner of achieving the intended effect. In many cases, in the vicinity of the target, the environment of the horsepower attachment itself provides the debris, for example on the chassis of vehicles, under the driver's seat or in its headrest.

5. Cover

In many cases, the outer casing helps to hide the device and adapts to the intended environment of the blast. If necessary, it is only used to hold the component parts together.

Their design may need to be more sophisticated due to the possibility of placement, as the lack of pavements in a war zone, the location of debris on the street, ruins, ruined buildings all help to hide the IED.

In connection with camouflage, I would mention a young man who became famous as a "ketchup" explosive in 1996 for his improvised device, which he placed in a bottle of the product in a shop in Esztergom. Luckily, the hell machine did not explode because there was something wrong with the operator's circuit, after which it was disarmed by bomb technician arriving at the scene.[18]

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[16] András Hatala and Ferenc Kelemen, *Jegyzet a katonai robbanótestek szerkezetének és működésének megismeréséhez és megértéséhez* [Teaching Aid for Cogniting and Understanding the Characteristics and Operation of Military Explosive Devices] (Budapest: Vitaliq, 2003), 144–150.

[17] Ibid. 152–153.

[18] Katalin Kiss V, 'Személyiségzavarban' [In personality disorder], *Hetek,* 11 July 1998.

3. The impact of terrorist organisations on development

For European countries, the most significant role is played by the IRA[19] which in its active period from 1970 to 2005 was attributed to a total of 19,000 improvised explosive devices. They began using long-delayed start-up methods, a method introduced at the Grand Hotel in Brighton, which was put into operation with a 3-week timing against the British Prime Minister. The interesting thing about the structure was that a timer unit for a video recorder was used to set the time of the explosion. One of the main strategies of the terrorist organisation was to injure or kill as few innocent civilians and its own people as possible during the attacks. Therefore, the most accurate modes of operation possible were used, such as remote-controlled or various electronic devices. They first introduced the mobile phone startup method, which they later gave up because they considered it unreliable. The IRA was instrumental in the tactical development of blasting and then shared their experience gained with several terrorist organisations (ETA,[20] PLO,[21] FARC[22]) as part of training. As a result, IED structural designs previously used by the IRA, such as the detonation triggered by a flash circuit, were blown up in 2005 in Basra against British soldiers. It began using ammonium nitrate-based explosives in the early 1990s, which was later used regularly by al-Qaeda in the Middle East wars.[23]

IEDs applied on the battlefields in Iraq and then in Afghanistan have had a direct and indirect impact on development. In addition to simpler designs, usually mechanically operated, various electronically controlled hell machines have become increasingly common. The kind of dynamic interaction between emerging versions of improvised explosive devices and the tactical elements developed for them is well observed in war zones. In this process following the principles of the action-reaction, the structural designs were in many cases constructed taking into account the currently used bomb technician activity. To eliminate jammers used as part of the disarming method, remotely controlled IEDs began to be transformed, resulting in the appearance of spiders. The receiver of the RC-IED[24] was placed further away from the explosive device, usually with a wired solution (some 10 m apart). This "pull-out" ensured the hell machine that the jamming equipment operated by the disarming technician could not prevent the explosion.

Arming switches have also been introduced for simpler electric start-up devices to prevent accidental operation, and this function has typically been implemented in remote-controlled IEDs with DTMF[25] coding, as this technique has been available for analogue hand-held radios.

Significant changes have also taken place in the production of explosives for IEDs, with virtually complete small plants operating to ensure series production. With the defeat of ISIS,[26]

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19 Irish Republican Army.
20 Euskadi ta Askatasuna.
21 Palestine Liberation Organization.
22 Fuerzas Armadas Revolucionarias de Colombia.
23 Andy Oppenheimer, 'IRA Technology', *The Counter Terrorist,* 08 September 2009.
24 Radio Controlled IED.
25 Dual-tone multi-frequency signalling.
26 Islamic State in Iraq and al-Sham.

we can see in reports how "roadside bombs" were used to manufacture explosive devices against military vehicles and convoys in Mosul. For example, a room that used to be a car repair shop has been converted into a plant, and the equipment used for production: scales, grinder, concrete mixer, barrels, bags prove the conditions under which the fertilizer-based explosive was produced.[27]

4. The impact of the Internet on development

With the proliferation of the social network, the exchange of experiences between the terrorist organisations described above is on a larger scale than the available wiring diagrams, functional demonstrations, descriptions of improvised initiators and explosives and, where appropriate, video footage of real assassinations.

In addition to the ability to train extremist groups, there is an additional danger in this type of "knowledge sharing" that provides so-called solitary offenders with IED production methods.

From the 2000s onwards, so-called terrorist sites appeared on the Internet, followed by video-sharing interfaces. In the next section, I use an online application to illustrate the statistical distribution of the words searched for the given term in terms of their proportions.

Based on Google Trends – search statistics broken down by date range (1 January 2008 – 23 October 2008, 100% by region, IED for YouTube channel).

Specifically, a search for the term IED revealed the following values for that time period, broken down by time in Figure 3 and broken down by region in Figure 4.

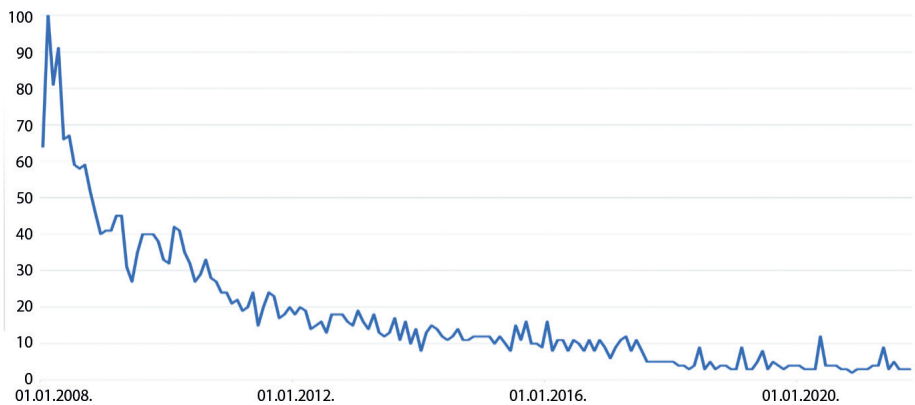

Figure 3: Number of searches by time according to Google Trends – search statistics from 1 January 2008 to 23 October 2021

Source: Google Trends, 23 October 2021.

[27] Ayub N Rudaw, 'The lurking menace of ISIS – How does ISIS make its bombs', *YouTube,* 17 November 2016.

The time scale showed the maximum number of searches for IEDs in its initial phase, which was probably related to war activities when read in conjunction with the following statement.

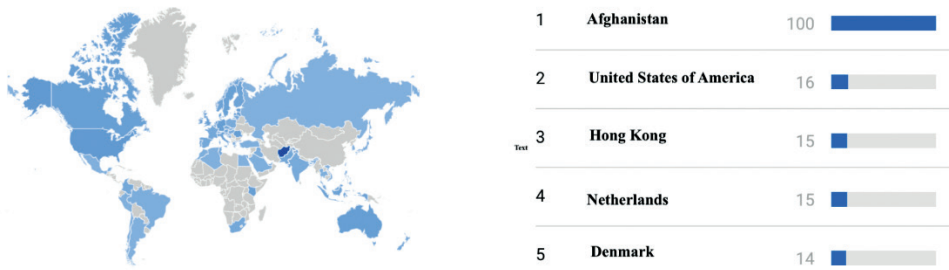

Figure 4: Number of searches by region according to Google Trends – search statistics from 1 January 2008 to 23 October 2021
Source: Google Trends, 23 October 2021.

The aggregation by area of interest is a good illustration of the fact that it was Afghanistan where most of the searches on improvised explosive devices were launched.

According to search statistics, Hungary ranks 36th with a value of 5%.

In the next section, a few thoughts on the content of videos viewed on the open video sharing portal that search for the concept of IED Trigger. The demonstrations are typically performed by a very experienced DIY,[28] in many cases describing the wiring diagram of the circuit, in some cases even adds descriptions. Separate examples are of the construction of light bulbs (Ni Cr wire), the design of the choke (duct tape, rope), the batteries used (Lion, Ni Cd) and the wiring itself.

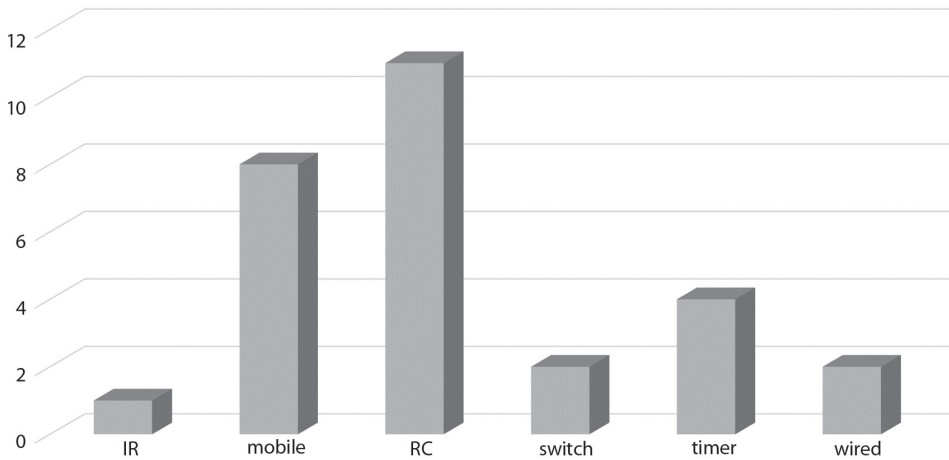

Figure 5: Trigger IED type/YouTube videos
Source: Compiled by the author.

[28] Do It Yourself.

In some places, the comments associated with the videos indicate that an attempt was made to build the structure after viewing it, but some details were not shown step-by-step, so it did not work. One such case was the use of a mobile phone vibration motor signal to start, which required separate additional components.

From the distribution of startup modes, it can be seen that remotely controlled solutions (mobile, RC) occur at a high rate in the videos watched. In many cases, after assembly, a functional test was made, usually with pyrotechnic articles.

With the help of IED trigger videos, even an absolutely untrained "DIY" can make a working trigger method for home-made explosives.

5. The emergence of a new dimension with the use of drones

Perhaps the most recent devices are UAVs,[29] which are emerging as an absolutely new category and dimension. These can range from commercially available to anyone to home-made aircraft.

The possibility of defence can be approached in two basic ways, on the one hand in terms of the detectability of improvised explosive devices and on the other hand in terms of the construction of protection against the effects of an explosion. Both approaches cover huge areas, which given the size of the article I do not aim to explain in detail; nevertheless, I would cite two recent examples. In both cases, there were bombings against VIP persons. One case took place in Caracas, Venezuela 2018, during which an attack was attempted on the president with a remote-controlled UAV equipped with explosives. The failure of the assassination was caused by the misalignment of the remote-controlled aircraft, as it collided with a nearby building at the moment of detonation.[30] The second incident occurred in Yemen in 2019, when several high-ranking military leaders were bombed with a drone during a parade.[31] The two incidents highlight the need to take into account the risks posed by UAVs when designing protection against explosions.

6. Imitations

In everyday civilian life, explosive-free, deceptive IEDs, so-called imitations, can appear in many cases. In such cases, we should act in the same way as if we were dealing with a real explosive device. In terms of their external appearance, the "bomb" character is more pronounced, which is usually manifested in the fact that in many cases the plasticine in the form of a dynamite rod or mimicking a plastic explosive is clearly visible. In most cases, it appears to be a timed

[29] Unmanned Aerial Vehicle.

[30] BBC News, 'Venezuela President Maduro survives 'drone assassination attempt',' 05 August 2018.

[31] Mohammed al-Kibsi, 'Houthi drone targets senior Yemeni officers, kills five soldiers', *Al Jazeera News,* 10 January 2019.

structure due to the striking counter. Their purpose may be simply to deceive, to force law enforcement to take action to monitor tactical elements, or merely to cause confusion.

7. Summary

The biggest change in the evolution of IEDs has been the creation of the World Wide Web, the possibility of widespread access to it. Given the ingenuity of the human mind, only the imagination can set the limits for the creators of IEDs to build the most destructive hell machine possible.

Continuous development at the scene of war conflicts has developed and continues to evolve in these places as a result of the interaction between the high number of incidents of bombings and the protection measures taken by military units.

The fabrication of improvised explosive devices and their discovery and neutralisation is a dynamic and constantly evolving process. The interaction shows a kind of follow-up to these two activities, and usually the defence tries to respond effectively to the future elimination of emerging IEDs.

Following the development of improvised explosive devices, taking into account the specifics of the area, it can be stated that the latest technologies provide only additional opportunities for bomb-makers, without excluding the "long-established" methods. Based on these aspects, the task of bomb disposal technicians is to decipher the operation of so-called "Stone Age" solutions or state-of-the-art technical equipment, even hybrid versions, in order to carry out successful response and research. It follows directly from this that, in addition to learning about new technologies, continuous training must include previously used structural designs in order to increase efficiency and avoid injuries.

The designers of the instruments used in the reconnaissance also have a great responsibility in this process, as more and more accurate and sensitive equipment need to be developed to ensure effective prevention and reduce the error rate.

References

Al-Kibsi, Mohammed, 'Houthi drone targets senior Yemeni officers, kills five soldiers'. *Al Jazeera News,* 10 January 2019. Online: www.aljazeera.com/news/2019/1/10/houthi-drone-targets-senior-yemeni-officers-kills-five-soldiers

Andrade, Tonio, *The Gunpowder Age: China, Military Innovation, and the Rise of the West in World History.* Princeton: Princeton University Press, 2016. Online: https://doi.org/10.2307/j.ctvc77j74

BBC News, 'Venezuela President Maduro survives 'drone assassination attempt',' 05 August 2018. Online: www.bbc.com/news/world-latin-america-45073385

Damó, Elemér, 'Utász harctéri tapasztalatok' [A sapper's battlefield experiences]. *Műszaki Katonai Közlöny* 18, nos 1–4 (2008), 175–306. Online: https://folyoirat.ludovika.hu/index.php/mkk/article/view/3013/2268

Daruka, Norbert, 'Bombers, Wires and Explosives Part I. – Death Within a Reach'. *Műszaki Katonai Közlöny* 23, no 2 (2013), 73–80. Online: https://doi.org/10.32562/mkk.2013.2.6

Daruka, Norbert, 'Bombers, Wires and Explosives Part II. – Death Arrives With Us'. *Műszaki Katonai Közlöny* 23, no 2 (2013), 64–72. Online: https://doi.org/10.32562/mkk.2013.2.5

Google Trends, 23 October 2021. Online: https://trends.google.hu/trends/explore?date=2008-01-01%202021-10-23&gprop=youtube&q=IED

Hatala, András and Ferenc Kelemen, *Jegyzet a katonai robbanótestek szerkezetének és működésének megismeréséhez és megértéséhez* [Teaching Aid for Cogniting and Understanding the Characteristics and Operation of Military Explosive Devices]. Budapest: Vitaliq, 2003.

Kiss V, Katalin, 'Személyiségzavarban' [In personality disorder]. *Hetek,* 11 July 1998. Online: www.hetek.hu/belfold/199807/szemelyisegzavarban

Kovács, Zoltán, 'Az improvizált robbanóeszközök főbb típusai' [Main types of the improvised explosive devices]. *Műszaki Katonai Közlöny* 22, no 2 (2012), 37–52. Online: https://doi.org/10.32562/mkk.2012.2.3

Kovács, Zoltán, 'Explosion of Improvised Explosive Device Effects on Structures'. *Hadmérnök* 11, no 1 (2016), 56–63. Online: https://doi.org/10.32567/hm.2016.1.6

Oppenheimer, Andy, 'IRA Technology'. *The Counter Terrorist,* 08 September 2009. Online: https://issuu.com/sbradman/docs/issue8.finalproof

Rudaw, Ayub N, 'The lurking menace of ISIS – How does ISIS make its bombs'. *YouTube,* 17 November 2016. Online: www.youtube.com/watch?v=oS0poO4vHGE

United Nations Mine Action Service, *Improvised Explosive Device Lexicon.* New York: United Nations, s. a. Online: www.unmas.org/sites/default/files/unmas_ied_lexicon_0.pdf