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SAFETY OF CREWS AND SZ RP VEHICLES EXPOSED TO THE IMPACT IN ASYMMETRIC ENVIRONMENT

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Abstract

In the article, a brief overview of the measures taken in order to improve the safety of the crews and vehicles is presented. A few examples have been shown. The analysis of the attacks impact on the vehicles was performed on the basis of Polish Military Contingents in Iraq and Afghanistan, In addition, the determinants of endangering of the crews are presented and the resolutions that were undertaken are discussed. It should be noted, that in today's armed conflicts, the safety of the soldiers pursuing combat jobs is a priority. Therefore, the most important issue is to meet the requirements for vehicles security levels. An appropriate vehicle protection level should be taken into account during the determination of the technical assumptions and in the next step verified while the prototype testing in research and development centres. It is assessed that the use of various systems and means of vehicle protection in the new 20 the century have been inspired by operations carried out in Iraq and Afghanistan, where the classics faced the new unpredictable form of combat. However, is unconventional, asymmetric war something new? This is a typical guerrilla war run by the other side by means available for them. It seems that the coalition was not prepared for that form of operations in many regards.

Keywords: *asymmetric actions, safety, armour resistance, levels of protections, vehicle equipment*

1. Introduction

From historic and military point of view, there is a competition between the armour and the means of destruction. Invention of a sword, then a bow, a machine gun or cannons, the combat tools have been improved systematically, forced counteractions in a form of manufacturing a shield or armour later on. One should pay attention to the fact that improvement of the means of destruction has been oriented towards, among others, penetration, distance of destruction and finally the accuracy of shooting.

Nowadays, in case of participation in the crisis response operation provided by NATO abroad, soldiers meet a new form of combat operations, i.e. asymmetric actions [17, p. 39], where a subject (or subjects), usually military weaker than its enemy, applies various methods and means, that are:

- unconventional, non-standard ones from the point of view of jeopardized country, do not have equivalents among its regular methods of operation, are not assumed as acceptable methods of combat – like terrorism for example,
- they tend to use the biggest weakness the attacked enemy against him,
- make difficult or impossible to make use of owned defensive potential effectively,
- allow (at least potentially) the subject that creates the asymmetric threat to obtain effects far more serious than the ones indicated by the scale of involved forces.

Intensity of military actions carried out by the rebels, as the example of Afghanistan shows, is diverse and is expressed in a number from several, over a dozen to tens combat actions per day. They run offensive operations in order to interfere with execution of tasks by military contingents. These actions make the NATO and government forces practically isolated and thus they force the armies to perform defensive operations, that are only limited to checking the area around the occupied territory. They also cause the loss of equipment and first of all the loss of soldiers of coalition [5, p. 165].

Undoubtedly, participation of the Polish Army in operations abroad (Iraq, Afghanistan, Chad and earlier in Serbia) forced the change of philosophy of thinking in many areas of the army operation, including most of all technical modernization, which was oriented, among many others, towards safety, as high as possible, (survival) of the crew, soldiers. It can be stated that typical military requirements have a direct impact on the latest materials, techniques and technologies [16, p. 147]. Although it is well known that in case of hitting and piercing the armour, a possibility of survival of people inside a vehicle is low, however a designers and manufacturers of military vehicles, and eventually the users, have an obligation to strive for minimizing the effects of the means of destruction.

2. Antitank obstacles

Antitank obstacles can be generally divided into natural artificial ones. The first group includes rivers, canals, dense forests, lakes and buildings that after proper engineering works and use of proper tactics, allow optimizing their effectiveness. While artificial obstacles include, among others, antitank ditch or mine fields. In case of antitank mines, the force of explosion, resulting in (caterpillar or wheeled) vehicle chassis damage is used to pierce the armour including the bottom one. Participation in operations in Iraq, Afghanistan provided an opportunity to meet the use of various forms and means of combat, making a basic form of antitank obstacles for the coalition army.

It should be noticed that the majority of actions in Iraq (85-90%) was carried out undercover, without exposure of attacking rebels to the enemy's retaliatory actions. Battles in Iraq were most often associated with remotely fired explosives. However this term includes a series of means of combat, both the ones manufactured in the weapon factories of Iraqi underground, and modern types of weapon supplied for Iraqi resistance movement from external sources (mostly from Iran and China). The most common weapon used in Iraq and currently used in Afghanistan was *Improvised Explosive Device (IED*), built on the basis of explosives, mines, artillery shells, placed near communication routes. They were mostly fired by means of radio waves, including such simple equipment as mobile phones. The use of Vehicle *Born Improvised Explosive Devices (VBIED*) or *House Born Improvised Explosive Devices (HBIED)*) as well as *Explosively Formed Penetrators (EFP*) [9, p. 8] are result in high destruction rate. This results in evolution of means providing better safety for the crews. The above facts are illustrated by the numerical data of attacks performed in Iraq during 2003-2009, which are presented in table 1.

Tab. 1. Approximate number of attacks of Iraqi resistance during 2003-2009

Year	**Number of attacks**	
	Total	**Including bombs and IED**
2003	5000	N/A
2004	21 500	16 500
2005	30 300	23 000
2006	44 500	26 000
2007	60 700	25 000
2008	16 500	9 800
to 05.2009	2 700	1 500
Total	**181 200**	**101 800**

Source: Jakubowski R., *War Victims – Iraq Occupation 2003-2009*, Report No. 8/2009, p. 8

On the basis of analysis of available materials describing situation in Iraq and current situation in Afghanistan, one can notice that possible attack can be practically expected in any location, where the coalition army appears. It can happen in locations and areas that are particularly convenient to organize a trap, like crossroads, roads on the hillsides, bridges or curves.

Paradoxically, long open areas are also dangerous as well, sections allowing the partisans observing the troops of coalition forces from a long distance. Linear field objects and interiors of abandoned houses are often used as locations of IEDs and mines. Attacks on coalition tanks can make an example, where 7 out of 8 attacks, organized by means of IED, were successful.

One attack resulted in light equipment damage, three attacks caused medium damage and three attacks resulted in heavy equipment damage. There was one soldier killed and 8 ones wounded in hit vehicles [7, p. 10]. It should be noticed that each number presented in the table indicates a particular number of damaged or destroyed military equipment (tanks, armoured personnel carriers or other vehicles), but also a particular number of loss among soldiers (wounded, fatal injuries).

3. Crew and vehicle safety determinants

Change of geopolitical and social-political situation during last 20 years resulted in significant revaluation of views in the aspect of planning and use of military forces or their components involved in operations. Francis Fukuyama's opinion that "nations will live in piece, harmony and happiness after the fall of communism" did not work. Modern armed conflicts make a huge mosaic of political interests, economic dependences and relations as well as national prejudice. [19, p. 70] They are carried out in the spirit of the fights against terrorism and actions of a possible enemy are of asymmetrical nature. Changing reality, often in surprising way and its new qualitative dimension force countries to continuous search for and development of new concepts of action, shaping new abilities and skills; search for new ways of cooperation, as well as reaching levels of interoperability that provide a possibility of carrying out multinational combined operations [4, p. 5]. It requires a permanent correction and modification of previous strategies of use and operation of structures, resources and abilities of armed forces [15, p. 22]. The security issue of crews and vehicles involved in armed conflicts fits in this area of modern conflicts and challenges faced by countries and international organizations. *Security* in general means a lack of concerns, living without anxiety and fear. While regarding the security of the crew it means assurance that their vehicle is resistant to the effects of means of destruction. Carrying out military operations in relation to the crew and vehicle security should be based on the following rules that include:

- minimization of destructive impact of means of destruction on the crews and vehicles,
- obtaining maximum psychological effect among the vehicle crews involved in combat, prevention and humanitarian operations,
- providing conditions for development of means of combat and paying attention to the crew safety at the same time.

Therefore, planning and execution of undertakings related to the crew and vehicle safety will mostly depend on the factors presented above. Due to common features, it is recommended that factors determining the aforementioned security should be divided into the following factors: mobility, armour resistance to the means of destruction, vehicle structure and additional vehicle equipment, shown on figure 1.

Military vehicles, moving in the armed conflict zone, should meet proper ballistic protection. In operations of conventional nature i.e. where the enemy's location is known and own terrain, direction of attack or the front line can be clearly defined, there is a possibility of adopting proper operation method in order to avoid higher threats. However, experience obtained in recent years, most of all from Grozny, from Balkan and Iraqi towns indicate that carrying out operations in towns and supporting them by introducing the mechanized equipment in the urban area [20, p. 79] is and will be one of the most difficult challenges.

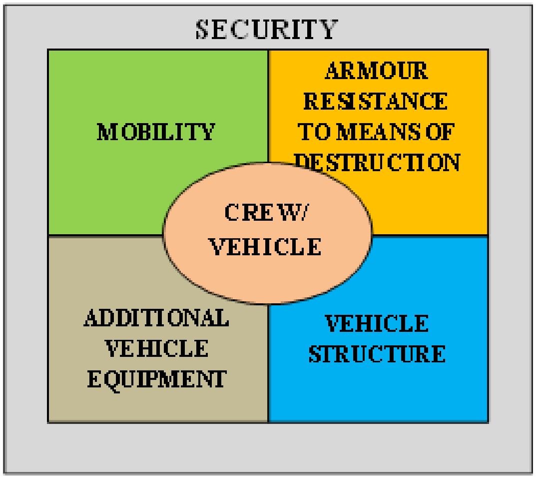

Fig. 1. Factors determining crew and vehicle security

Asymmetric actions so common in Afghanistan, unexpected, of various intensity and level of impact, should be mentioned here. Many situation development scenarios, characterized with various risks, are possible when performing appointed tasks. They are presented in table 2. As one can easily see, there is a variety of tasks to execute in the conflict area. They are both of police and military nature, while using various means affecting the risk.

The armour resistance to the means of destruction is undoubtedly an important determinant referring to threats presented in table 2.

Tab. 2. Possible threats occurring in the conflict zone

	TASKS	THREATS
Traditional	Arrest and detention of offenders, Roadblocks, Demonstration protection, Building protection, Transport of troops to operation location, Supporting pedestrian operations.	Stones, bricks, cans with paint and corrosive agents, Nails and other objects causing tire puncture, Burning tires and other homemade materials, “Molotov Cocktails”, Knives and other tools, Gun bullets.
Terrorism	Border protection, Protection of strategic buildings (airports, power stations), Prevention of attacks.	Threats resulting from asymmetric nature of operations, including action of demonstrators, partisans, criminals, terrorists. Directed most of all against security forces, patrols, posts, logistic convoys, technical teams – no clearly defined “battlefield”, “frontline” or “backs”.
Organized crime	Arrests, Liquidation of crime groups, warehouses, headquarters.	
Peace Support Operations	Patrolling, convoying and reconnaissance, Escorting convoys, Evacuation of wounded, Transport and protection of lightly armed troops, Supporting pedestrian operations, Combat using the on-board weapon,	Regular and armour-piercing machine gun bullets, Grenades, Anti-infantry mines, IED - improvised explosive devices, Artillery shells, Mortar shells, Bombs, Antitank mines, RPG.

Source: Szudrowicz M., *Vehicle Armouring Effectiveness*, Weapon Technology Issues, 14th Scientific-Technical Conference: ”Issues of Weapon Technology Development, Manufacture and Use. Reference – part I, Booklet No. 1, Zielonka 2005, p. 80.

It is worth to quote the basic document valid in NATO here. It makes a basis to impose requirements in relation to the vehicle ballistic defence. This document is called STANAG 4569 ”Levels of protection of passengers in light logistic armoured vehicle”. The subject document in Annexe A includes 5 levels of protection against piercing by bullets and fragments of artillery shells. It includes regular and armour-piercing bullets of the following calibres: 5.56 mm, 7.62 mm, 14.5 mm, 25 mm.

While levels of resistance to piercing by fragments of artillery shells depend on the distance of detonation of the 155 mm calibre shell. While the Annexe B of that STANAG includes levels of protection against piercing by fragments of grenades and mines. Proper requirements referring to STANAG are presented in tables 3, 4 and 5 below.

Tab. 3. Levels of protection against piercing by bullets (Annexe A)

Test conditions		
1	7.62 x 51 Ball; V = 833 m/s, 5.56 x 45 SS109; V = 900 m/s, 5.56 x 45 M193; V = 937 m/s. **Angle: azimuth 360°** **Elevation angle: 0-30°**	
2	7.62 x 39 BZ; V = 695 m/s. **Angle: azimuth 360°** **Elevation angle: 0-30°**	**30 m**
3	7.62 x 51 API (WC); V = 930 m/s, 7.62 x 54R B32; V = 854 m/s. **Angle: azimuth 360°** **Elevation angle: 0-30°**	
4	14.5 x 114 B32; V = 911 m/s, **Angle: azimuth 360°** **Elevation angle: 0°**	**200 m**
5	25 x 137 APDS-T; V_0 = 1335 m/s. **Angle: ± 30°** **Elevation angle: 0°**	**500 m**

Tab. 4. Levels of resistance to fragments of artillery shells (Annexe A)

Test conditions	
1	Shell: 155 mm **Distance of explosion: 100 m** **Angle: azimuth 360°** **Elevation angle: 0-18°**
2	Shell: 155 mm **Distance of explosion: 80 m** **Angle: azimuth 360°** **Elevation angle: 0-22°**
3	Shell: 155 mm **Distance of explosion: 60 m** **Angle: azimuth 360°** **Elevation angle: 0-30°**
4	Shell: 155 mm **Distance of explosion: 25 m** **Angle: azimuth 360°** **Elevation angle: 0-90°**
5	Shell: 155 mm **Distance of explosion: 25 m** **Angle: azimuth 360°** **Elevation angle: 0°**

Tab. 5. Levels of protection against fragments of grenades and mines (Annexe B)

Test conditions			
4	**4b**	Explosion under the central part of the vehicle	**AT mine weight 10 kg**
	4a	Explosion under the vehicle wheel or caterpillar	
3	**3b**	Explosion under the central part of the vehicle	**AT mine weight 8 kg**
	3a	Explosion under the vehicle wheel or caterpillar	
2	**2b**	Explosion under the central part of the vehicle	**AT mine weight 6 kg**
	2a	Explosion under the vehicle wheel or caterpillar	
1		Hand grenades, antitank mines, unexploded artillery explosive ammunition and other small anti-infantry explosives **detonated in any place under the vehicle**	**200 m**

It should be noticed that numerical parameters shown in the tables and included in the aforementioned STANAG allow for building a vehicle, which should be safe for its crew.

In order to unify the views, terms of armour and armouring should be recalled. In the professional literature, the term *armour* means a properly shaped shield used to protect people and equipment against the impact of the means of destruction (bullets, fragments, shock waves etc.). It can make an integral part of the structure, e.g. tank body and tower or it can make an additional protective layer, e.g. bulletproof vest [3, p. 95]. In that sense the armour can be active and reactive. While armouring is a permanent set of protective plates, used temporarily, designed to protect people, equipment, cargo etc. against the impact of bullets, fragments, shock waves, penetrating radiation, and also against cutting and sticking (e.g. with a knife or bayonet). Effectiveness of armour plates depends on a type of material and plate thickness. Steel plates (armour plates) and light alloy plates are mostly used as well as ceramic plates, plates made of plastic, composite plates and combinations of these materials [3, p. 523; 2, p. 456].

Fig. 2. Buffel – first MRAP type mine-proof vehicle
Source: *Military Training* 2/2014

Quality of tank (vehicle) shield, in other words effectiveness [11, p. 41], is a resultant of material used in its structure, structure features and its size. For many years, tanks have been made of steel armour plates, usually of nickel-chrome-molybdenum steel, rolled or cast. A good design improves the effectiveness of the armour. For example, inclination of the surface to increase the real thickness to pierce and avoiding perpendicular fragments and bending or just using thicker plates, which obviously results in higher tank weight.

Vehicle structure is the next considered determinant, which evolved over the last few decades. In that case, the term ”vehicle” refers to armed vehicles, transport vehicles and cargo-passenger high mobility vehicles. It was a common knowledge that the term armoured vehicle indicates that the vehicle is resistant to the impact of the means of destruction, while there is no need to armour transport vehicles.

Only vehicles used to transport very important persons were armoured. However, participation of the army in various armed conflict, commonly referred to as stabilization, training, humanitarian missions, set a new trend in vehicle structures. It has been determined by the method of combat with partisans, rebels, which have been defined as asymmetric operations or ”dirty wars”. In this sense, the asymmetry means unfair combat, hitting a weak point, information war, psychological war, threatening or using the weapon of mass destruction or action, organization, thinking in a different way from the enemy in order to maximize one's own advantage, using the enemy's weakness to take over the initiative or to obtain higher freedom of actions [17, p. 39]. At the beginning of the 21st century, the experience of the South Africa (RSA) was used. This country has run an official war with discriminated black population for several decades in the 2nd half of the 20th century. This is here where special vehicles were born, the protoplasts of today's MRAP (Mine Resistant Ambush Protected) vehicles. One of the examples is presented on figure 2. Those vehicles used the following structure features to increase the anti-mine resistance:

- maximum distance from the vehicle bottom to the ground surface – potential location of detonation of the trap explosive,
- V-shape of the vehicle bottom,
- vehicle bottom made of thick steel sheets,
- vehicle weight as high as possible.

These features also make a basis of structure of modern mine-resistant vehicles that include additional items:

- the-so-called deflectors placed under the vehicle bottom in order to provide protection similar to the previously used V-shaped vehicle bottom, see figure 3,
- use of double walls, particularly near the vehicle bottom, where sometimes additional energy-absorbing items are placed between them,
- ”floating” floors separated from the vehicle bottom to protect feet against direct impact,
- flexible floor lining, cushioning the hit in the feet,
- seats installed as far as possible from the wave impact point – fixed to the walls or the roof,
- seats consisting of items absorbing the wave impact energy and thus reducing the loads, affecting the spine [8, p. 113].

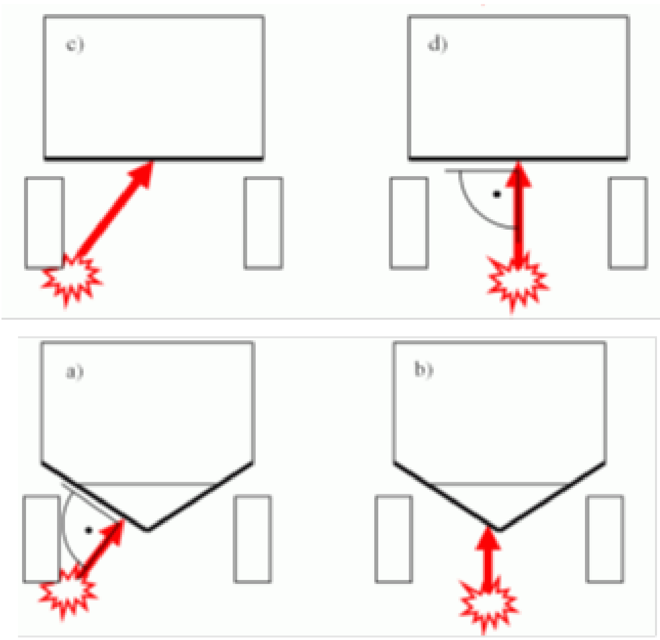

Fig. 3. Diagram of angles of incidence for various bottom shapes and various places of explosive detonation

Source: Iluk A., *Selected Aspects of Shaping the Anti-mine Resistance of All-terrain Armoured Vehicle*, Scientific Booklets WSOWL No. 4, Wroclaw 2010, p. 113.

It should be noticed that apart from obvious advantages, vehicles of that type have also disadvantages that include:

- significant vehicle load and resulting transport difficulties (e.g. by air) and during use: high fuel consumption, and difficulties in crossing the terrain (e.g. they easily get buried in sandy area, they cannot drive over the bridges of low carrying capacity),
- high vehicle height – making it more noticeable and making the firing by the enemy more easy,

- high location of the centre of mass decreases the stability of the vehicle and increases probability of capsizing, particularly in the mountain area (that type of terrain dominates e.g. in Afghanistan).

The use of monocoque type of armoured self-supporting body makes a kind of ballistic protection. All walls of that body are inclined at high angle both upwards and downwards. That type of body inclination provides high probability of ricochets of bullets hitting the vehicle, as well as dispersion of explosion of the explosive placed under a wheel [14, p. 39]. Allowing the vehicle crew to easily get on and get off a vehicle in full equipment configuration (protective vest, helmet, equipment vest, weapon) also makes an important issue in the area of the vehicle structure. It is assumed that leaving a vehicle cannot last longer 13 seconds for the crew of 4-6 members. It is of considerable importance in case of the combat use of the vehicle.

Special attention should be paid to the fact that vehicles of that type are manufactured in many countries of high significance in the automotive industry. Apart from the USA, United Kingdom, France, they are also manufactured in Turkey, Russia or Poland and Croatia.

The additional vehicle equipment is also an important determinant in the crew safety field. It includes such elements as additional shields, seats for the crew or interfering electronic devices. Each of these items, though built in a different technology, meets the imposed requirements in its own way. One should consider a fact that, explosives fired with a pressure extraction detonator that often explode under a vehicle wheel or vehicle bottom [6, p. 14], are commonly used in Afghanistan. Therefore, there is a need to undertake actions in order to provide the crew with maximum safety conditions. The equipment, which was good in Iraq (vehicles) absolutely, did not work in Afghanistan, e.g. high mobility multi-purposed wheeled vehicle (HMMWV). According to the analysis of materials coming from the operation regions (Iraq, Afghanistan and other conflict areas), currently the use of active, reactive armour (consists of exploding plates of the explosive), or the layer armour made of several types of material (two armour plates of various thickness, where ceramic elements placed in alloy cast or plastic mass are located between them), is not sufficient anymore. There is a need to install cumulative screens. Inclined armour makes an efficient protection particularly against armour piercing sabots like APDS (*Armour-Piercing Discarding Sabot*), APFSDS (*Armour-Piercing Fin Stabilized Discarding Sabot)*. However, it is of little use in case of hitting by HEAT (*High Explosive Anti-Tank*) missiles. Screens that cause head explosion outside a critical distance for the stream of melted metal make a better protection against that type of attack. The laminated armour also provides an effective protection against the impact of HESH (*High Explosive Squash-Head*), HEP (*High Explosive Plastic*) – American equivalent of HESH) [12, p. 25] missiles. An example is shown on figure 4. The laminated (composite) armour is made of several dozen layers of glass fibres bonded with thermosetting polyester resin and it is covered with ceramic tiles. This additional armour provides protection against firing by antitank 14.5 mm calibre machinegun bullets fired from a short distance (level 4 STANAG 4569), and in some range also by the heads of the antitank grenade launchers. While the cumulative screens allow for minimizing the impact of the cumulative missile fired from a RPG grenade launcher. Based on the experience obtained in Iraq, Jelcz 146 armoured cabin, presented on figure 5, was used in high load capacity Jelcz trucks that were used in Afghanistan. It is made of armour steel, it has two separate windshields with flat armour glass and the doors include points for fixing the modular shields with a bulletproof glass. That version of the cabin meets the requirements imposed by STANAG 4569 at the level 1 of ballistic resistance (resistance to firing by 7.62 mm x 51 BALL) and at the level 1 of the anti-mine resistance (explosion of F1 grenade, anti-infantry mine

Fig. 4. Example of the use of the cumulative screen on KTO Rosomak vehicle
Source: DPI Ministry of National Defence

etc.). This is obviously a new quality and an answer to soldiers' demand in the field of safety. A soldier (the crew) taking care of his life by himself, that was the reason of the "homemade" extra armouring of Honker vehicles in Iraq, should not make a standard. It finally resulted in a professionally designed version of Scorpion 3.

It is evaluated that the crew safety does not depend only on the armour but also on various electronic equipment used in Iraq and Afghanistan. They include "Rhino" detonator initializer, CREW radio signal jammer or a system jamming the equipment used for radio remote firing of EJAB-C type trap mines. The PILAR Mk IIw acoustic system for shot detection and localizing a shooter, which was integrated with KTO Rosomak vehicle and has been operating since the first shift of the Polish Military Contingent in Afghanistan, should be mentioned as well. A knife for cutting the wires, installed on a vehicle, which was used in Iraq, is also worth mentioning. Anti-explosion seats and four-point seat belts also play a significant role in the crew safety improvement.

Fig. 5. Jelcz 146 armour cabin
Source: Report 1/2008

It should be also noticed that the crew safety field does not only include the military equipment and the passive safety system, aimed at reduction of explosion effects, but also the active safety system including: ABS, ASR, BAS, etc. All together, they should provide high desired level of the vehicle crew protection.

Mobility – In other words, manoeuvrability is the last presented determinant affecting the crew safety. It depends on two factors: the ratio of the engine power to the weight of the vehicle and a type of applied suspension. It is evaluated that manoeuvrability, understood in terms of operation and tactics, includes mobility, agility and the ability of crossing. In relation to mobility, that is a vehicle ability to develop average maximum speeds in various terrain conditions, it determines a possibility of long-distance trips. In addition, it is important particularly at the operation scale, i.e. fast moving on the battlefield and it significantly affects the vehicle or the crew safety. In case of agility, it will include a possibility of making turns of various radiuses in a short time. It affects the speed of bypassing various terrain obstacles, change of direction, proper position of the vehicle in relation to the enemy, resulting in significantly reduced possibility of destruction and allows for better use of own weapons. While the ability of crossing, will be understood as ability to cross various terrain obstacles. Most often it is defined as a possibility of crossing such obstacles as: hills, dips, ditches, slopes and counter-slopes, walls, forests, wetlands, snowy terrains and all types of water obstacles [10, p. 42]. Higher vehicle ability of crossing the terrain obstacles is also obtained thanks to the reduction of unit pressure on the ground (e.g. caterpillars in case of a tank or infantry fighting vehicle) and a good traction. It should be underlined that the mobility parameter or agility parameter is strictly related to the aforementioned determinants: armour resistance to the means of destruction, vehicle structure and additional vehicle equipment. It is a difficult choice between the armour resistance and mobility or buoyancy.

4. Evolution within a scope of crew and vehicle safety improvement

The increase of availability and saturation of the battlefield with various means of destruction, presented in the above sections, has become a very dangerous weapon of common use, difficult to detect and destroy. In order to provide protection against them in Afghanistan and Iraq, vehicle shields in a form of rods, wire mesh of very high resistance to tearing or additional plate shields were used. However, it significantly limits their manoeuvrability and mobility, particularly in the urban area. Recently, the works have been carried out more and more intensively on vehicle shields, providing protection against cumulative missiles, consisting of plates at very high voltage.

The core formed under the influence of explosion of the cumulative explosive, when piercing further plates, it shorts the electrical circuit, which in turn causes weakening and dispersion of that core [21, p. 24]. However, these are solutions from the area of the passive vehicle protection. The use of the active protection systems, allowing undertaking action ahead of the missile action in order to prevent from piercing the vehicle armour, makes a kind of perspective. The systems of that type have to detect approaching missiles of the enemy in advance by means of detection system, a then they have to destroy these missiles at safe distance or cause their detonation or change its flight direction. Operation of the active protection systems can be divided into the following stages:

1. environment recognition, analysis and verification (classification) of the approaching threat;
2. threat tracking and guidance of means of threat prevention,
3. making decision on activation of means of prevention,
4. destruction or weakening of threat at the point of interception [21, p. 25].

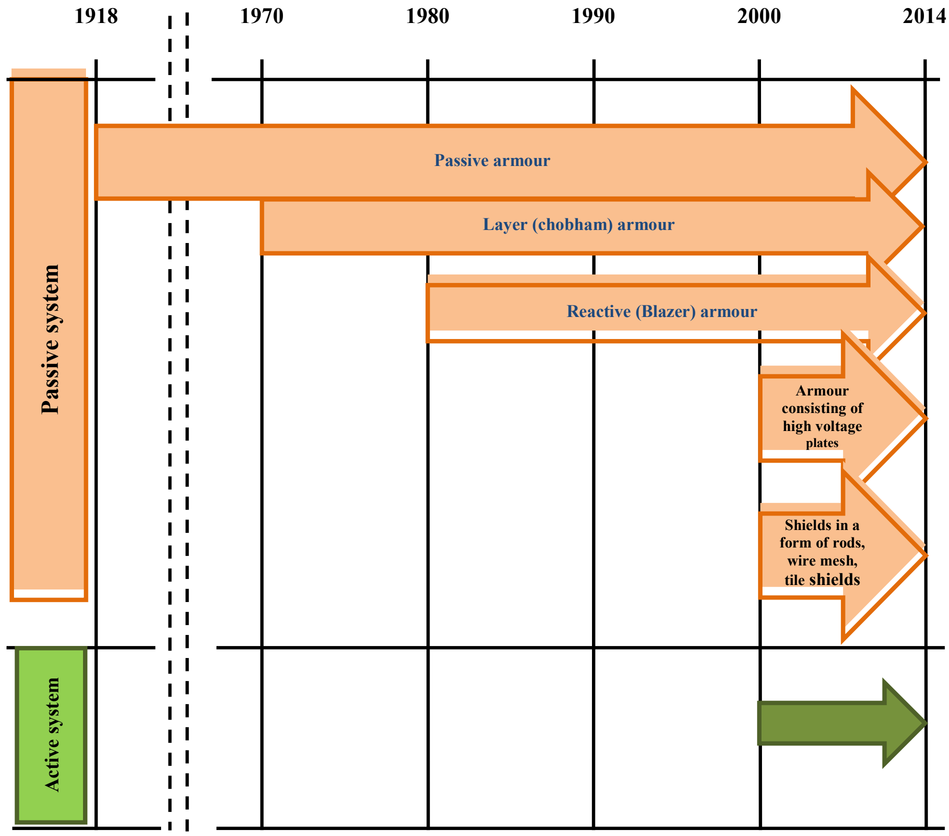

Fig. 6. Evolution of the vehicle protection systems
Source: Own work

Common features of undertaken actions include increase of safety and crew protection improvement. The truth is that the course of classic war is somewhat predictable. You can adjust proper means, prevention systems to it. While the war of asymmetric nature, as mentioned above, is unpredictable in many aspects. You can put an argument that each action, requiring more or less financial expenses, improving the crew safety is right. Even action like covering the vehicles with sandbags (Iraq). The crew protection evolution is presented on figure 6.

According to the analysis of the development of the vehicle protection systems presented on figure 6, armed conflicts carried out in the 2nd half of the 20th century inspired designers to make changes in the field of the crew safety, and hence to improve its vitality, as shown in table 6. This thought is also continued nowadays. Currently, newly designed vehicles have modular armouring and seats providing protection against the effect of explosion of mines under the vehicle body.

Moreover, vehicles are adapted to a quick assembly of external rod shields, reactive armour and steel-ceramic modules. Ballistic and anti-mine resistance of vehicles has already reached the level IV according to STANAG 4569 version A and B. Designers seek to keep a relatively low vehicle weight at the same time. Stryker DVH carriers, equipped with a double bottom of the body, designed in order to significantly improving their resistance to the effects of the improvised explosive devices (IED), can make an example. Moreover, they have been equipped with reinforcement of the load capacity of 55 000 pounds (app. 25 tons), and several other improvements, including the seats absorbing the energy of explosion for the members of the crew and the landing troops as well as new items of the on-board power generation system [18, p. 8]. It seems that this is not the end of capabilities of the industry working for the benefit of the army.

5. Summary

The term – *force protection* has become popular in recent years. That means providing the maximum protection for the soldiers against the enemy's action and keeping the ability to execute assigned tasks at the same time. This is significant that the authors of the MRAP concept, manufacturers as users have not expected that the mine-resistant vehicles are indestructible and nobody said that they are [14, p. 34]. It should be noticed that each structure has its limitations, resistance limits also within a scope of ballistic and anti-mine protection. Apart from protection, a vehicle has to provide the users with, among others, mobility, off-road capabilities and proper load capacity. Therefore, it is difficult to keep proper relations between protection, vehicle dimensions and mobility. This configuration makes a triangle of interdependences (*iron triangle*), which decides about the suitability of a particular structure to the execution of particular tasks. It is assessed that improvement of each of these parameters will negatively affect other parameters, e.g. the increase of the vehicle armour weight results in deterioration of mobility properties and limits its load capacity. In addition, vice versa, the improvement of vehicle mobility or load capacity limits the level of ballistic and anti-tank protection. Moreover, here come the new technologies like composites and light metals to provide the aid. Human being should be of the highest importance in every action. It is assessed that a human being is the weakest component of the safety system. I mean his behaviour and mistakes made by him. That is why it is important to eliminate the cause by analysing the experience and mistakes made during operations and use the lessons as part of training.

It is assessed that the use of various systems and means of vehicle protection in the new 20th century have been inspired by operations carried out in Iraq and Afghanistan, where the classics faced the new unpredictable form of combat. However, is unconventional, asymmetric war something new? This is a typical guerrilla war run by the other side by means available for them. It seems that the coalition was not prepared for that form of operations in many regards.

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