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Norbert ŚWIĘTOCHOWSKI
General Tadeusz Kościuszko Military University of Land Forces, Command Institute, Wrocław, Poland

The History and Use of Electromagnetic Weapons

Historia i zastosowanie broni elektromagnetycznej

• Abstrakt •

Artykuł został poświęcony problematyce powstania oraz rozwoju broni elektromagnetycznej, a w szczególności jej roli – jako broni nieśmiercionośnej – w działaniach policyjnych i wojskowych. Po raz pierwszy rozważono zastosowanie broni elektromagnetycznej – jako policyjnego lub wojskowego środka rażenia – pod koniec lat 70. ubiegłego stulecia. W latach 80. w Stanach Zjednoczonych realizowano już kilka programów obronnych poświęconych rozwojowi broni laserowej, przeznaczonej do zestrzeliwania pocisków balistycznych oraz broni mikrofalowej dużej mocy, niszczącej sprzęt elektroniczny. Te technologie zostały przejęte później przez amerykański Połączony Dyrektoriat Broni Nieśmiercionośnej i wykorzystane do opracowania nieśmiercionośnych środków rażenia, które mogły znaleźć zastosowanie wojskowe. W drugiej połowie lat 90. ubiegłego stulecia dysponowano już kilkoma typami broni elektromagnetycznej, które mogły być wykorzystane praktycznie w operacjach militarnych. Do najważniejszych z nich należał Active Device System oraz generatory impulsu elektromagnetycznego wielkiej mocy, np. tzw. Bomba E,

• Abstract •

This thesis is about the origin and development of electromagnetic weapons used in policing and military tasks as a non-lethal tool. The electromagnetic weapon was taken into consideration as a military or police means of antipersonnel engagement in the late 1970s. In the 1980s the USA conducted some defense programs towards development of lethal high energy laser weapons, to shoot down ballistic missiles and high-power microwave weapons designed to destroy electronic equipment. This technology was adapted by US Joint Non-Lethal Weapons Directorate (JNLWD) to construct new or adapted non-lethal delivery systems, which could be used in military operations. Until late 1990s several types of electromagnetic weapons were created and taken into account for practical use. The most important were: Active Denial System and electromagnetic pulse generators devices, for example E-bomb, which was probably used against Iraq in 2003 war.

która prawdopodobnie znalazła zastosowanie w wojnie przeciwko Irakowi w 2003 r.

Słowa kluczowe: broń elektromagnetyczna; historia; wojna; użycie; rozwój

Keywords: electromagnetic weapons; history; war; use; development

Introduction

Electromagnetic weapons are means and devices that utilize electromagnetic energy occurring mostly in the form of electromagnetic waves propagating in free space. The electromagnetic waves spread in: the ground, equipment, water, as well as in the atmosphere. The electromagnetic energy is frequently referred to in the English specialized literature as "directed energy". The most popular types of electromagnetic weapons include: millimeter and microwave generators, low-power diode lasers, high-power chemical lasers, high power electromagnetic pulse generators. Those means have been developed in order to use them as a non-lethal weapon towards persons and objects, allowing the reduction of prospective victims in case of police interventions, street riots, robberies, etc. They are also used for military purposes. Progressive technological development opens up new capabilities for the electromagnetic force, including those ones that can determine the success of a military operation.

The main purpose of this article is to present modern electromagnetic means used as a non-lethal incapacitating weapon.

The Introduction of Electromagnetic Weapon

The history of electromagnetic weapon starts with the birth of conception of non-lethal weapon (NLW), as an alternative means of engagement in policing tasks, especially for crowd control. In the early 1960s a group of varied weapons technologies began to be described collectively as "non-lethal" weapons (NLWs; Davison, 2006). In this period the irritant chemical weapons were the most popular means of riot control and were widely used in many western countries. In the USA the 1960s were named "the era of protest and riots" against the Vietnam war and other military and political conflicts led in this time. As a result of this there was a technological explosion of new non-lethal devices and weapons, such as kinetic energy impact projectiles (wooden, rubber and bean-bag) and electrical-shock weapons.

In the 1960s and the 1970s the mainstream of literature devoted to the use of NLWs was focused on policing tasks with little reference to potential military application beyond policing-type situations such as riot control in which the military may be involved. Although there had been conducted a public discussions in the military and peace research communities over the possibility of "war without death". In 1970 J. Coates, one of the employees of the US Institute for Defence Analyses in Washington, wrote a paper entitled *Nonlethal and Nondestructive Combat in Cities Overseas* in which he suggested a wider role on NLWs in low-intensity warfare (Coates, 1970). Coates observed that: "There will be both more intermingling of aggressors and civilians and a greater blurring of the distinction between the two in many anticipated types of conflict". He underlined that this situation might be the case especially in urban combat (Coates, 1970).

The electromagnetic weapon was taken into consideration as a military or police means of anti-personnel and anti-material engagement in the late 1970s. In 1978 the authors of Stockholm International Peace Research Institute's (SIPRI's) study of anti-personnel weapons observed that "…new developments in anti-personnel weapons derive from three main areas of physics: electricity, acoustics, and electromagnetic radiation" (Lumsden, 1978). The authors pointed that none of this technologies had the military application in this time. The electromagnetic generators were considered for use by police in 1960s, but there were no right technology to build a useful and safe weapon.

In the 1980s the US Armed Forces were going towards development of lethal high energy laser weapons, to shoot down ballistic missiles and high-power microwave weapons designed to destroy electronic equipment. This technology was adapted by Joint Non-Lethal Weapons Directorate (JNLWD) to construct new or adapt existing non-lethal delivery systems, which could be used in military operations. Significant research and development work was conducted on anti-personnel "non-lethal" weapons that employ various types of electromagnetic energy: radio frequencies, low energy lasers, and high energy lasers. However it was not until late 1990s that several types of electromagnetic weapons could be created and taken into account for practical use. Two most important technologies were based on millimeters waves propagation (Active Denial System) and high energy pulse generation (E-bomb).

Active Denial System

First electromagnetic technology that had attracted considerable interest was the Air Force Research Laboratory's (AFRL) development of the so-called Active Denial Technology (ADS) employing millimeter wave electromagnetic radiation to heat the skin and cause pain. In late 1990s the prototype system integrated the technology onto a HMMWV armored vehicle and was termed the Vehicle Mounted Active Denial System (VMADS). For a long time the system was classified project and it was not declassified until December 2000 (Davison, 2007).

The millimeter wave generator was constructed by the *Raytheon* company. The device is a large, directed antenna mounted on a vehicle, which emits waves with a frequency of 95 GHz, burning the human skin within a 500–600 meter distance, theoretically without any adverse side effects. Millimeter waves are often confused with microwaves, which are at a frequency of about 2.5 GHz, with a length more than 10 cm. Therefore, they may heat, and even toast food in an oven, as they penetrate the entire depth thereof. In contrast, millimeter waves have a length of a fraction of a millimeter, and therefore, they penetrate only a thin layer at the surface of the human skin. Hence, they are relatively safe to use. However, they irritate the nerve receptors located at the surface of the skin, causing relatively strong, burning pain, causing an unconditioned reflex of escape from striking wave distance.

The device is designed to prevent people from entering a specific area and it is known as ADS *(Active Denial System*; Allison, Garwin, 2004). A demonstration model that was supposed to proof the legitimacy of the use of the millimeter wave technology while construction of non-lethal weapons, was developed in the late nineties of the last century and was named SYSTEM 0. It included a container on which the large, directed antenna was mounted, and the equipment necessary to generate waves (Le Vine, 2009).

In order to demonstrate the ability of the system on the field, SYSTEM 1 has been constructed. It has been done by placing the generator on a HMMWV (*High Mobile Multi-Wheeled Vehicle*) wheeled chassis, which had been equipped with a hybrid engine (Fig. 1) powered by electricity and diesel oil. The vehicle had an electric generator which could be used to generate electricity for the millimeter wave generator. Between 2005 – 2006 three field tests were conducted. Their purpose was to examine the possibility of using the system in a variety of tactical situations, including operations in urban areas, protection of sea ports, as well as operations at checkpoints. The tests were successful and, therefore, further development of the system has been approved.

Thanks to relatively small weight and size, the system can be transported and deployed on the field as needed. The device can be used as stationary (for force protection or infrastructure protection) or mobile by mounting it on a car chassis or even on a plane.

Figure 1. *Active Denial System*

Source: U.S. Army.

The main source of electricity, which is needed in a large amount, primarily to power a gyrotron, is the HMMWV electric-hybrid generator. The millimeter waves produced by a gyrotron are sent by the system that produces a wave beam to a small sub-reflector mounted in front of the main antenna. The sub-reflector strengthens the beam and illuminates with it the entire antenna, from where it is sent to the desired direction. The antenna consists of 25 mirrors, each of which reflects the waves in a different way. Notwithstanding, together they produce the correct beam of millimeter waves, sent to a specified distance. The radiation from the antenna is channeled to the target by the operator thanks to a day observation camera and an infrared night vision camera, both controlled by a joystick. The guidance system precisely allows to direct the beam of millimeter waves towards a man located in the distance of several hundred meters. In this case there is no risk of shock for bystanders. The wave is sent after the trigger is pressed by the operator. In order to prevent a radiation overdose, the wave emission is stopped immediately after releasing the trigger mechanism or after the maximum time of the continuous wave emission. The system is equipped with a laser rangefinder used to accurately determine the distance to prospective targets in that the beam is properly adjusted to the distance, which makes it more effective and safer (Le Vine, 2009).

Along with the development of the Active Denial System, research on the effects of millimeter waves on the human body has been conducted. The works have been carried out to solve the following fundamental problems:

– discovery of the physical phenomenon of the millimeter waves and their influence on mental and physical condition of humans;
– impact of the millimeter waves on human skin;
– impact of the millimeter waves on human eyes;
– prospective risk of the skin cancer due to the millimeter wave shock.

The research found that electromagnetic waves with the frequency of 95 GHz do not have enough photon energy to change the structure of organic cells. The energy affects only the surface of the skin (no deeper than 0.01 mm) and raises its temperature the same way as the infrared radiation emitted by the sun. The feeling of pain is quite intense, but the radiation, if it is not run for too long, does not cause skin burns, and the pain disappears immediately after the cessation of the radiation.

Since the radiation raises the temperature of the skin at the place, where there are extremely sensitive receptors, the sudden pain causes an unconditional reflex of escape from the range of the radiation. The studies have shown that this reflex is present in all people regardless of how immune to pain they are or in what mental state (morale) they are. The findings prove the Active Denial System's advantage over other types of non-lethal weapons, e.g. stun guns or tasers, whose effectiveness depends on individual traits or a physical condition of a man. It has also been proved that there is a safety margin between the time after which a person feels the pain and the quick escape from the striking wave distance, and the time in which the radiation can cause skin burns (Walter, Blick, Johnson, Adair, Foster, 1978).

As far as the formation of skin wounds is concerned, in the vast majority of cases there have not been any traces of the radiation. In more than 11 thousand examined cases, only eight patients have had second-degree skin blisters – in six of which the blisters have disappeared on their own. The other two patients required treatment. Yet, their therapy has been quite short, with no complications (Le Vine, 2009).

The issue of the electromagnetic wave impact on the human eyes has been taken under close scrutiny as well. The cases of people who wear goggles, masks and those ones with no protective devices have been examined. It has been found that human eyes react to the radiation by immediate blinking, which effectively protects the eyes from damage. Additionally, a man exposed to radiation instinctively protects the face and eyes by raising hands, which also effectively protects the eyes.

It has been assumed that due to the fact that millimeter waves have a low portion of energy, they do not change the structure of the cells, and thus, they cannot

cause skin cancer. Studies on animals, during which the feasibility of the skin changes' formation while the subject is exposed to single or multiple radiation for 12 weeks, have proved that there is no connection between the electromagnetic wave impact on the skin with the possibility of creation of the skin cancer (Mason, Walters, Di Giovanni, Beason, Jauchem, Dick, Mahajan, 2001).

The ADS has as many supporters as opponents. The supporters maintain that one of the main system's advantages is undoubtedly the possibility of using it as a non-lethal weapon towards humans from a distance greater than the existing measures are capable of. It can significantly increase the possibility of reaction on aggressive behavior of a crowd. This device, however, cannot be effectively used while the enemies protect their bodies by using aluminum foil fitted with small holes for observation. At the same time, the opponents of the ADS implementation believe that it can be dangerous, because when the trigger mechanism or a device which adjusts the wave power, depending on the distance, is damaged, the target can be struck for too long or too heavily, which in turn may lead to death.

One of the ADS derivatives is a microwave cannon. The very high frequency electromagnetic waves emitted by a device of size of a grenade launcher, make the water molecules present in the tissue begin to vibrate. This process raises temperature locally – in this case, this is the temperature of the human body. The intensity of the microwave beam is chosen very carefully – so that to heat the water, but not to boil it. In this way the radiation beam causes terrible pain, but concurrently it is harmless. Eric Adams, a journalist of the American magazine *Popular Science* bet that he could withstand the impact of such weapon for more than three seconds. He stood in a designated place on the military field, and a US Air Force technician took aim at him with the microwave cannon and fired. Adams felt searing pain in his back. After two seconds he ran away from the line of fire because of extremely severe pain.

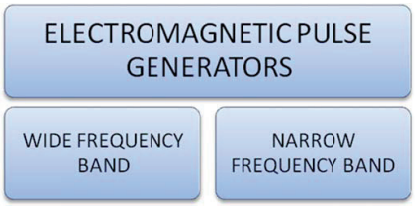
Electromagnetic Pulse (EMP) Generators

One of the most decisive combat factors in the post-industrial era is information, which is collected, processed, and distributed in computerized and digital communication networks. Information dominance is becoming a determinant of the success of a military operation. On the one hand, the development of digital systems has allowed the armed forces to gain a more comprehensive picture of the battlefield and has reduced the time of the decision making process, but on the other hand, it has hinged the operational success on a complex network system

that can be attacked by the enemy via non-military actions, such as hacker attacks, or by measures that interfere or destroy command and control systems.

Electromagnetic pulse (EMP) generators are devices whose purpose is to destroy or interfere with electronic devices, including computers, communication measures and Internet networks by using strong electromagnetic energy emitted in a very short period of time. The energy propagates in the atmosphere in the form of waves and has access to devices usually through the antenna and other elements of the equipment that are exposed directly to the radiation. As shown in Figure 2, generators can be divided into two main groups. The first group are generators operating in a wide frequency band, emitting a massive amount of energy that is generated by a strong explosion or electromagnetic generator directed against all available electromagnetic devices. The second group are generators that emit electronic pulses in a narrow frequency band directed against selected electronic devices.

Figure 2. Division of electromagnetic pulse generators



Source: own work.

Electromagnetic pulse generators can be used to damage electronic and electrical devices, to delete information in databases, to cause failures in computer systems, to cause explosions or neutralizations of minefields. Using this type of weapon is neither prohibited by law, nor it raises socio-political objections.

Hand electromagnetic weapons can be constructed from elements widely accessible on the market. The only things needed to construct such weapon are knowledge and a sufficient amount of money, which currently is no longer a problem for numerous terrorist groups. A basic, small size explosively pumped flux compression generator (EPFCG) resembling a radio with a tube can be built for a few hundred thousand dollars.

A portable emitter of the electromagnetic radiation from a short distance can immobilize a car, destroy a computer, and even turn off a bank alarm system. Paradoxically, the most modern computer equipment is utterly exposed to such

weapons as newer microprocessors have lower operating voltage, high speed, and plastic housings that do not protect them from radiation.

The influence of the electromagnetic weapons on the human body has not been examined yet. The electromagnetic pulse can negatively affect both people and matter. Violation of functioning of nerve cells and the central nervous system might occur at a particular frequency and power level of radiation. It can result in momentary inability to act. An affected person might temporarily feel discomfort by hearing noise and whistles as well (Rusjan, 2002).

Electromagnetic Bomb (E-bomb)

An example of a weapon emitting energy in a wide range of electromagnetic waves is an electromagnetic bomb; the bomb is also called E-bomb. This is a device that is capable of generating and sending an extremely strong and short-term electromagnetic pulse (EMP) of high power causing interruptions or total failures in the operation of electronic systems.

The phenomenon of generating an electromagnetic pulse with immense power was observed for the first time in 1962. It was an accidental discovery during a test, when a hydrogen bomb with a power of 1.4 megatons was detonated on one of the central Pacific Ocean islands. The explosion destroyed installations of satellite communications within a radius of 30 km, and there was interference in radio communications within a radius of 1200 km from the explosion site. After examining this occurrence, it was found that the electromagnetic shock wave caused by the detonation stimulated induction of electricity in the antennas, electrical cables and metal parts, destroying all unsecured electronic components. Prepared calculations showed that a single nuclear explosion with a capacity of 100 kT at an altitude of 110 km can generate an electromagnetic pulse capable of destroying electronic equipment on the surface equal to a half of the United States (Dura, 2015).

The E-bomb is considered a conventional weapon, because in order to generate a pulse there is no need to use nuclear weapons. However, due to the effects that it causes, it can be classified as a weapon of mass destruction. There is a serious risk of its use by terrorist organizations. Therefore, this technology is treated very seriously, it is covered by professional secrecy and state secrecy. No country admits to its possession, although, the United States and Russia are said to possess it. What is certain, however, that intensive work on the construction of E-bomb in these countries has been in progress; they have E-bomb prototypes, which are said to have already been used for military purposes.

The United States are said to have used such bombs in Iraq. According to the *Guardian* newspaper, during the first days of the attack on Iraq in 2003 an E-warhead was applied to the AGM-86 Cruise aviation maneuvering rocket. The decision to use this type of weapon had probably been motivated by prevention from collateral damage among the civilian population (Fig. 3) in the vicinity of which anti-aircraft defense measures had been deployed (Dura, 2015). The information about American use of the E-bomb in Iraq was also reported by CBS News. According to CBS the United States deployed an experimental E-bomb on March 24, 2003 to knock out Iraqi satellite television and disrupt the broadcast of propaganda.

One of the known types of E-bomb is an American *Mk 84* bomb weighing about 900 kg, with a length of 3.84 m. Its operating radius is close to 1 km. The bomb during the detonation sends a directed beam in a narrow frequency band (Dura, 2015).

Figure 3. E-bomb exploding over a city

Source: www.defence24.pl.

Destructive actions of the E-bombs involve sending in less than one millionth of a second an electromagnetic wave with a length from fractions of a millimeter to several dozen centimeters, with power equaling to billions of watts. The wave spreading through space, reaches electronic devices, and by the variable electric and magnetic fields causes a change in voltage, which in turn leads to equipment damage (Szubrycht, Szymański, 2005).

The electromagnetic waves are generated by the microwave generator with a virtual cathode, called a vircator (*VIRtual CAthode OscillaTOR*). Fulfilling the function of the cathode, a metal cylinder is placed inside of a metal tube and at the same time separated from it by an annular insulator. Situated opposite the cathode, the anode is made of a metal mesh and connected to the tube. The tube

outlet is closed by a window made of the dielectric. The cathode and the tube are connected to the poles of an explosively pumped flux compression generator (EPFCG). When the generator starts, the cathode emits a cloud of electrons, which is accelerated in the direction of the anode, creating behind it a cloud called "a virtual cathode". With such a distribution of the energy, inside the tube there are induced electrical vibrations of a high frequency. Their energy is radiated in the form of a short, but very strong microwave pulses (Szubrycht, Szymański, 2005).

The vircator produces directed waves of very high frequency, which can easily penetrate into buildings and electronic devices through small cracks and holes. It makes the vircator an extremely useful and effective tool of the electronic warfare (EW; Dura, 2015).

The electromagnetic pulse (EMP) can also be produced by a chemical reaction, from which the energy is transferred to the very strong magnetic field induced just before the explosion. An example of such a device is the explosively pumped flux compression generator (EPFCG), also known as "a coaxial generator". This type of generator is composed of a copper cylinder filled with explosive material and surrounded by a coil made of copper winding. All the elements are placed in a casing of non-magnetic material (usually it is the epoxide or fiberglass). The wave produced in an EPFCG bomb is of a frequency lower than 1 MHz, it propagates in a omnidirectional way. It is difficult to aim it on a specific target, and even when a high-power pulse is induced, it is likely to lack effectiveness and efficiency (Dura, 2015).

The E-bomb is not a perfect weapon as certain counter-measures, which are able to limit its effectiveness, can easily be applied. First of all, it should be emphasized that this device emits waves of small length, so they penetrate only a small depth of the subject. It will be enough to surround the computer with a slightly thicker metal housing, which absorbs and deflects radiation. This way, only a small portion of the radiation has access to the device.

The E-bomb has a limited area within which it is effective enough. Firstly, the area can be further reduced as a result of adverse weather conditions (the electromagnetic propagation in the atmosphere). Secondly, the E-bomb is of a large size. Its effectiveness is also determined by the precision with which the bomb strikes the target – deviation reduces its effectiveness significantly.

Nonetheless, the E-bomb can be extremely effective during the fight against unprotected devices of the electrical and telecommunication infrastructure, especially in large cities. For example, the low-frequency electromagnetic pulse produced by the explosively pumped flux compression generator (EPFCG) can easily damage telephone and power lines.

The effectiveness of the E-bombs equipped with a vircator is determined mainly by the amount of the energy that can be directed by the bomb at a specific target. This is done by an antenna system, which is located in the warhead. The power and the striking distance depend on the height of the explosion. The higher the explosion occurs, the larger striking distance, but concurrently, the lower pulse power. Therefore, before using the bomb, there is the need to specify what will be the object of the bomb attack, and how the object is protected against an electromagnetic pulse. In the case of the attacks on military buildings and installations, which are protected against an E-bomb attack, the explosion of the bomb is to be carried out at low altitude. This method of attack allows to strike the target with a high-power electromagnetic pulse, but simultaneously significantly limits the striking distance (Dura, 2015).

The E-bomb can be used to incapacitate or destroy targets which are essential for the functioning of a state, social organizations and for the combat capability of the armed forces. The objects to be struck by the E-bomb are inter alia:

- public administration and government buildings and installations;
- elements of the economic state system;
- factories, power plants and industry installations;
- military bases;
- communication and command centers, radar stations (Dura, 2015).

The electromagnetic pulse can be also used to incapacitate e.g. elements of the enemy's combat formations i.e.: aircraft, helicopters, missiles and light combat vehicles. It is even possible to combat vessels, despite the fact that the electronic equipment is located inside of a thick steel hull, because most of the equipment has outwardly projecting parts, e.g.: antennae, radars, communication systems. The destructive energy has access to the attacked objects through those enumerated elements.

The E-bomb does not affect in any way the human body and it is considered to be the safest non-lethal weapon. Using the E-bombs is non-spectacular and it is not related to the immediate damage that can visually be assessed. It may be a part of a hybrid war, because it will be difficult to prejudge, who and why has used a particular type of weapon. Simultaneously, at present the following phenomena occur: power outages, communications blackouts, communication and bank system failures, cyber-attacks, and other events for which the reason and source are not easy to be determined. What is more, the electromagnetic weapon can become a part of international blackmail. It is likely, as this is a conventional weapon, with a relatively low price, and it does not cause loss of human lives. Furthermore, the weapon destroys crucial systems for the functioning of a state. Thus,

there is a risk that the electromagnetic bomb might be misused in the same way as the other non-lethal weapons are. Using E-bombs by a prospective aggressive state towards another one would be difficult to prove. Hence, in a consequence it would probably not be *casus belli*.

If terrorists gained access to the E-bomb, it would bring negative consequences for the security of citizens. Although, the people would not directly be exposed to the loss of their health and life, but, overnight, they would live in an environment impossible to normal existence, i.e. without electricity, water and communications.

The implementation of the E-bomb to the military weaponry significantly enhances the military capability. The implementation is not dictated by the thought to save a human life – even though it is extremely significant. The E-bomb is said to increase the so-called humanization of war, if there is such a thing. Still, it must be emphasized that the most pivotal factor that determines the weapon's implementation is its battle efficiency.

Conclusions

The history of electromagnetic weapons is not long, it began at the end of the last century. In this article, it was considered as a non-lethal weapon. For the time being, the electromagnetic weapon is intended mainly for military use. Firstly, the use of non-lethal weapons in tactical operations can help to increase the efficiency of the armed forces. Moreover, it enables the military personnel to conduct their assignments in a far more effective way with concurrent lower losses of friendly and enemy forces. The possession of such weapons extends the ability to influence the enemy in different situations, especially when the use of lethal weapons is not recommended. The use of weapons appropriate to the situation makes feasible the execution of tasks by smaller, but simultaneously more efficient forces in a relatively shorter period of time. The electromagnetic weapons described in this paper are applied in military tactics to achieve the following goals:

- to reduce the military combat potential by incapacitating the manpower and military equipment of an enemy;
- to limit freedom of movement;
- to block access to critical objects (areas);
- to disorganize reconnaissance systems;
- to incapacitate command and communication systems;
- to immobilize vehicles;
- to diminish capability of logistics systems.

Based on the above studies, one can draw a conclusion that thanks to a substantial development, electromagnetic weapons should be increasingly applicable in the armed forces. Thanks to the development of new technologies, it is possible to implement multi-purposed weapons that will conduct, inter alia, tasks previously carried out only by conventional weapons. In military applications, the primary task of the multi-purposed weapons will be strengthening the capacity of combat troops by adding another means of choice available to an operational commander. The humanitarian aspect, which chiefly concentrates on reduction of the number of fatalities in a conflict, will obviously still remain relevant, because the human life is paramount. Nevertheless, in certain cases, e.g. in need to achieve the objectives of the military operation and providing the proper level of force protection, it will be treated as a minor issue.

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