THE GENERAL JONAS ŽEMAITIS MILITARY ACADEMY OF LITHUANIA

CHALLENGES TO NATIONAL DEFENCE IN CONTEMPORARY GEOPOLITICAL SITUATION

CNDCGS`2018

International Conference and Live Firing Show' 2018

April 25-27, 2018

Proceedings

COGITA UNIVERSALITER – AGE REGIONALITER
NATIONAL DEFENCE FOUNDATION

kaunas university of technology

GENERAL JONAS ŽEMAITIS MILITARY ACADEMY OF LITHUANIA

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PROCEEDINGS OF THE INTERNATIONAL SCIENTIFIC CONFERENCE

ISSN 2538-8959 (on-line)

GENERAL JONAS ŽEMAITIS MILITARY ACADEMY OF LITHUANIA
KAUNAS UNIVERSITY OF TECHNOLOGY
NATIONAL DEFENCE FOUNDATION
LITHUANIAN RIFLEMEN'S UNION

CHALLENGES TO NATIONAL DEFENCE IN CONTEMPORARY GEOPOLITICAL SITUATION

CNDCGS`2018

PROCEEDINGS OF THE 1th INTERNATIONAL SCIENTIFIC CONFERENCE

EDITORS
S. BEKESIENE AND S. HOSKOVA-MAYEROVA

April 25-27, 2018
Pabrade, Lithuania

VILNIUS 2018

CONFERENCE IS ORGANIZED BY
General Jonas Žemaitis Military Academy of Lithuania
Kaunas University of Technology
National Defence Foundation
Lithuanian Riflemen's Union

The proceedings of the 1th International Scientific Conference CHALLENGES TO NATIONAL DEFENCE IN CONTEMPORARY GEOPOLITICAL SITUATION contain selected papers of ten topics: Defence Technologies and Aviation; Cyber Threats and Security Issues; Democracy, Contemporary Threats and Warfare; Modern Technologies and Social Sciences; Multi-Criteria Decision-Making; Sustainable Defence Solutions; The Impact of New Defence Technologies on Human; Defence Technologies: Education and Training; Environmental Issues and Modern Technologies; Challenges to Face New Defence Technologies.

All published papers were peer-reviewed by independent reviewers.

The language of the papers was not edited. The language quality falls on the authors' responsibility. Only minor editorial corrections were made by the Publisher.

Conference Organizing Committee address:
Military Academy of Lithuania
Šilo Str. 5A, LT-10322 Vilnius, Lithuania

PREFACE

The first international conference *Challenges to National Defence in the Contemporary Geopolitical Situation* (CNDCGS-2018) was held on 25–27 April 2018 at Pabradė Training Area, Lithuania.

The conference was organized by the General Jonas Žemaitis Military Academy of Lithuania, Kaunas University of Technology in cooperation with the National Defence Foundation and Lithuanian Riflemen's Union.

The CNDCGS-2018 brought together practitioners and researchers to discuss important issues related to current and future challenges to European defence capabilities and helped to collect great innovative ideas for future development. Also, essential contribution was made to defence innovation. The conference attracted a significant attention of the Lithuanian society and increased the international political community, U.S. and European decision-makers' awareness of the Baltic region security.

The CNDCGS-2018 aimed at sharing the latest information on the national defence issues in the contemporary geopolitical situation. The primary goal was to present the highest quality research results on different aspects of defence. The main areas covered in plenary sessions included sustainable defence solutions, defence technologies, environmental issues, modern technologies, multi-criteria decision-making and other relevant topics related to specific challenges to the European defence in the contemporary geopolitical situation. A critical element in achieving it was the evaluation and selection procedure developed by the Scientific Committee of the conference.

The invitations to the CNDCGS-2018 listed the instructions for preparing reports, abstracts, manuscripts and deadlines. All the works presented during the conference and published in the Proceedings Book underwent the procedure for submitting proposals, including requirements and deadlines (http://www.lka.lt/lt/moksline-veikla/konferencijos-ir-seminarai/2017-m._983/tarptautine-moksline-konferencija-zne8/guidelines-for-abstracts.html).

The CNDCGS-2018 participants presented their research results in the extended abstract format of 500-1000 words for the Abstract Book and full-length papers of approximately 10 pages for the Proceedings Book. The Scientific Committee selected authentic and original full-length articles which have never been published before. All the papers were evaluated in terms of topicality, originality and general quality. After a double-blind peer review, all the accepted full-length papers were included in the Proceedings Book. Following the requirements, the proceedings became a valuable source of new information which allows evaluating the researches of scientists from different countries.

The conference was the result of a collective effort, and, therefore, I would like to express my very great appreciation to everybody who has made it possible to organize the CNDCGS-2018. I am particularly grateful to the members of the organizing committee for strong motivation and smooth process throughout the conference. Also, I want to thank all of the authors for contributing their articles. Finally, I would like to express sincere gratitude to all of the Scientific Committee who has guaranteed the quality of the accepted papers.

Prof. Svajone Bekesiene
Chairman of the CNDCGS-2018

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Analysis of Dismounted Operation Support with Robots

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Abstract

Military operation in rough terrain are very often conducted as dismounted operation. In this condition the logistic support is very problematic because all equipment is carried by soldier. It reduces the mobility and agility of troops.
In the paper the demand for supporting dismounted operation UGV are described and concept of robot's solutions are presented.

KEY WORDS: *mobile robot, Unmanned Ground Vehicle, UGV, logistic support, dismounted operation.*

1. Introduction

Increasing combat abilities and the range of tasks performer by certain subdivisions results in an upsurge in both the weight of armaments and equipment that they must transport with them. That problem is particularly prominent in groups performing their tasks on foot. It's currently estimated that a 3-day expedition requires each soldier to carry up to 75 kg of equipment, while a single day military patrol indicates a burden of up to 45 kg. Single-handed carrying of such weights decidedly decreases the mobility of soldiers, thus prolonging the time needed to complete a task and lessening the probability of success. It also creates a considerable hazard in terms of battlefield survival.

In order to improve the situation, the carried weight would have to be limited to 25 kg per soldier – including standard armament, ammunition, uniforms, bulletproof vests, a helmet and personal means of connections. Other equipment necessary for fulfilling the task should be shipped via separate means of transport, moving directly with a team or a platoon, as indicated by military experience of British and American armies in Afghanistan. The forces used crossing quads with trailers (carrying capacity of 300-400 kg). That solution improved both the mobility and the combat quality of pedestrian subdivisions, but it was not devoid of shortcomings. When crossing a rough terrain, the speed of marching falls to 1-3 km/h and since the quads' powertrains were neither adjusted to such slow speeds, nor used to overcoming certain hurdles, problems arose. It is also worth mentioning that the number of soldiers ready for interventions was decreased, as drivers were forced to focus solely on steering the quads. In addition, they have too low off-road mobility.

It can be concluded that in order to support the soldiers directly on the battlefield, one should use UGVs (robots) capable of following a guide – a selected soldier. They should navigate around obstacles autonomically and exhibit mobility close to that of an infantry soldier. Unmanned vehicles (platforms) are expected to transport the necessary supplies of ammunition, warfare, team weapons, food and water, communications, backup power supplies, camping gear, etc. If necessary, they will also serve as means to evacuate the wounded. Transportation at an operational level does not place vehicles on such high demands in terms of off-road properties. The available communication routes are used, which in most cases allow the use of standard trucks. A separate issue is that there must be a significantly higher efficiency of such a system. To ensure these vehicles with a load capacity of a dozen or so on even tens of tons should be used. By using the results of one of the research programs, commissioned by the US Army, it can be concluded that the implementation of robots of logistic support at the operational level is currently pointless. As part of it, trucks were robotized and adapted to autonomous movement in the marching column. Despite the positive results of the work, it was not decided to apply this solution in practice. It was dictated, among others experience gained by the American army from the activities carried out in recent years in Iraq and Afghanistan. As part of it, trucks were robotized and adapted to autonomous movement in the marching column. Despite the positive results of the work, it was not decided to apply this solution in practice.

In addition to tests under normal road conditions, where the system worked properly, simulated its behavior in the fire action of the opponent (such as the explosion of the trap mines) and tested the resistance to takeover by the opponent. They showed that in such a case there may be a serious increase in the risk of internal forces, which negatively affect the safety of operations and the size of losses. To avoid this, it is therefore necessary to provide a high degree of protection for the march of unmanned vehicles. In the opinion of project commissioners, the balance of advantages and disadvantages, in connection with the total costs of implementing and using the system, turned out to be unfavorable.

Bearing in mind the above conditions, it can be concluded that the most desirable logistic support platforms will be solutions based on the tactical level, i.e. the team, team and troop.

The analysis of operations conducted as part of contemporary armed conflicts allows us to conclude that at least two sizes of robots for logistic support are desirable:

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a) light - with a load capacity of 200 ÷ 400 kg and own weight of 500 ÷ 800 kg,

b) heavy - with a load capacity of about 2,000-3,000 kg and own weight of 4,000 ÷ 5,000 kg.

The smaller one would be intended to support team or team level activities. The weight of the transported cargo is sufficient to carry 30 ÷ 40 kg of individual and team equipment for each team soldier.

The heavy platform would have to support team or platoon activities. It would be possible to provide supplies for sub-units (ammunition, weapons, food, water, dams, etc.) directly to the places of their dislocation, where often there are no roads that could be used by off-road vehicles. In the area of applications, it would also be possible to transfer the equipment of the whole troop, moving in a pedestrian formation into a new place of task implementation. A desirable feature of the case of this platform is to make it easy to take and transport palletized loads

2. Investigation Results

The tactics of logistic support robots' usage will depend on the nature of tasks performed by each subdivision. There are three main scenarios of their usage that can be predicted.

The elementary scenario consists of transporting the equipment of subdivisions on platoon level, a team, a group or a single soldier operating on foot on a rough terrain, where using standard SUVs proves to be difficult, impossible or futile. The robots will then move within or behind the grouping, using the option of remote control by the operator or follow the soldier-guide independently. In addition to the transfer of the equipment itself, it is also possible to use such platforms as a means of transport for soldiers. Control should then take place using the on-board system

Another form of usage will be an autonomically transport of equipment between given points, allowing for complementing soldiers' provisions or providing additional tools. The platform should then move in a coordinated way. This type of activity will be able to be implemented in areas and at distances that minimize the risk of taking over the robot by the opponent or making it his own combat agent, as well as in areas This type of activity will be able to be implemented in areas and at distances that minimize the risk of taking over the robot by the opponent or making it his own combat agent, as well as in areas threatened by its fire action.

The third nature of platform's actions will be tied to evacuating wounded soldiers from areas unsuitable for first-aid. Such a task would be carried out by a robot i if it would be dangerous for life or health to be carried out by humans. The robot control would then take place in the teleoperation mode. It is also expected that platforms with adequate payload (min 80 kg) and the size of the cargo space will be able to be used to transport wounded unable to move on their own - to medical help points. This task should be carried out autonomously.

An additional function of the logistic support robots would be to use them as a power source, mainly electric, for other devices and systems (radio stations, listening stations, interfering stations, etc.).

It is also acceptable to use them for simple image recognition, based on standard on-board cameras. This would take place when the development of the combat situation would make it impossible to use (owning, reaching or bringing back) dedicated applications for this purpose.

A very important feature of these platforms is mobility in the broad sense. Its basic indicators will be speed, ability to overcome obstacles and maneuverability. No less important is also the time of continuous work, i.e. without refueling or power sources. It should be enough for at least one day mission, both day and night. In military conditions, it cannot be less than 10 hours, 80% of this time should be for driving at a speed of 5 km / h. It is desirable, however, that it is possible to carry out missions lasting 24 ÷ 72 h.

Logistic support robots should be equipped with a control system ensuring them to perform tasks in the following modes:

- following a designated soldier-guide (so-called "follow me" function) with autonomous detection and bypassing obstacles (including mobile ones);
- remote control with the controller (range at least 100 m in urban areas and at least 500 m in open areas) with the desired teleoperation option;
- autonomous navigation around the designated route;
- on-board control (an operator driving on a robot or walking close to it).

It is also desirable to consider the possibility of issuing selected commands by a voice or gesture.

The maximum speed should be at least 13-15 km / h, which is equal to that obtained by a soldier running with armament. It is advisable to develop up to 30 km / h, which in turn results from the maximum speed achieved by the average person. Efforts should be made to minimize robot signatures, ensure protection of transported equipment and protect against unauthorized use.The option available for these carriers should also be to equip them with a system allowing the evacuation of the wounded. In the basic scope, it should be understood as taking them from the area endangered by the enemy's fire action. It is permissible to do this by grasping the victim for the uniforms (equipment), limb or stretcher and pulling after the robot. It is desirable that this task could be carried out in the mode of teleoperation. In the extended form of the evacuation function, one should additionally ensure the possibility of wounded transport on the / to the place where specialized assistance was provided.

In order to meet these expectations at the Military University of Technology, work was undertaken to create a base chassis for a light logistic class platform. By entering the design works, it was assumed that its total weight should be about 800 kg, and mobility should correspond to the possibilities of a man moving with 30-40 kg load. In terms of terrain properties, it was assumed that the robot should be able to, inter alia:

- overcome high curbs;

- drive up the standard stairs;
- move around the rubble;
- move in the desert area;
- overcome the narrows with a width of approx. 1.2 ÷ 1.5 m (narrow streets, forest and mountain paths, etc.).

In turn with reference to maneuverability, the turning radius should definitely be smaller than that obtained by light off-road vehicles, below approx. 4 m. It is even desirable to make a return in place. The logistic platform designed for direct and comprehensive logistic support of pedestrian sub-units operating in very rough terrain, which eliminates the possibility of support by standard vehicles, must be able to overcome difficult terrain and develop the speed of travel, adapted human capabilities. Difficult terrain should be understood as both the type of the ground and its sculpture, obstacles and vegetation growing on it. The ability to overcome should be considered in conjunction with the expected speed and secrecy of moving sub units. These speeds largely depend on the type of tasks being carried out:

- during the walk, in favorable terrain conditions usually take the form of 3-5 km / h;
- if necessary, fast regrouping can reach 7-8 km / h (fast march), and even 12-15 km / h (gear with equipment and weapons);
- during patrol in the area with high threat of advancing speed they drop below 3 km / h (up to 1 km / h).

Such low speeds cause problems for standard vehicles because their traction characteristics are adapted to higher travel speeds. In addition, there are problems with overcoming obstacles due to the low speed and inability to use the inertia of the vehicle.

The main advantage of the platform should be the ability to overcome terrain obstacles not available especially for standard military wheeled vehicles, at a speed adapted to moving supported sub-units. They include:

- areas with low bearing capacity, in particular crop areas, after rainfall or during thaw;
- stony areas (boulders);
- dune areas (sandy);
- areas covered with vegetation with available narrow forest paths;
- wilderness with large inequalities;
- roadside and drainage ditches.

According to the assumptions, the main purpose of the platform is to transport loads weighing 250 kg, which may include: team weapons, team and personal weapon ammunition, personal soldiers' equipment, means of communication, spare batteries, food rations and water . If necessary, the platform should allow transport of the wounded. It is anticipated that the basic form of using the platform will be to support the infantry squad or platoon. The platform will be brought to the area of operations, and during the implementation of support tasks will be controlled by means of a personal control station or by means of a system following the guide. Effective implementation of this type of mission requires from the platform:

- high transport susceptibility (indispensable for not having to accompany the main forces and quickly reach the area of operation);
- quick transition from transport to work position;
- ability to overcome terrain obstacles both when driving at full load and without load;
- in favorable conditions, the ability to follow a guide;
- very high longitudinal and transverse stability, both unloaded and loaded.

Critical for the mission are:

- the ability to overcome ground road ditches and other obstacles with and without load;
- ability to maintain stability with and without load;
- ability to develop low speed also while overcoming obstacles;
- ability to support subunits for a long time without replenishing energy sources.

This places particularly high demands on the chassis together with the drive system and the load space, which should be shaped in such a way that the mass of the load influences the distribution of pressures to the ground and developed tractive forces as well as does not disturb the platform's stability. The task analysis indicated that the chassis should meet a whole range of different requirements, including:

- ensure high stability while driving and working - it is therefore inadvisable to use flexible suspensions;
- provide a large cargo space necessary to assemble the attachments, in particular the manipulator in the transport position;
- provide a relatively long platform length, significantly improving the ability to overcome roadside ditches;
- copy terrain irregularities very well and ensure an even distribution of pressure on the ground in order to develop high traction forces necessary to overcome terrain obstacles and develop towing and pulling forces;
- ensure low unit pressure on the ground (indicated smaller than necessary for detonation of mines), enabling to overcome areas with low carrying capacity;
- provide low rolling resistance - with a long length and limited width, it eliminates the possibility of using a side-turn steering system;
- provide low resistance movements, also on unpaved surfaces;
- reduce vibrations generated by ground unevenness, disrupting the operation of detectors and teleoperation system cameras;
- reduce noise emissions during ride.

In addition, it should have a relatively small width (it should not exceed 1.25 m) and low own weight.

The imposed expectations limit the possibilities of shaping the chassis structure. The problem is aggravated by relatively small allowable sizes and low weight. The theory and design principles developed for standard, heavy vehicles cannot be directly used. This is particularly true in the area of terramechanics (vehicle-terrain interaction), where extrapolation becomes very risky. In this field, knowledge is based on experimental research and the size of systems cooperating with the ground and the magnitude of the pressures. The developed relationships are valid only in the scope of the studied population of solutions and the existing loads. The designed platform differs significantly from them, both in terms of weight, pressures and dimensions - hence, you cannot uncritically reach for recommendations and indicators developed for tanks or other off-road vehicles. In the case of heavy vehicles, the best ability to overcome terrain obstacles (and developing tractive forces) is characterized by tracked vehicles with side torsion, which are normally used by metal tracks, sometimes equipped with rubber overlays. They are characterized by low ground pressure and relatively low rolling resistance. On paved roads, they do not exceed 4-5% of gravity. The disadvantages of this solution include: very high rolling resistance, low durability (about 6-9 thousand km, i.e. 250-400 h at speeds of 25 km / h) and high operating costs as well as the generation of relatively high noise. For this reason, in mini machines (weighing up to 6-7 t) and because of significantly lower loads - elastomer tracks are dominant. They are characterized by: significantly longer durability (about 2,500-4,000 hrs. of work), a relatively low price, and are quiet and allow you to move on hardened roads (they do not damage the surface).

The research carried out at the Military University of Technology confirms these advantages. However, they point out (the "Dromader" testbed vehicle that the rolling resistance of elastomer tracks even on load-bearing substrates is 2-3 times higher (reaching 15% of gravity) than the resistance of rolling heavy steel tracked caterpillar tracks. This results in a much higher engine load and proportionally higher fuel consumption. This is essential for the weight of the drive unit (extended cooling system) and the necessary size of the fuel tank, and consequently its mass. These features are extremely important and disadvantageous for the intended application. In addition, drive road wheels of the protrusions and grooves of the elastomeric tread induce significant vibrations of the entire vehicle - it is advisable to use susceptible elements to suppress the generated vibrations. A serious disadvantage of standard solutions of tracked chassis, with side steering systems, is their high rolling resistance. The resistance reduction requires that the length of the track on the ground does not exceed 80% of track spacing, and it is a solution commonly used in mini-machines, excavators, bulldozers and other maneuvering machines. However, this results that the machines are relatively short and wide, with low longitudinal stability and high sensitivity to unevenness. For these reasons, this indicator is about 170% in high-speed vehicles. The price for good longitudinal stability is high resistance to turning. A certain solution to the problem is the division of the track and the use of an articulated steering system. With a relatively large track length on the ground (the sum of the length of 2 tracks), the rolling resistance is only about 2 times higher resistance to driving. Such a system was tested on the testbed vehicle "Dromader". It uses commercial, standard delta elastomer tracks. Tests of undepreciated elastomeric systems have shown that despite the undoubted advantages (availability, reliability, high adhesion), the use of standard solutions leads to an increase in the mass of the structure (mass of a single track exceeds 40 kg), generates high rolling resistance (reach 15% of gravity on smooth hard surfaces) and can generate significant vibrations. The reduction of these defects would require the development of their own design, which would increase the risk of the project. For these reasons, it was assumed to use wheeled chassis. The review of the solutions of drive system used in high mobility vehicles shows that in terms of the ability to overcome obstacles, the most advantageous solution is 8x8 wheeled drive systems. Wheels are then most often connected in pairs attached to a trolley one. To ensure high maneuverability and terrain copying ability (uniformity of wheel loads on the ground), an articulated steering system and swivel elements connection are used. This solution also allows for the installation of track belts. The high mobility of the platform with such a chassis has been confirmed by computer simulations carried out in MUT.

Designing the chassis, it was necessary to pay attention to the possibility of its significant overloads. This is indicated by the report of months of tests of the combat use of robots carried out by the United States Army. During maneuvers, it was common to overload their bearing structure by up to 100%. The soldiers did not comply with the technical limitations and used them not only for transporting cargo, but also as means of their own transport. In almost two months practically all were seriously damaged due to this. During designing, special attention was also required for lateral stability. A report from these tests indicates that all platforms involved in the test had problems in this area and were knocked over. Most often this occurred during night exercises with the use of night vision devices, which shorten the perspective and distort the assessment of distances and obstacles. It also pointed to common problems with overloading and overheating drive systems, especially in rough terrain, when riding at low speeds. The platforms were equipped with an electric drive and required stopping the engines to cool down. They were also characterized by far too small operational range (in the order of 16 km). Power generators were commonly used to supply them. In addition, it was found that platforms developing maximum speeds of 8 km / h limit the mobility of sub-units (they limited the speed of movement of soldiers). Therefore, it is advisable to develop speeds of at least 12 km / h. Two load standards were adopted when creating the logistic platform concept, two elementary loading standards were assumed – a military backpack (height of 70 cm, width of 35 cm, depth of 30 cm, loading mass of 30 kg) and an ammunition box (height of 17 cm, width of 35 cm, depth of 50 cm and mass of 24 kg). Moreover, possibilities of transporting the wounded on stretchers (width of 60 cm, length of 220 cm) were considered. It was assumed the platform should transport 10 ammunition boxes or 8 backpacks (payload 240 kg). The conceptual solution developed for the platform (Fig.1.) allows transport of 3 rucksacks on the front and 5 rucksacks on the rear section and radio stations in an easily accessible place on the side of the front platform part. Backpacks are inserted into the cargo space and hooked (hung) additionally by the ear of a special frame. They can also be hung outside the rack

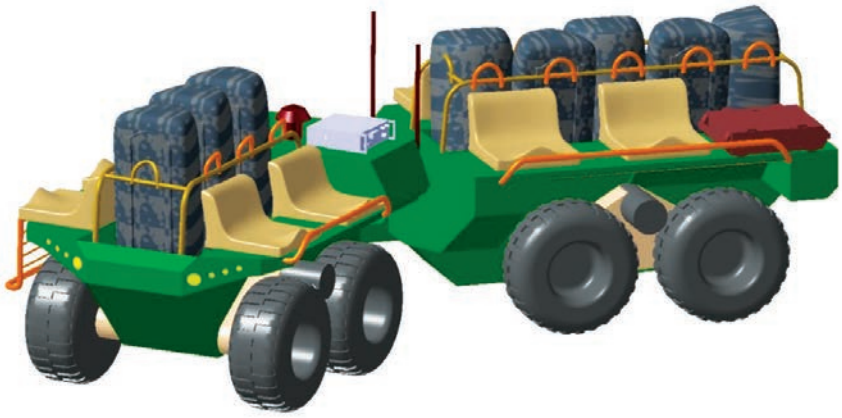

Fig.1. The maximum load on the platform with backpacks

Inside the cargo space (between the sides) there are 10 ammunition boxes in 2 layers (4 on the front part and 6 on the rear section) allowing you to load lightweight equipment or backpacks on them. This can cause overloading of the structure by an additional 250 kg. The distribution of the load in this case is beneficial and should not pose a significant problem. Of course, the platform with an additional load will not be able to overcome steep climbs (60%) and other obstacles due to the limited amount of propulsive force and deterioration of its stability. Optionally, 8 seats can be placed on the sides of the platform, which in favorable conditions (low rolling resistance, low resistance of the slope, small transversal inclinations) enable transport of soldiers – (Fig.2.).

However, it can cause a significant overload of the structure - up to 500 kg. This is a serious structural challenge, causing the necessity of extremely meticulous analysis of the impact of this factor on the accepted mass of the carrier. The dimensions of the platform, and especially its rear section, allow transport of two injured on a stretcher - Figure 3 - placed on the sides. It does not reduce the load space, however it requires the use of additional telescopic brackets and slightly reduces the stability (especially when the load is asymmetric).

Another option for transporting injured people is to assemble the central frame of the rear section and place the stretcher in the middle - Fig.4. It does not require the use of telescopic brackets, it improves transverse stability, but it significantly reduces the load space.

Fig.2. Under favorable conditions, the platform can carry up to 8 soldiers - the legs of soldiers must be protected with special folding shields

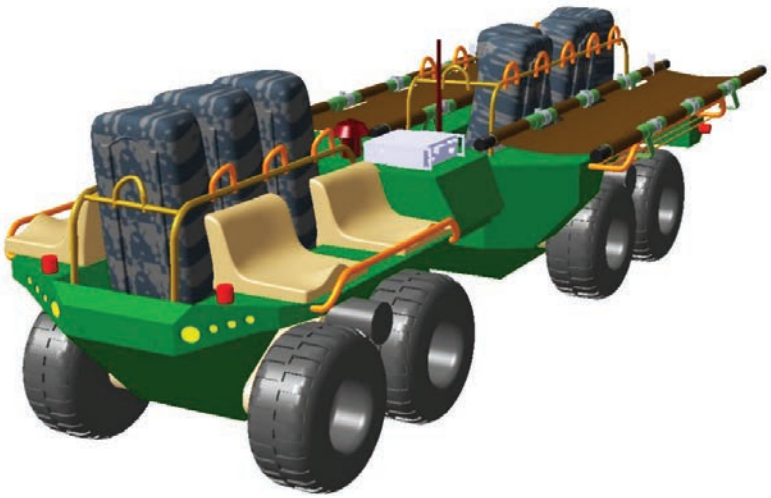

Fig. 3. The platform allows transport on the sides of 2 stretchers, but this requires the use of additional telescopic brackets

The developed platform concept ensures high longitudinal and lateral stability, also in the turn (Fig.5) - due to the appropriate configuration of the load space and even load distribution.

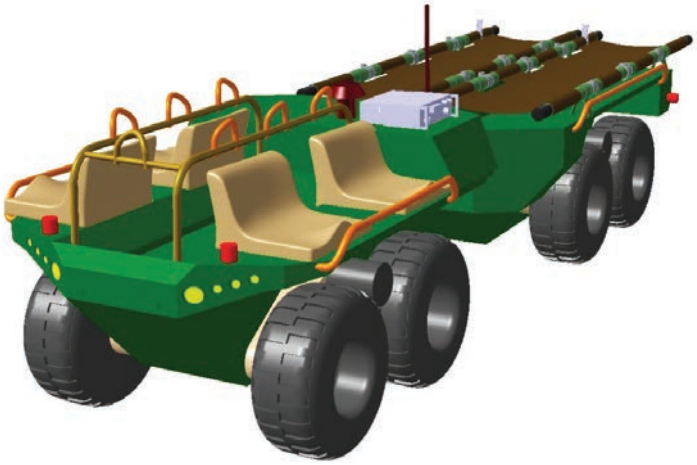

Fig. 4. Transport of the stretcher after folding the central frame of the rear section

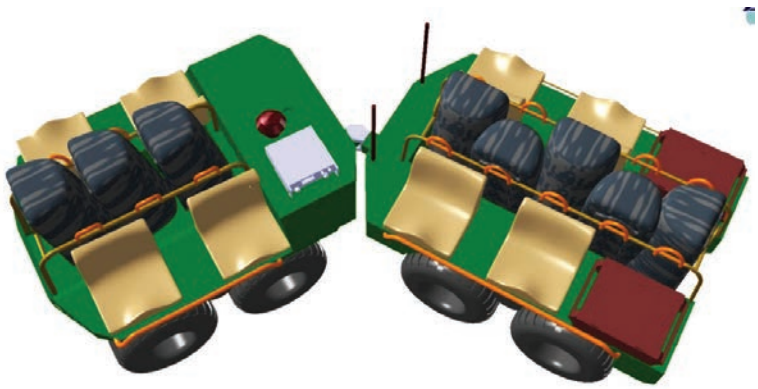

Fig.5. Load distribution ensures high platform stability also in the turn

Conclusions

The developed conception will be the basis to building mobility demonstratives, which will allow for verifying the assumptions and for final shaping of the logistic support robots, which could – in the nearest future – become a part of equipment of the Polish military forces. The logistic platform concept has been shaped in terms of mobility and

work possibilities in such a way as to obtain the right traction force, maximum speed, transverse static and dynamic stability, distribution and mass values (distribution of component components), ability to overcome terrain obstacles, overall platform width, tire selection, approach and departure angles and ground clearance. The analyzes necessary for this purpose were carried out in an analytical and simulation way. During shaping its constructions, following conditions were presumed:

– maximum speed - 12-15 km/h;
– climb slope - 60% (ability to drive);
– cross slope - 30% (ability to drive);
– payload - 250 kg;
– weight - 550 kg;
– turning radius (curb-to-curb)- 2,5 m;
– width - 1,25 m;
– worktime - 10 h;
– the ability to cross roadside ditches with a hill slope of 50%, a bottom width of 0.4 m and a depth of 0.7 m;
– possibility of observing the area from a height of 3.5 m;
– width 1,2 m;
– deck height 0,75 m;
– height to the antenna frame 1,8 m.

Acknowledgements

This work was conducted within the framework of the project "Platforma średnia (klasa 800 kg)" - grant no. DOBR-BIO4/083/13431/2013. The authors are thankful for the Polish "National Centre for Research and Development".

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Experimental Study on Ballistic Resistance Test of AA2519/AA1050/ Ti6Al4V Laminate According to STANAG 4569 Level 2

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Abstract

The aim of this paper is to investigate the ballistic properties of laminates made of light alloys under various configuration and thickness. The laminates were obtained by explosive welding method. Composite components are aluminum alloy AA2519 and titanium alloy Ti6Al4V with the aluminum alloy AA1050 as intermediate layer. The paper describes the influence of the bullet impact energy on the structure of the panel, depending on the configuration of the laminates: thickness of the layers and the applicated heat treatment. Ballistic resistance tests were carried out in accordance with the standards STANAG 4569 Level 2. The results of the research were compared to the ballistic resistance of typical material used for ballistic shields production.

KEY WORDS: *explosive welding, cladding, laminates, aluminum, titanium, ballistic resistance, STANAG standard*

1. Introduction

An important factor for the development and reliability of technical objects exposed to bullets is adequately high ballistic resistance and, at the same time, the lowest density. Typical metallic ballistic shields are supporter for the objects and additional shields depending on the type of threat. The high weight of the armored steel often used to produce ballistic shields leads to limit the protected elements in military construction [1]. Additionally, steels shields are used as a monolithic shields which protect the construction against the impact of small bullets with the lower range of velocity. To protect the most sensitive elements of the construction, Whipple shields are typically used as a passive ballistic shields located in exposed zones [2,3]. The type and thickness of these boards varies depending on the degree of hazard and exposure of the place exposed to damage. Currently, the most promising ballistic shields are explosively welded laminates made of aluminum alloy AA2219 and titanium alloy Ti6Al4V [4].

The explosively welded laminate made of base materials: aluminum alloy AA2519 (AlCuMgMn + ZrSc) and the titanium alloy Ti6Al4V were described only in few publications [7,8]. Previous works included examination of layered composite material Ti6Al4V/AA1050/AA2519 indicate present of diffusion layer Al3Ti between titanium and aluminum alloy which provide high mechanical properties including high ballistic resistance [5-7]. It was assumed that such laminate is characterized by unique properties that combine the beneficial properties of titanium alloy, aluminum alloys (high strength, high plasticity and low density) and intermetallic phases Ti-Al (high hardness and stiffness) [8-11]. Properties of the laminate change depending on the applied heat treatment [12].

Different properties of the base materials have an influence on energy dissipation in materials during ballistic resistance test. A significant is also thickness of the layers and their order relative to the projectile shot direction [13]. Energy absorption by the layers of the laminate is manifested on only by the rapid deceleration of the projectile, but also by the level of fragmentation of the laminate. In layered materials, there is also a risk of delamination of the material [14].

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2. Materials and Methods

Explosive welding process was performed by EXPLOMET High-Energy Techniques Works. Chemical composition and mechanical properties of base materials are shown in Tables 1-3.

Table 1

Mechanical properties and chemical composition of the Ti6Al4V alloy

Mechanical properties			**Chemical composition (wt %)**							
Rp0,2 (MPa)	Rm (MPa)	A (%)	O	V	Al	Fe	H	C	N	Ti
950	1020	14	<0.20	3.5	5.5	<0.30	<0.0015	<0.08	<0.05	rest

Table 2

Mechanical properties and chemical composition of the AA2519 alloy

Mechanical properties			**Chemical composition (wt %)**								
Rp0,2 (MPa)	Rm (MPa)	A (%)	Si	Fe	Cu	Mg	Zn	Ti	V	Zr	Sc
312	335	6.5	0.06	0.08	5.77	0.18	0.01	0.04	0.12	0.2	0.36

Table 3

Mechanical properties and chemical composition of the AA1050 alloy

Mechanical properties			**Chemical composition (wt %)**							
Rp0,2 (MPa)	Rm (MPa)	A (%)	Fe	Si	Zn	Mg	Ti	Mn	Cu	Al
120	115	3	0.4	<0.25	<0.05	<0.05	0.03	<0.05	<0.05	rest

Heat treatment included annealing for 2 hours at 530º C with rapid cooling in water and then aging for 10 hours at 165º C. Heat treatment was applied to improve the strength properties of the material by precipitation hardening of AA2519.

The observation of the produced laminates were carried out with the use of the Scanning Electron Microscope (SEM) Jeol JSM-6610 equipped with energy-dispersive x-ray spectroscopy (EDS) and back-scattered electron (BSE) detector. SEM was used to observe the cross section through the components of the laminates. Observations were performed using acceleration voltage 20 kV. The cross-sections were prepared by cutting the samples in direction perpendicular to laminates surfaces with precision diamond saw. Before structural examinations samples were subjected to the metallographic preparation involving grinding on SiC papers with granulations of 240, 600, 1200, 2400 and in sequence, polishing with diamond suspensions 3 μm and 1 μm.

Ballistic resistance tests were performed on the both of base materials (AA2519 and Ti6Al4V) and panels made of laminates in different conditions (before and after heat treatment). Ammunition used in tests was projectile BZ rifle cartridge 7,62x39 mm according to the class III STANAG 4569 (Tab. 4.). The energy of cartridge in the moment of impact is 1300-2300 J. Tests were performed according to the standard STANAG 4569 Level 2 (Fig. 1,2.). Rifle 7.62 mm model 1944 was placed on the bench in order to ensure proper trajectory of the projectile flight. Proper mounting of the arms and putting the barrel axis relative to the sample was performed before each test. During the shot the distance between the weapon and sample was equal to 2.5 m.

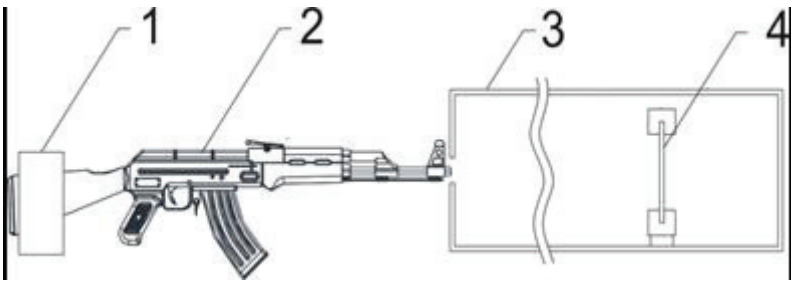

Fig. 1. Scheme of the stand for testing ballistic properties of the base materials and laminates:1 - bracket for mounting weapons, 2 -throwing device (suitable caliber firearm), 3 - butt, 4 - the test sample mounted in a holder

a) b)

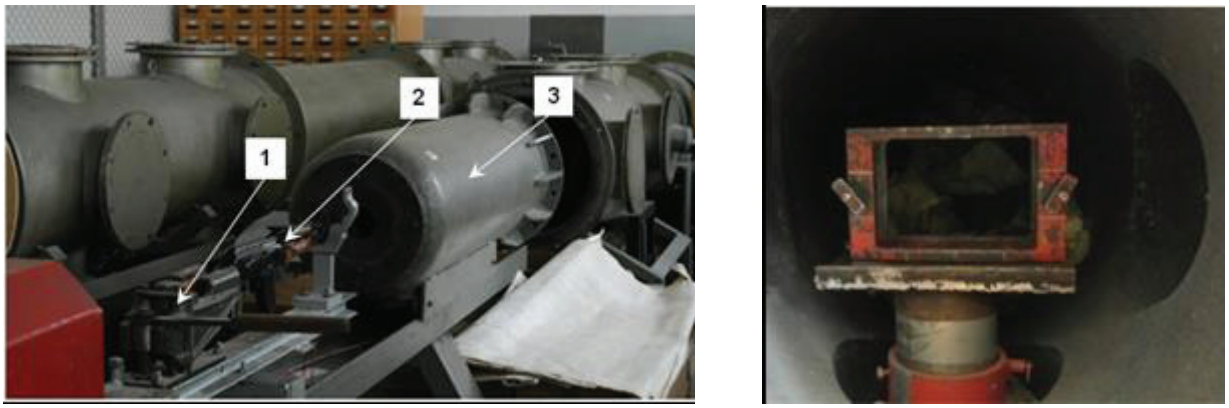

Fig. 2. The weapon mounting scheme during ballistic resistance tests (a):
1 - the start gate, 2 - struck, 3 - gate stop (b)

Table 4

The ammunition used in the test

Ammunition used	Type of projectile	Velocity
Indirect missile – 7,62 x 39	BZ	695 m/s

Results of the ballistic resistance tests of the base materials provided information on the mechanisms of projectile penetration. The obtained results allowed to determine the required amount of laminates needed to stop the appropriate type of projectile. These results was used for preliminary analyzes including, among others, a comparison of the ballistic resistance of the laminates in states before and after heat treatment. Results were compared to ballistic properties of base materials as well (Fig. 3a,3b.). Specimens for tests of ballistic properties of Ti6Al4V titanium alloy were made of a cold-drawn titanium rod with diameter 100 mm (Fig. 3c.).

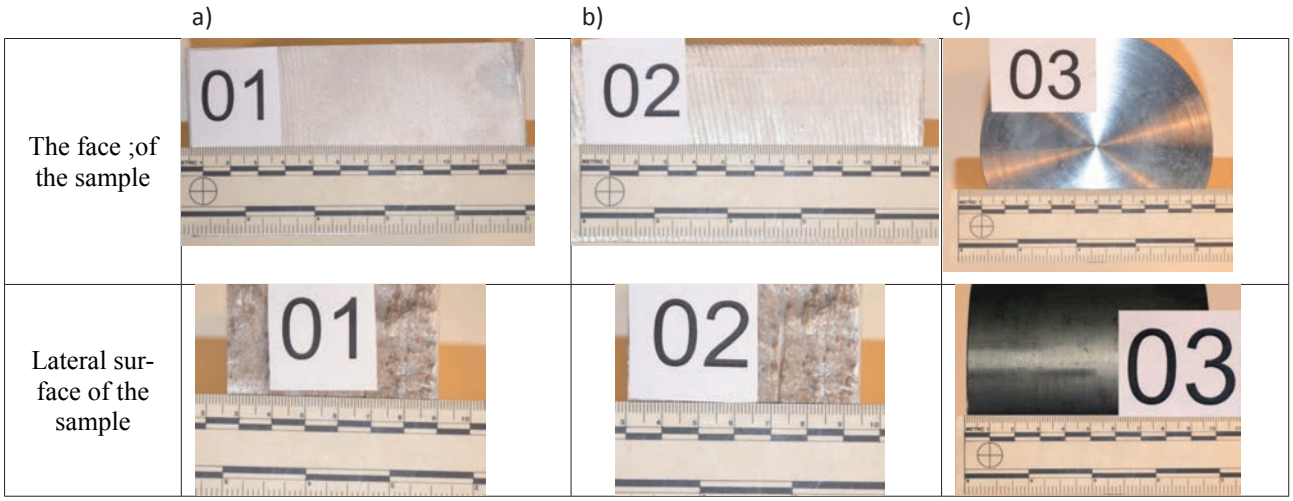

Fig. 3. Samples of base materials of the produced laminate: a) aluminum alloy AA2519 in casting form, b) aluminum alloy AA2519 in casting form after heat treatment, c) titanium alloy Ti6Al4V

Each panel used for ballistic resistance test was composed of AA2519/AA1050/Ti6Al4V laminates with thickness of 11 mm. Joining of the laminate layers was performed by the method of explosive welding with the interlayer made of aluminum alloy AA1050 (thickness 0.8 mm). In the first ballistic test three laminates for panel was used. The distance between the laminates was 15 mm. In this study impact of the projectile was from the side of AA2519 layer (Fig. 4.). First results enabled to estimate the number of laminates and their thickness, necessary to avoid the perforation.

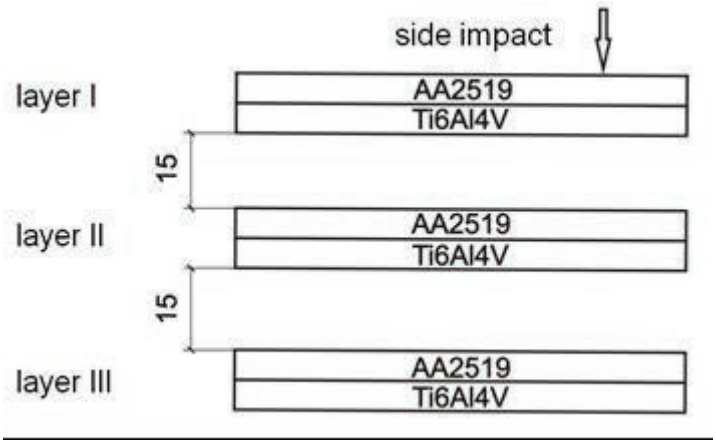

Fig. 4. Scheme of the ballistic test

Results of the first ballistic resistance tests allowed to estimate number of laminates with three different thicknesses: 3 laminates (each 10 mm thickness) per panel, 6 laminates (each 6 mm thickness) per panel and 2 laminates (each 20 mm thickness) per panel (Fig.5.). Laminates with dimensions 200 x 120 x thickness [mm] were selected. The presented configurations of the panels had the same mass. The obtained results allowed to choose optimal configuration of the panels with the highest ballistic resistance. In this part of study impact of the projectile was from the side of AA2519 layer and Ti6Al4V.

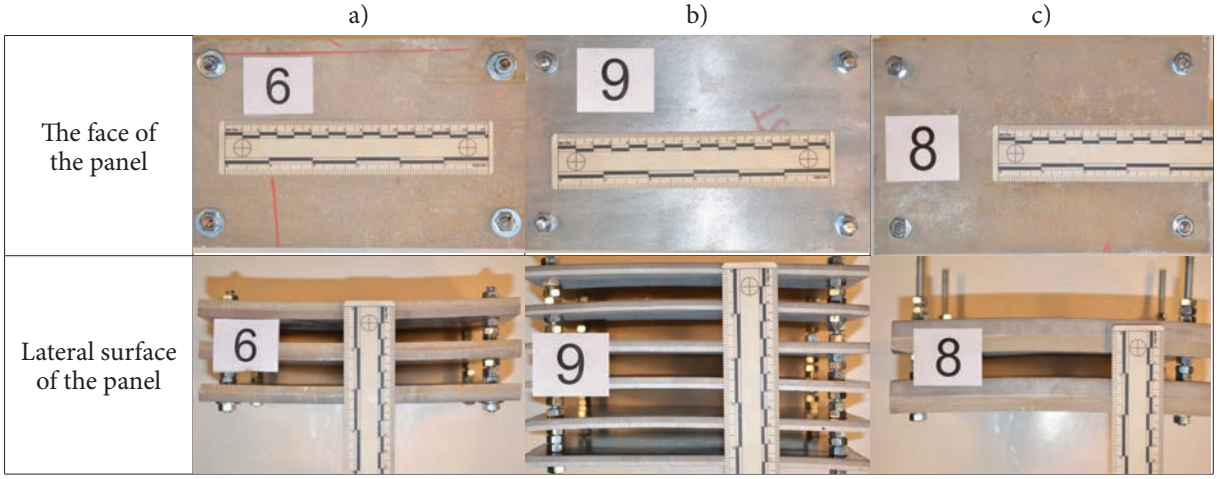

Fig. 5. Ballistic panels made of laminates: a) 3 laminates (each 10 mm thickness) per panel, b) 6 laminates (each 6 mm thickness) per panel, c) 2 laminates (each 20 mm thickness) per panel

3. Results and Discussion

3.1. Microscopic Observation

The cross-section of the laminate (Fig.6.) shows the bonding zones Ti6Al4V/AA2519 and AA1050/AA2519. At the AA2519/AA1050 joint characteristic waves are observed. Ti6Al4V/AA1050 joint is characterized by the flat surface. The wavy structure, characteristic for the joints of materials with similar densities and masses, is the result of properly selected joining parameters. In the case of a flat interface between the AA1050 and Ti6Al4V alloys, its joint quality can be obtained by the formation of intermetallic zone in the form of an additional sublayer.

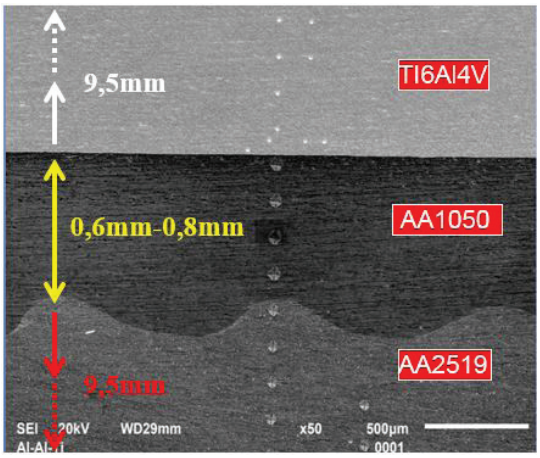

Fig. 6. Cross-section of the AA2519/AA1050/Ti6Al4V laminate with the thickness of the layers

3.2. Ballistic Resistance Test – Base Materials

The mechanism of base materials penetration by the projectile is the same for each case. On the surface of the aluminum alloy, the inlet creates a crater with the effect of flaking resulting from the ejection of the material. Macroscopic images of the craters for AA2519 before heat treatment are shown in Figure 7a. The BZ projectile stopped in the material at a depth of 40 mm. In the case of penetration of the material after heat treatment with a BZ projectile (Fig. 7b), an enlarged inlet resulting from the impact of the projectile is visible. The BZ projectile stopped in the material at a depth of 46 mm. In the case of the Ti6Al4V after the heat treatment, the penetration mechanism caused numerous surface cuts in the vicinity of the hole formation (Fig. 7c).

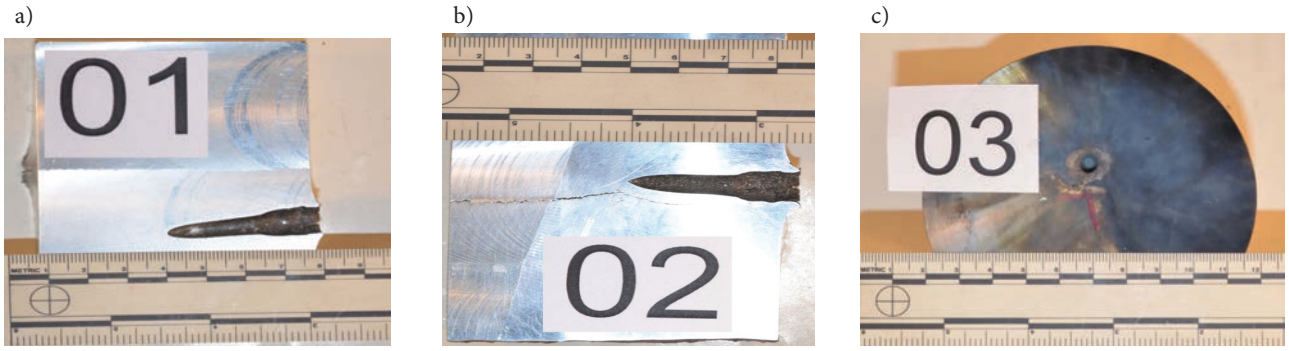

Fig. 7. Cross-section of the samples after the BZ projectile impact: a) aluminum alloy AA2519 before heat treatment, b) aluminum alloy AA2519 after heat treatment, c) titanium alloy Ti6Al4V

3.3. Ballistic Resistance Test – Panels

The cumulative list of ballistic shield space results is presented in the Tables 5-7.
Signs:
¤ - overshoot
x - no hole
¤/x - stopped projectile, cracked layer

Table 5

The ballistic resistance test results of panel Al-Ti made of 3 laminates with thickness of 10mm for each one Material before and after heat treatment

	side shooting	1 layer	2 layer	3 layer
before a heat treatment	AA 2519	¤	¤	x
after a heat treatment	AA 2519	¤	¤	¤/x

Impact of B32 API projectile into the 3x3 mm panel from the AA2519 alloy side in state without heat treatment caused perforation of all three layers. The inlet of the projectile in AA2519 alloy of the first layer was formed by a shell of the projectile, which at the moment of impact in the titanium alloy swelled (Fig. 8a) and the accumulated material was located between the alloys of aluminum and titanium. The third layer did not undergo of plastic deformation and the image of the perforation of this layer indicates the occurrence of soft plugging (figure 8b).

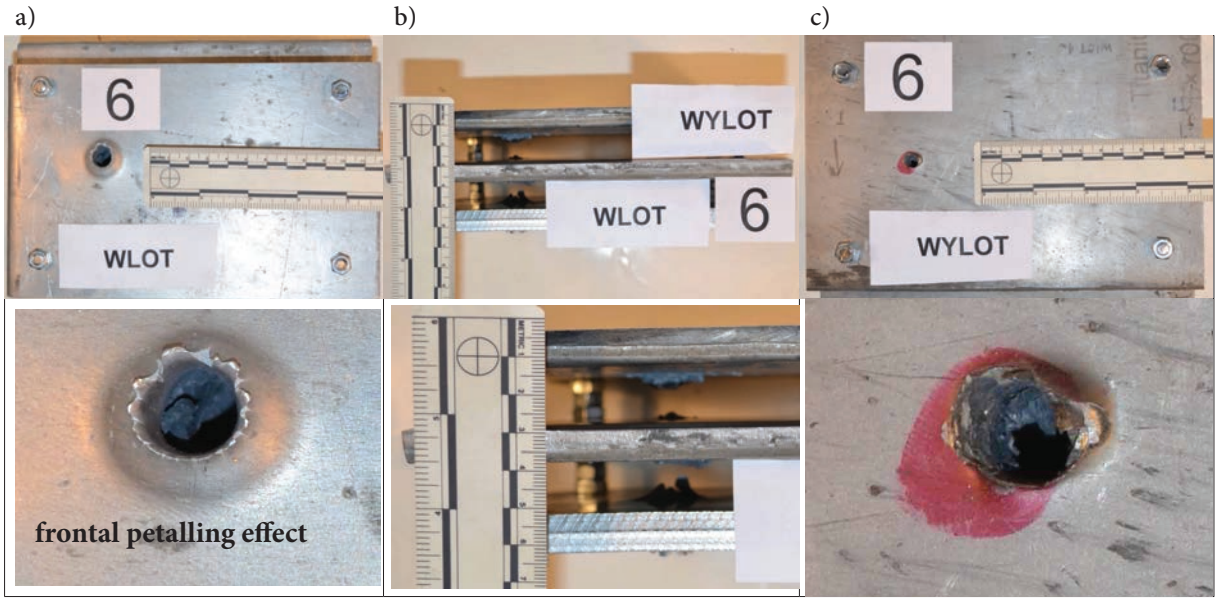

Fig. 8. Sample 3x10mm after the BZ projectile impact into AA2519 in state before the heat treatment, a) The face of the sample, b) Lateral surface of the sample, c) outside titanium alloy Ti6Al4V

Impact of B32 API projectile into the 3x3 mm panel from the AA2519 alloy side in state after heat treatment also causes the penetration of all 3 layers. (Fig. 9). During the impact the first laminate of the panel was delaminated (Fig. 9b). Small crater with local loss of aluminum was visible (Fig. 9a). The third layer did not undergo of plastic deformation during its perforation. The inlet and outlet of the projectile are characterized by a circular profile (Fig. 9a,c). During the tests, it was found that the panels made of laminates in initial state exhibits higher ballistic resistance than the panels subjected to the additional heat treatment. On the last surface (Ti6Al4V) effect of material plugging was visible. The edge of the crater is jagged and sharp (Fig. 9c).

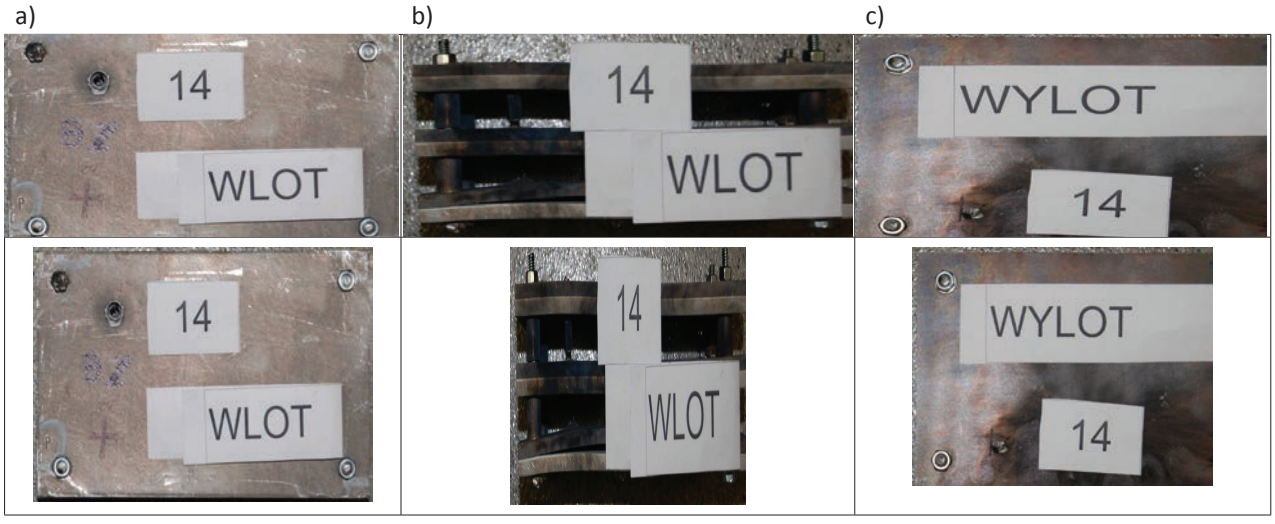

Fig. 9. Sample 3x10mm after the BZ projectile impact into AA2519 in state after the heat treatment, a) The face of the sample, b) Lateral surface of the sample, c) outside titanium alloy Ti6Al4V

Table 6

The ballistic resistance test results of panel Al-Ti made of 6 laminates with thickness of 6mm per each one. Material before and after heat treatment

	side shooting	1 layer	2 layer	3 layer	4 layer	5 layer	6 layer
before a heat treatment	AA 2519	¤	¤	¤	¤	¤	x/¤
after a heat treatment	AA 2519	¤	¤	¤	¤	¤	x

Figure 10 shows the effects of impact of projectile into the 6x6mm panel by a B-32 API projectile. Impact side was from the AA2519 alloy and the laminates were in state before heat treatment. Five laminates of panel have been perforated by the projectile. The inlet of the first layer is characterized by surrounding flange (Fig. 10a). The observed type of inlet was produced by the plastic deformation of the plate forming a characteristic crater with deformed edges. In the side view of the panel (Fig. 10b), a drawn line presents a variable trajectory of the projectile's motion which is a the result of penetration of the laminates layers with different hardness. Delamination of the first laminate was observed. In subsequent layers the size of the local deformation at the point of impact of the projectile was gradually reduced. The main part of the projectile was stopped in the fifth layer, but a small part of the core performed to the sixth layer, leaving a crater with a depth equal to the thickness of the AA2519 alloy. In the vicinity of this crater single, small recesses formed after the impact of debris were observed.

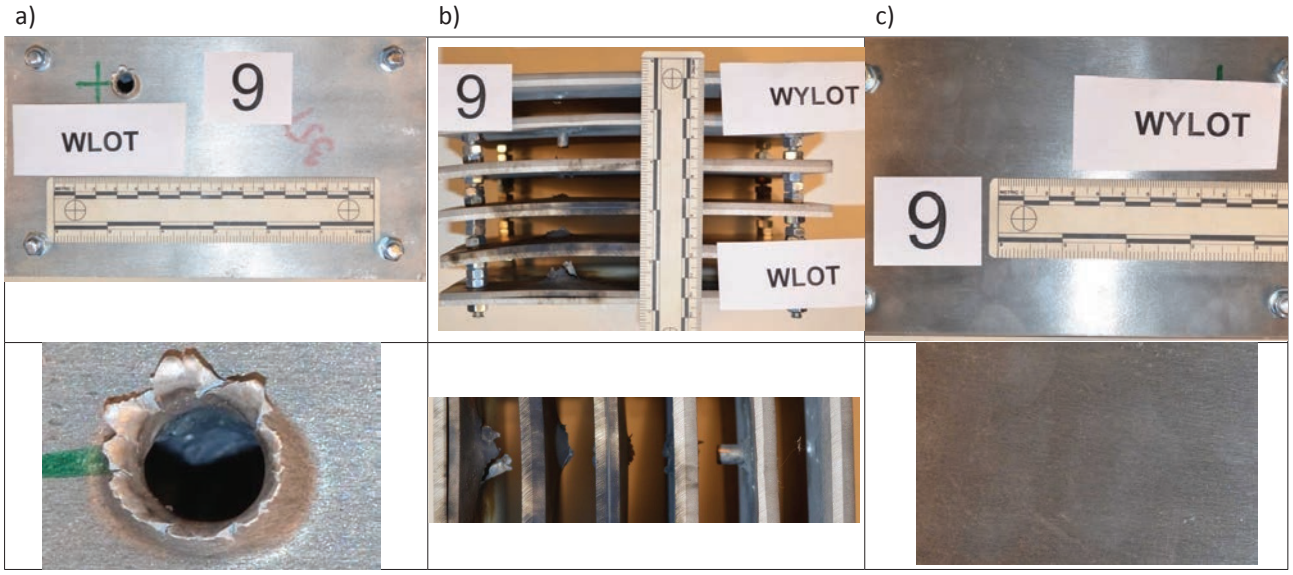

Fig. 10. Sample 6x6mm after the BZ projectile impact into AA2519 in state before the heat treatment, a) The face of the sample, b) Lateral surface of the sample, c) outside titanium alloy Ti6Al4V

Effect of the impact into the panel in state after heat treatment is shown in Fig. 11. In the first laminate, the inlet hole has a regular outline (Fig. 11a), and its edge was formed due to plastic deformation of the AA2519 plate, caused by the dynamic impact of the projectile (frontal petalling). During the impact six laminates were perforated. The penetration does not show significant deviations from the linear trajectory of the projectile's movement (Fig. 11b). In the second laminate of the panel, as a result of the impact of the projectile, permanent deformation of the titanium alloy with simultaneous delamination of the joint was observed. The outlet of the projectile in the sixth layer has a ragged outer edge, and a zone about 15 mm wide from the edge of the hole has been slightly pushed out by the projectile as a results of significant reduction of its velocity.

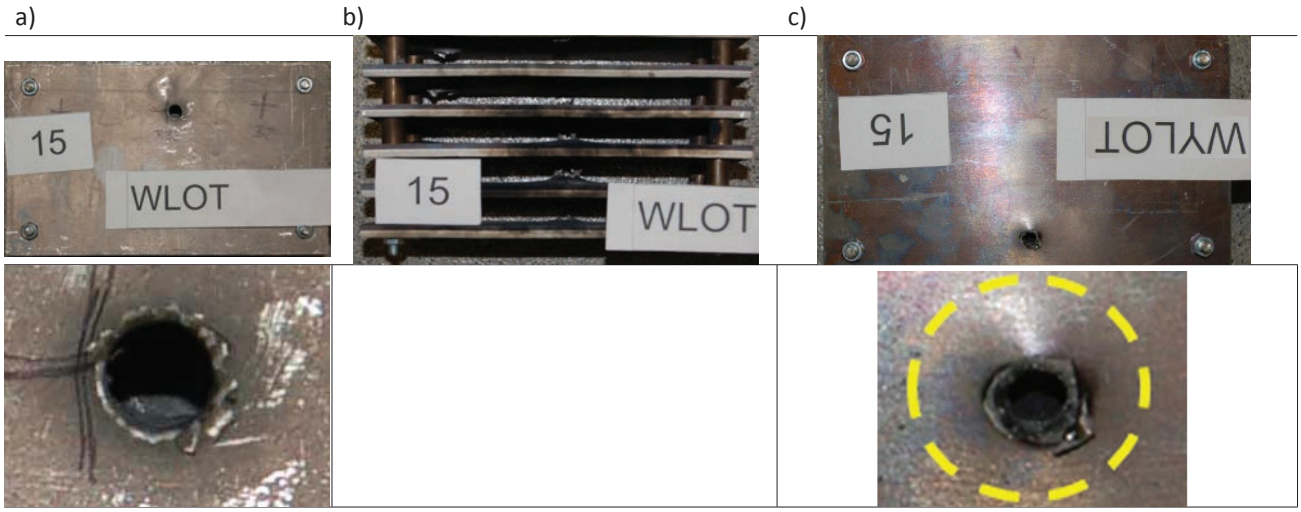

Fig. 11. Sample 6x6mm after the BZ projectile impact into AA2519 in state after the heat treatment, a) The face of the sample, b) Lateral surface of the sample, c) outside titanium alloy Ti6Al4V

Table 7

The ballistic resistance test results of panel Al-Ti made of 2 laminates with thickness of 20mm per each one. Material before and after heat treatment

	side shooting	1 layer	2 layer
before a heat treatment	AA 2519	¤	x
after a heat treatment	AA 2519	¤	x

Figure 12 shows two-laminates panel in the state before heat treatment after projectile impact from the AA2519 side. The inlet hole in the first layer is result of the occurrence of the frontal petalling penetration mechanism (Fig. 12a). The projectile stopped in the middle of the second layer in AA2519 alloy (Fig. 12b).

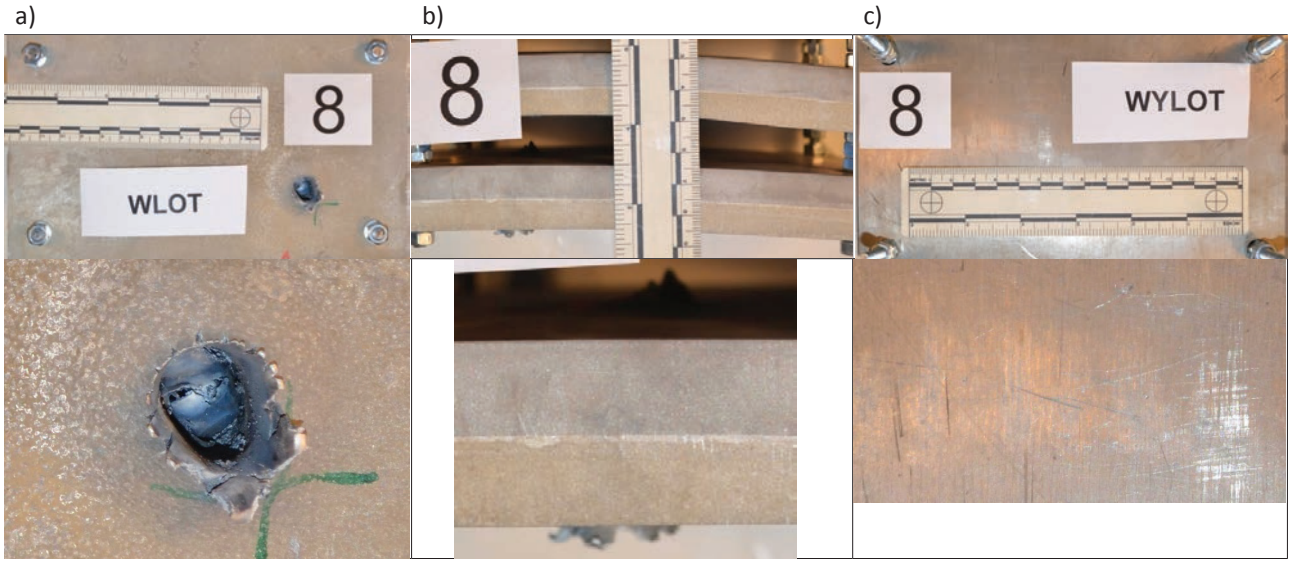

Fig. 12. Sample 3x20mm after the BZ projectile impact into AA2519 in state before the heat treatment, a) The face of the sample, b) Lateral surface of the sample, c) outside titanium alloy Ti6Al4V

Two-laminates panel after heat treatment impacted from the AA2519 alloy side is shown in Figure 13. In this case, the perforation of the two layers was observed. The inlet hole in the first laminate is the results of the frontal petalling penetration mechanism (Fig. 13a). In the first laminate, the presence of delamination was found. The projectile stopped in the second laminate with simultaneous fragmentation of the bullet core, which caused the plugging effect in the titanium layer (Fig. 13c).

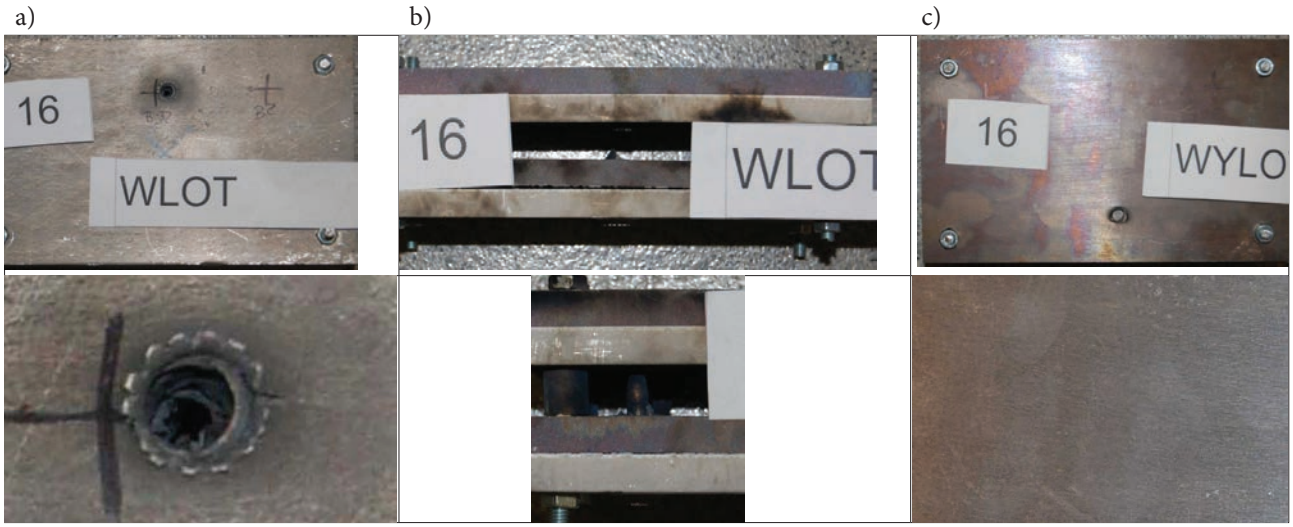

Fig. 13. Sample 2x20mm after the BZ projectile impact into AA2519 in state after the heat treatment, a) The face of the sample, b) Lateral surface of the sample, c) outside titanium alloy Ti6Al4V

Conclusions

The experimental ballistic resistance tests were performed to estimate the applicability of the explosive welding technology in the production process of laminates made of aluminum alloys AA2519 and Ti6Al4V titanium, which could be applied as a construction materials on the ballistic shields. The field of the research included ballistic resistance tests of base materials and developed panels made of the laminates. Panel subjected to the impact of the projectile from the aluminum side is characterized by the low rate of fragmentation of the materials. Impact from the side of titanium alloy will be the subject of further research. Independently from the thickness, number of laminates and applied heat treatment, all impacted panels were perforated in a similar manner. The global deformation mode changed from a ductile hole enlargement, through a mechanism of highly localized shear around the projectile nose, to the final plugging. Plug is a part of a metallic material of the specific shape, which is sheared out from a target plate by a deformed projectile. In all cases the perforation caused fracture between the two aluminum interfaces.

Acknowledgements

The project is carried out under Project PBS2/A5/35/2013 funded by the National Research and Development Centre and PBS applied research program.

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Assessment of River Crossing Possibility with Existing Pontoon Bridge

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Abstract

In the paper the possibility of river crossing in different conditions are described. The influence of river and equipment characteristics are analyzed and existing unitation on crossing capacity are indicated. Moreover, the unique demand for river crossing in Eastern Europe are defined.

KEY WORDS: *river crossing, ribbon bridge, military load classification, hydrodynamic stability, bridge capacity*

Introduction

Crossing large, deep aqueous obstacles is a complex tax and the possibilities of its realization depends on many factors including: crossing conditions, its organization, efficiency of direct traffic, training of crews and maintenance of crossing equipment and even masking and organizing emergency and evacuation services, etc. and the expected efficiency of the crossing, number of crossed forces and means and expected crossing time. From a technical point of view the most important factors are: characteristics of aqueous obstacles and technical characteristics of the used equipment and their mutual relations.

1. Characteristic of the Aqueous Obstacles

The characteristics of an aqueous obstacles should be understood as a set of features affecting the possibility of overcoming aqueous obstacles and they include:

- **road / terrain characteristics of the direct approach to the obstacle -** there may be local backwaters and floods, oxbow lakes, escarpments (slopes), embankments, dense vegetation and trees, logs and terrain obstacles and other elements limiting the availability and the possibility of crossing the terrain by conveyed equipment – they result from that crossed equipment mobility requires which concern: permissible ground pressure and low-capacity terrain ability, permissible angles of descent and driveway and the requirements for the need to conduct engineering preparatory work including the road sections paving, and improving their profile and strengthening them;
- **characteristics of the bank–** to the most important factors affecting the ability to overcome an obstacles should be included the water entry profile (the tilt angle of entry into the water), type of ground at the descent and bottom, presence and speed of the stream, and the depth of the obstacle directly at the edge - it results from the requirements for earthwork necessary to obtain acceptable angles of entry to the bridge, type of ramp support and ramp bay and the necessity to strengthen the berth, maximum depth of permissible dipping of pontoon loaded bridges and the minimum depth of the obstacle due to the possibility of launching pontoons and proper work of propulsion.
- **characteristic of the obstacle profile** includes: profile (depth), occurrence of underwater obstacles and shoals, occurrence and stream speed distribution and occurrence and height of waves – it results from the requirements in the range of the necessary pontoon speed during the construction of bridges, displacement reserve and the stability of the bridge while working in the river's stream, protection against the possibility of flooding by waves and necessary work efficiency of propulsion and the need to use bridge anchoring systems.
- **Characteristic of the opposite bank-** it includes: obstacle's depth directly at the edge, occurrence and current speed, the angle of departure from the aqueous obstacles, ground traction at the exit of the obstacle, presence and type of vegetation limiting the availability of land and bearing capacity of the ground and presence of obstacles limiting the possibilities of fast moving deep into the terrain - it results in the requirements for the necessary engineering works resulting from the permissible angle of departure from the obstacle, allowable pressures on the substrate and the need to strengthen the bank in the place of cooperation with ramps. The main large and deep aqueous obstacles in Eastern Europe are unregulated rivers. They are characterized by high variability of water level, occurrence and meandering a strong current, bottom with shoals of relatively low load capacity and often steep, sandy or loamy banks. The speed of the current is variable and also depends on the general condition of the waters. At high water level, the mainstream speed may reach 3.5 m / s, in average conditions it often reaches 2 m / s on a large width.

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Hence the essential factors affecting the ability to overcome the obstacle are:

- the angle of entry to the obstacle;
- obstacle depth, main current speed and its distribution;
- presence of shallows and other obstacles;
- angle exit from the obstacle and traction

Some of the characteristics (load-bearing capacity of the ground for access to obstacles, entry and exit angles) can be improved by engineering works, however, the basic way to improve the characteristics of the aqueous obstacle is to choose a convenient place for the crossing - which puts less demands on bridge equipment. However, this limits the tactical and operational mobility. Bridging equipment making low demands, well- matched to the river crossing, allows them to be overcome anywhere, anytime which will surprise the opponent.

2. Limitations of Pontoon Bridges

Bridge crossings using pontoon bridges type ribbon bridge are organized for drastic purposes in relation to crossings amphibious equipment, bridging and ferry, increasing the ability to transfer forces and resources. The armored tracked vehicles, armored wheeled vehicles and wheeled logistic support vehicles are mainly conveyed. The hardest to crossing are heavy tracked vehicles because their weight reaches 70 short tons (63.5 t), length of track on the ground does not exceed 5 m and a width of the vehicle is approx. 3.5 m (weight of the structure with additional armor or equipment can reach 80 short tons). This results in a high concentration of loads and requires a wide roadway width. Wheeled vehicles, although they may be the dominant group, are not such a big problem because they do not usually exceed the weight of 32 t and the width of 2.55 m. Hence, the most important parameters of pontoon bridges include:

- bearing capacity of the bridge - deciding which means can be crossed;
- bridge capacity - defining the efficiency of the crossing;
- permissible speed of the current - determining the possibility of organizing the crossing;
- minimum depth of aqueous obstacle - determining the possibility of organizing the crossing;
- bridge construction time - defining its tactical availability;
- forces and resources necessary to build a bridge;

According to STANAG 2021[1], the bridge load capacity is defined by comparing the loads exerted on the bridge by the vehicle's chassis in the form of bending moments and shear forces with loads caused by reference vehicles for individual classes. Because tracked vehicles model dimensions do not differ significantly from actual vehicles, MLC class usually corresponds to the weight of the vehicle expressed in the so-called short American tones (1 t = 2000 lbs. = 908 kg). In the case of wheeled vehicles, due to the dissipation of the load over a longer length and thus inducing smaller bending moments, the MLC class of the vehicle is lower than its mass expressed in US tons.

The load-bearing capacity of a pontoon bridge is not a fixed value and in the case of crossings by rivers depends on the speed of vehicle travel, current speed and load eccentricity. The speed of the passing determines the amount of dynamic loads and influences the necessary reserve of strength, whereas the influence of the current speed and the load eccentricity results from the character of the work of the ribbon bridge and hydrodynamic interactions occurring between the pontoon bridge and the aqueous medium.

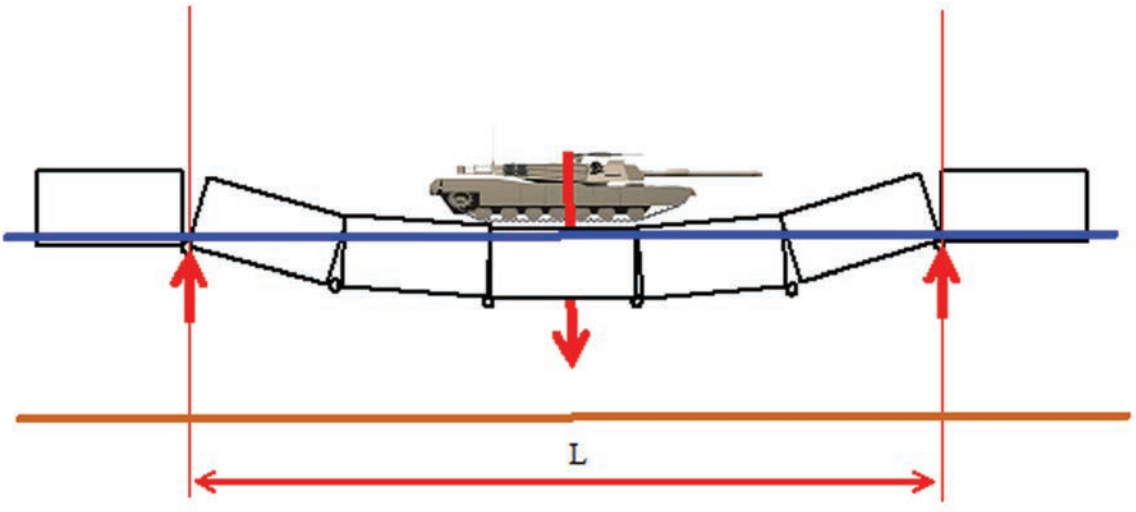

Fig.1. Deflection of the pontoon bridge under load

The ribbon bridge usually consists of pontoon blocks hingedly connected to the bottom band, which under load thanks to the clearances in the upper belt, they assume the shape of a curve - fig.1. By increasing the clearance and increasing the draft, the bridge builder can reduce the number of working pontoon blocks and thus reduce the bending moments of the

1 STANAG 2021: Military load classification of bridges, ferries, rafts and vehicles.

bridge and the load on the construction nodes. As a result, it can provide a higher nominal bearing capacity of the bridge.

The increase in draft (Figure 1), however, causes flow disturbances under the pontoon bridge as a result of a change in the flow cross-section. This phenomenon is particularly dangerous in connection with the asymmetric bridge load (Fig. 2), which causes lateral inclination of the bridge. As a result, under a more recessed part the flow section decreases and the flow rate must increase. Because the amount of hydrostatic pressure and hydrodynamic pressure cannot change according to Bernouli's law an increase in hydrodynamic pressure (increase of flow velocity) causes a drop in hydrostatic pressure, causing an additional inclination of the pontoon.

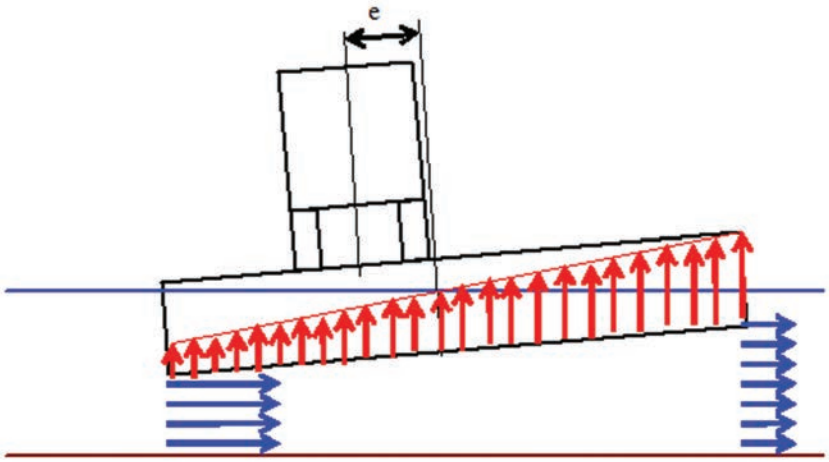

Fig.2. The effect of the eccentric loading of the pontoon bridge

Excessive inclination of the pontoon can cause flooding and loss of stability, despite having a displacement reserve. The effect of the eccentric load decreases with the depth of the obstacle. It is assumed that it can be omitted at depths above 6 m. For safety reasons, it is assumed that the freeboard height should be at least 100 mm. The acceptable current speed can be estimated as 80% of the critical speed causing the pontoon to flood.

$$v_{ik} = \zeta\sqrt{g \cdot L}\sqrt{1-\frac{D}{\left(1-\frac{e \cdot P}{L \cdot D}\right)^3 D_o}} \qquad (1)$$

where :

ζ - coefficient of depth of the watercourse;
L - the width of the pontoon;
D - used buoyancy of the pontoon;
Do - maximum displacement of the pontoon;
P - external load on the pontoon;
e – load eccentricity.

Taking into account the impact of dynamic loads and load eccentricity, to clearly determine the bridge crossing capabilities three load classes of pontoon bridges have been defined [2]:

- **normal crossing** – determines the possibility of using the bridge in normal operation conditions - the distance between vehicles on the bridge should not be less than 30 m, the permissible eccentricity of the load is 0.5 m and the permissible vehicle speed is:
  - MLC 30 class - 25 km/h (desirable 40 km / h);
  - Above MLC 30 class - 15 km/h (desirable 25 km/h);
- **caution crossing** () – to be used with stricter safety conditions - the distance between the vehicles is determined by the bridge manufacturer (usually greater than the length of the arch of the bridge after selecting the clearances of the upper belt), load eccentricity is unacceptable (the guide on the bridge controls the position of the conveyed vehicle), the maximum speed does not exceed 5 km / h, braking and acceleration are prohibited (minimization of dynamic loads);
- risk crossing () - allowing for crossing the bridge in high risk conditions - only one vehicle on the bridge is allowed, the eccentricity of the load is unacceptable (a necessary guide controlling the position of the conveyed vehicle), driving speed cannot exceed 5 km / h, braking and acceleration are not allowed.

[2] Trilateral Design and Test Code for Military Bridging and Gap-Crossing Equipment. TARDEC BRIDGING. USA 2005

Because each of them depends on the speed of the current and the depth of the aqueous obstacle, the bearing capacity of the bridge should be presented in the form of a characteristic. An example is shown in fig.3.

The load-bearing capacity of a pontoon bridge therefore depends not only on the construction of the bridge (its strength and displacement) but also from the place of the crossing organization - determining the speed of the current and the depth of the aqueous **obstacle.** Analyzing the dependence (1) it can be concluded that the greatest influence on the bridge's resistance to the impact of the current has it width**.** The wider the bridge, the greater its stability and resistance.

The bridge crossing capacity, i.e. the ability to transfer forces (vehicles) through a water barrier, depends mainly on:

- speed of access to the bridge - this is influenced by: the condition of the ground, profile and width of the road, traffic organization;
- speed of entry to the bridge - it is limited by: the condition of the ground, the entry profile, the width of the roadway, the strength of the bridge;
- speed on bridge restricts: the strength of the bridge, the width of the roadway, the allowable eccentricity load, the bridge waving;
- dependence between vehicles on the bridge - it is mainly related to the strength of the bridge;
- speed of exit from the bridge - depends mainly on: exit profile, ground condition (scour), exit width, bridge strength;
- speed of leaving the crossing - depends mainly on: the condition of the ground, profile and road width;
- organization of vehicle column movement - the speed of the slowest vehicles decides (mixed columns not indicated);
- technical breaks necessary to maintain the crossing (strengthening entrances and descents (washing as a result of waves), improvement of anchoring, replacement of damaged pontoon blocks, etc.).

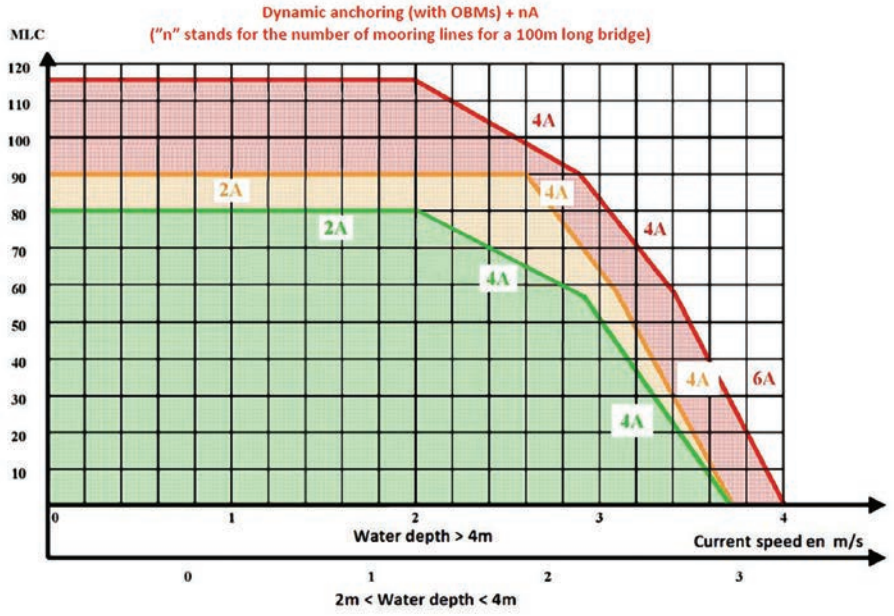

Fig.3. Characteristics of the load capacity of the PFM pontoon bridge as a function of the speed of the current - the maximum (green) capacity is marked by the red (outer) line– nominal load, and orange - conditional capacity

The greatest impact on the capacity of the bridge has the speed of entry into the bridge, the speed developed on the bridge, speed of descent and technical downtime necessary to maintain the crossing. All these parameters depend on the structural solutions of the bridge. The speed of entry to the bridge and the speed of the exit are primarily influenced by: longitudinal profile and strength of the access ramp or peripheral pontoons and their width. The permissible speed on the bridge depends mainly on the width of the lane (for MLC 70 the recommended width is 4 m, for larger values 4,5 m is recommended) and the length of the pontoon blocks and the number of joints with play deciding on the curvature of the deck and the draft of the bridge. The time of service depends on the ease of maneuvering the pontoons during their replacement and on the bridge's cooperation with the bank. In the case of unpaved, sandy or clayey banks and the use of bank pontoons, they are intensively scour as a result of the bridge's undulations under the influence of vehicle traffic. Incoming ramps are a better solution. However, they should have the appropriate profile and width enabling high-speed ride to dispel.

Fig.4. Pontoon bridge with ramps increasing the capacity of the bridge

3. Characteristics of Selected Pontoon Bridges

Taking into account the described limitations and conditions of using pontoon bridges, it can be stated that commonly used construction solutions of pontoon bridges are significantly diversified- tab. 1.,2. For these reasons, their usefulness and capabilities differ significantly. They also differ in terms of forces and resources necessary to organize the crossing - tab.3.

It should be noted that, taking into account the year of design development, there is a clear trend in the use of ever larger pontoon blocks (only the Polish PP-64 bridge does not cross road gauges).

This is possible because increasingly larger means of transport are available.

Table 1

Basic parameters of pontoon blocks and transport units
selected pontoon bridges of the ribbon type

	PP-64 (Polska)	**PFM (Francja)**	**IRB (Niemcy)**	**PP-2005 (Rosja)**	
				60	**120**
Year of development	1964	1984	1962/72/02	1962/2005	
Width of the ribbon, m	2 x 6,25	9.8	8.4	8.28	15.5
Pontoon / block length, m	1.84/3.7	10.2	6.71	7.36	
Pontoon / block heigth, m	0.90	0.73	0.75	0,75	
Pontoon block weight, kg	3 600	10 500	6350	8 550	17 100
Block displacement, kg	19 600	52 500	40 000	43 200	86 400
Displacement reserve, kg	16 000	42 000	33 650	34 700	69 400
Unit weight, kg / m	1 950	1 030	950	1 160	2 320
Width of the composite bl., m	2.5	3.6	3.4	3.1	
Heigth of the composite bl., m	2.0	2.1	2.35	2.28	
Width with the vehicle, m	2.5	3.60	3.60	3.35	
Length with the vehicle, m	9.0	18.0	11.7	10.7	
Heigth with the vehicle, m	3.4	4.0	4.0	3.7	
Vehicle weight, t	7.1	12 +7.5	16.4 +2.7	12,7	
Vehicle weight, t with bl. pont., kg	10 700	30 000	25 600	21 250	
MLC class of the vehicle	12W	25W	28W	25W	

Table 2

Basic operational parameters of selected ribbon-type pontoon bridges

	PP-64	PFM	IRB	PP-2005	
				60	120
Width of the bridge	12.5	9,8	8.4	8.3	15,5
MLC bearing capacity	80W/80T	80W/70T	96W/80T	66T	130W
Lane width, m	4.35	4.0	4.50	4.50	2 x 4.50
Speed of tracked vehicles, km/h	15	15	10 (25)	30.	
Speed of wheeled vehicles., km/h	40	25	20 (40)	b.o.	
Bearing capacity of 2 lines	2 x 40W	-	2 x 20W	2 x 30W	2 x 66T
Width of lanes	2 x 4.35 m	-	2 x 2.75 m	2x2.75 m	2 x 4,5 m
Permissible speed of the current (MLC 80 bridge), m/s	2.9	2.0	2.1	3.0 *	3.5s
Permissible speed of the current (MLC 80 ferry), m/s	3.5	2.5	1.8-3.0	3.0	3.5
Resistance to wind	1°B	1°B	1°B	2°B*	4°B*
Number of loaded pontoons	15	16	7	7	
Length of the load zone, m	25	160	46	50	
Draft own / loaded, m	0.17/0.70	0.17/0.33	0.13/0.50	0.15/0.50	
Bridge deflection (MLC 80), m	0.53	0.16	0.37	0,38	0,25
Freeboard, m	0.20	0.40	0.25	0.25	
Speed on the bridge, km / h	10-15	15	10	30	

Table 3

Basic operational parameters of selected ribbon-type pontoon bridges

	PP-64	PFM	IRB	PP-2005	
				60	120
Number of blocks per ferry MLC 80	16+4B	3+2R	3+2B	3 + 2B	
Number of blocks per ferry MLC 40	8+4B	2+2R	2+2B	2 + 2B	
The number of middle blocks (100 m bridge) - including with a drive	50	9 9	13	13 4	26 8
Number of bank blocks	4	2 (R)	2	2	4
Bank block / ramp length, m	4.0	12	6.7	6.7	
Height of the bank, m	1.0 m	3.0	2.2	2.2	
Number of bridge boats / blocks with drive	6	-	6	2	4
Number of trailers	6	-	-	-	-
Number of cars	60	11	21	21	42
Number of soldiers	126	42	65	65	130

Comparing the tactical possibilities of bridges, it should be noted that the Polish PP-64 bridge is one of the best adapted to work on unregulated rivers and is characterized by one of the best resistance to river currents. However, its disadvantage is the large number of people and equipment necessary to build the bridge.

The most interesting construction is the PFM bridge. It is characterized by the longest pontoon blocks (10 m), rigid links between them (no joints) and the use of outboard engines. As a result, the construction:

- allows you to reduce the number of soldiers and vehicles required four times in relation to the PP-64 bridge and two times in relation to the IRB bridge;
- allows for the construction of a bridge on two-fold shallower waters (dipping under load does not exceed 0.30 m);
- thanks to long ramps (12.5 m) and inducing slight waves it does not require large earthworks and consolidation of abutments before scour with the help of fascines, sandbags or road coverings;
- it is unnecessary to have towing boats, maneuvering on water is more precise, and assembly requires less effort;
- in relation to the IRB bridge it behaves better on rivers with faster currents;
- it is more susceptible to storage and modernization (easy storage and replacement of outboard engines).

However, it has a lower nominal load capacity and a narrower roadway of 0.5 m compared to the IRB bridge and the geometry of the ramps and their small width limit the uphill speeds.

By far the largest crossing capacity offers Russian bridges. Thanks to the use of additional hydrodynamic skids, they

enable the organization of the crossing at the current flow over 3m/s. In eastern European conditions this means that it is possible to organize the crossing regardless of the time of year and water level. In contrast to French (PFM) and German (IRB) constructions, they use modern structural steels.

This allowed to limit the deflection of the bridge and increase the speed of vehicular vehicles. Traditional bridge boats are traditionally used for propelling pontoons on water, but recently their number has been reduced and motor blocks have been replaced instead.

Conclusions

Possibilities of crossing aqueous obstacles are always associated with the characteristic of crossed obstacles and equipment's characteristics. Their mutual adjustment and taking into account the limitations decides to a large extent about tactical success of the carried-out activities. The main large aqueous obstacles in Eastern Europe are unregulated rivers. They are characterized by high variability of water level, occurrence and meandering a strong current, bottom with shoals of relatively low load capacity and often steep, sandy or loamy banks. This puts specific requirements for pontoon bridges ensuring the ability to organize crossing of heavy equipment.

Analysis of available structural solutions indicates that from the tactical point of view, the bridge PP-64 is difficult to replace. It allowed for the organization of crossings of MLC 80 class equipment at a main current up to 3 m / s thanks to its large width and hydrodynamic stability. Commercially available light alloy bridges IRB and PFM types offer at this speed not exceeding carrying capacity of MLC 50. Therefore, they do not provide freedom of operational maneuver. Russian bridges with a nominal load can operate at a nominal current up to 3,5 m/s.

An important advantage of the new bridge system is a significant forces reduction and the measures necessary for the construction of the bridge crossing. In this context stands out the PFM bridge which requires only 11 cars and 40 soldiers for building 100 meters long bridge. It is the result of using pontoon blocks of longer length and eliminating the need for using cutters. Therefore, it is possible to significantly increase the efficiency of using forces and measures during the crossings organization, however, it requires the availability of modern equipment adapted to local conditions of use. It is advisable to start works on a new pontoon bridge better adapted to the specificity of rivers in Central and Eastern Europe.

Acknowledgment

The work presented in this article has been supported by the Polish National Center for Research and Development – (Grant No. DOBR -BIO4/083/13431/2013).

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Employment of the new advanced structural materials in the military vehicles and heavy equipment

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Abstract

This paper presents a review of the advanced materials used in the structure of a novel armor systems and the bodies or frames of the military equipment and vehicles. One of the most often materials engaged in armors are the ceramics among of which the aluminium oxides are the widest spread. Nevertheless, there are more advanced ceramics alike a silicon carbide or boron carbide used for example to shield the pilots of assault helicopters. The section of the paper concerning the materials for the bodies is focused on the high strength steels and the conditions of appropriate joints realization. The examples of the welding imperfections were showed and its influence on the structure integrity was discussed taking into account also others factors.

KEY WORDS: *ballistic protection, armor system, ceramics, nanomaterials, high strength steel, welded structures, construction design*

1. Introduction

A force protection and preservation of the mobility are ones of the most important issues which must fulfill the military equipment within the battlefield or widely, on the combat zone. The combat vehicles, means of conveyance or equipment of supporting units must be designed with taking into account their destination and basic tasks that should be done. In each case they move through the combat zone on roads, tracks or cross-country, when the ability to move in the last one case is always necessary. Nowadays, the requirements of appropriate protection level are defined not only for combat vehicles, weapons carriers or personnel carriers. More often it is an option for logistic vehicles operating in areas when can be endangered by rifle firing or fragments from artillery indirect fire. Regardless of the armor type it is mounted to ensure appropriate protection level of the crew and to shield crucial components of the vehicle i.e. an engine with their equipment, a drive system, a weapon or electronic systems. Secondly, protection of some supply classes must be guaranteed, like for ammunition, explosives or mines.

Additional armor always increases the total weight of the unit and make worse the ability of forces to movement on the battlefield. For this reason, it is necessary to use the novel lightweight materials or materials with improved ballistic protection capabilities on the armor protective systems like ceramics, composites or nanomaterials. They are characterized by higher level of protection simultaneously with decreased specific weight. On the other hand, these materials are very characteristic and cannot be joined by using welding technologies and other are insufficient. Therefore, full-sized elements of structure like crew hatches or ramp doors are manufactured, otherwise shaped protective panels are mounted by using screws, rivets or special mounting systems.

The weight of military vehicles is increasing despite the use of new protective materials. It is caused by the necessity to mount or carry novel weapon systems, power generators or numerous additional specific equipment. For this reason, self-supporting structures of the vehicles or frames are designed and made of high strength steels. The usage of steel is necessary because it is much better weldable than other structural alloys. Utilization of the modern high strength structural steels (*HSS*) leads mainly to the reduction of the structure weight. Variable grades are widely adopted in civil applications on frames or highly loaded components to increase the capacities of mobile cranes, trucks, trailers and others. Except the above mentioned advantages, HSS steels are less sensitive to welding compared to common used mild steels due to their microstructure stabilized by micro alloyed additions and exploited strengthening mechanism. It cause that thicker elements can be welded without preheating. On the other side the welding technology must be low hydrogen and made weldments of high quality due to the sensitivity of HSS steels on imperfections or discontinuities. These defects can be the origins of fatigue cracking and result in the failure of structure. For this reason numerous different precautions are taken on each stage of production, from design to manufacture.

2. Ceramics, Laminates and Nanomaterials in Armor Systems

The exigency to ensure suitable level of mobility and protection cause that many modern protective materials are developed. High-explosive anti-tank (HEAT) warheads and kinetic energy penetrators (*armor-piercing* AP) are used

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on battlefield to destroy enemy over years. Armors produced by casting or welding of rolling armor steel are very often homogenous and then have decreased ability to protect the crew against penetrating factors. This is not important whether the armor was exposed to action of a high-velocity superplastic jet of liquid metal from HEAT projectile or the high velocity penetrators made of tungsten or special steel alloys which pierce the armor by kinetic energy. Equally, HEAT and AP projectiles are extremely effective against above mentioned classic armors. An increase in thickness is not appropriate solution and causes deterioration of vehicle mobility. For this reason advanced types of ballistic panels were developed. Ceramic components or composite systems are one of the most popular solutions.

Ceramics are one of the most advanced armor materials what is caused by their effectiveness as disruptors. There can be distinguished both opaque and transparent ceramics made of oxides and nonoxides including also the amorphous glasses. However, ceramic is brittle and contain pre-existing manufacturing flaws which give rise to some bulk properties. Ceramic tiles do not exist as separate elements [1,2]. They are normally very difficult to shape and are manufactured in the simple form of square or hexagon. This materials as result of the impact of projectile disrupt by crumble through their brittleness, what is caused by an extremely high hardness. For this reasons it is a necessity to employ proper technical solutions allowing effective utilization of this group of material. Lightweight ceramic armors consist of a ceramic tiles bonded to a backing plate as shown in Fig. 1. The role of the ceramic is to erode and break up an impacting projectile, whereas the backing plate have two aims: firstly, together with the ceramic it increase stiffness of compound to delay the onset of ceramic tensile fracture, and secondly, this plate absorbs some of the impact energy of the projectile through plastic strains.

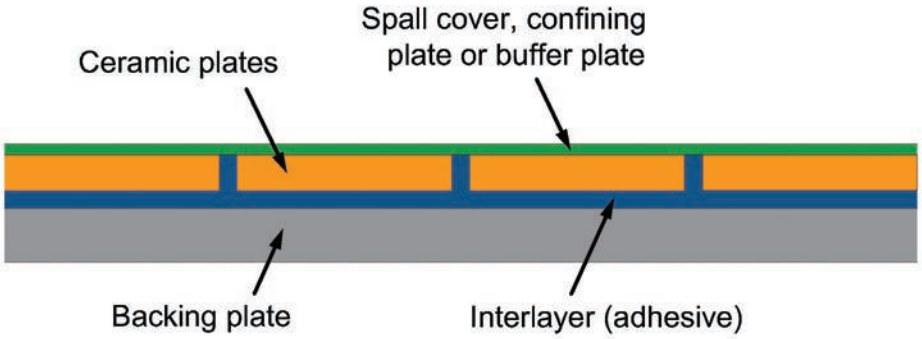

Fig.1. Configuration of a lightweight ceramic armor system

The failure process associated with the penetration of ceramic armors is explained schematically in Fig. 2. Here is presented an example of an armor-piercing projectile impacting an armor ceramic system consisting of ceramic segment and deformable bonded multilayered backing plate.

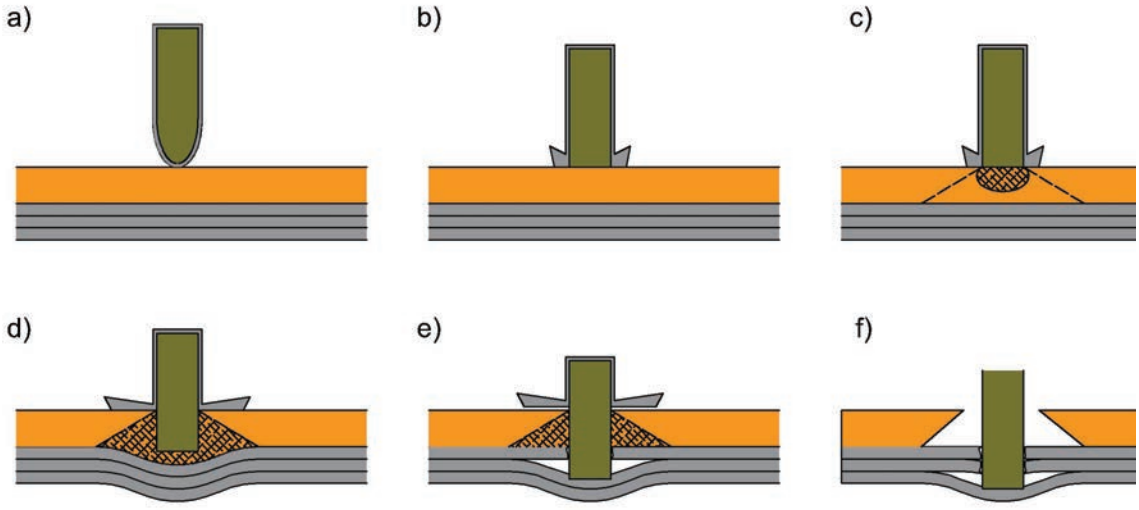

Fig.2. Schematic of typical sequence of physical events during the penetration of an ceramic armor– detailed description in text [3]

First picture (Fig. 2a) shows start position when the hard-cored, jacketed projectile gains contact with the shielded target. Initially, the jacket begins to get stripped out of impact zone and the tip of core is eroded. The core becomes more blunt and loses small volume of its mass (Fig. 2b). Afterwards the cone formation stage takes place

(Fig. 2c) when around the point of impact the Herzian cracks are initiated and then the conoidal fracture follows. The formation of the conoid increases the area of contact with the backing material. At this phase of impact the ceramic component is locally brought to repentance and the core starts to penetrate the armour. Initially eroded core pierces the comminuted area of rubble and continues the erosion (Fig. 2d). Advancing core causes the pressure which influences the backing plate material causing its deformation in the form of bulge what absorbs energy principally through membrane stretching. Next, the eroded, blunt core exerts through-thickness compression in backing material. Consequently, the backing plate begins to delaminate (Fig. 2e). At the last phase of penetration when the core comes to rest in the rear layers of the light ceramic armor, most of the fractured ceramic from the point of impact gets ejected and removes energy from the impact site (Fig. 2f) [3]. It must be stated, that not all types of cracking absorb energy or the absorption ability is very limited. In the work of Woodward et al.[4] was calculated that fracture of any kind absorbs less than 1% of the total impact energy. However, the ceramic rubble ejected as front spall removed a large proportion of the total energy. Moreover, the formation of radial cracks from the point of impact takes place, followed by circumferential cracking of the plates. Mentioned second type of cracks are induced by the bending moment from distorted backing plate bonded together with ceramics. This cause the cracks on the tension site.

Nowadays tree basic groups of ceramic materials are used for the armor systems: aluminum oxides, silicon carbides and boron carbides including their numerous modifications. It is most important that the ballistic efficiency against small arms ammunition increase with purity of composition, because it is connected with the material hardness. That's way ceramic armor panels are very often used to provide personal protection against blast or ballistic threat.

First aluminum oxides ceramic armor panels were developed over 40 years ago. AD85 grade, with an alumina content of 85%, was the standard material in use for helicopter applications, as well as body armor plates [3]. Numerous investigations are made in order to achieve the most effective aluminium oxides armor composition. For example some tests were made to assess ballistic efficiency. The most important factor is the ratio of projectile diameter to plate thickness. Comparable tests were made using AD95 and AD995 aluminas by the ratio of 0.8 to 1.0 [5]. As had been expected the AD995 grade had superior ballistic properties. But in some cases the results were variant, eg. if the tile thickness was changed from 10 to 14 mm, the ballistic efficiency decreased for theoretically more advanced AD995 and simultaneously increased for standard AD95. More over nowadays the attempts are made to improve the aluminium oxides by modification using zirconia or nanotubes [6,7].

Second group of ceramic materials applied in the armor systems are silicon carbides, especially the grade known as SiC-N. The Si-C composition has a ballistic efficiency greater than the aluminas, mainly due to its higher hardness, but also due to its consistent performance across the full range of small arms ammunition. Nevertheless, the silicon carbides are difficult in production, because they are manufactured using different additives, sintering aids and also different process controls. For this reason this ceramic materials are very expensive. That's way numerous research attempts are made to limit the costs using other production processes or dry-pressed powders [3].

Boron carbides are the last group of ceramic materials used in lightweight armor systems and considered in this paper. These carbides are one of the hardest ceramic materials known, falling slightly of diamond or cubic boron nitride. Boron carbides have the density of ~2520 kg/m^3 [8], what means that this value is more than three times lower in comparison with armor steel (~7860 kg/m^3). Its properties like hardness (Vickers 3770 kg/mm^2), mechanical properties and density cause that boron carbides are excellent for use with confidence in high-end, weight-driven armor applications i.e. bulletproof vests. But this carbide have two main drawbacks, namely the cost of production and formability. Boron carbides are produced in the form of powder directly or by milling the lumps with very low granularity (0.1 – 5 μm). Next, the powder is sintered at very high temperature (2100-2200□) with the aids of alumina, Cr, Co Ni or glass. Nevertheless, this ceramic material have underperformance of ballistic protection due to shear localization occurring under shock loading. Recent achievements in the area of boron carbides production are focused mainly on the cost reduction what was reached by developing the pressureless sintering operation [3]. Different examples of application the ceramic materials in lightweight armours are presented in Fig. 3.

a) b)

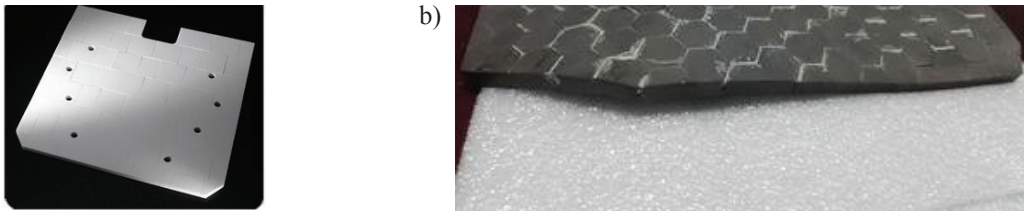

Fig.3. The applications of the ceramic materials: a vehicle protection system made of alumnium oxides (a) [9] and a bulletproof ceramic armor plate made of silicon carbides (b) [10]

Laminates and layered structures are the next category of materials used in armor applications. Already, many years ago it was observed that the layered compositions have more better protection properties than homogenous armors against the high-speed impact of projectile. For this reason numerous new laminated armors were developed. They consist of a few different layers of steel, ceramic, fabrics, polymers or composites. Moreover, the quality of joints between the plies is crucial because an incorrect bonding or a lack of the connection causes significant deterioration of the protection. Layered structure influences the better absorption of impact energy because of the mismatch of physical and mechanical properties. A thin layer

of bonded adhesive plays often the role of a flexural plate which absorbs the impact and support the joined layers. Due to the specific loads induced by impact, namely compression, shear and three-dimensional bending of materials causing local tension of interlayer, this layer can be fractured by created cohesive delamination, what exemplary was presented in Fig. 4.

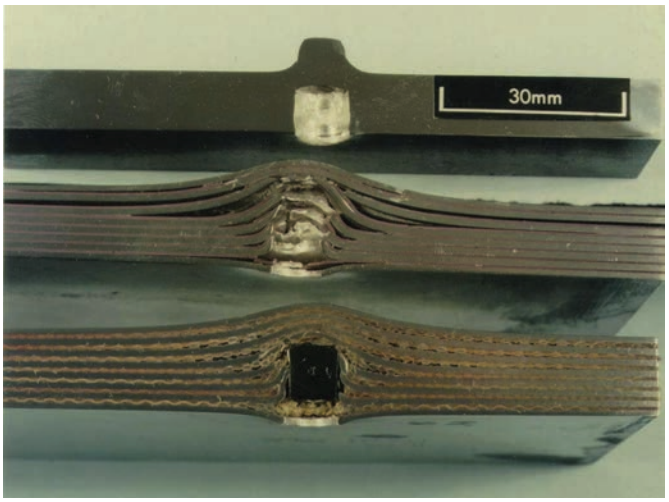

Fig.4. Examples of adhesively bonded aluminium laminates and a monolithic aluminium alloy impacted by a high-velocity fragmentation simulator projectile [11]

Various compositions of materials are designed and tested to obtain stated level of protection. One of them are the adhesive bonded aluminium laminates ABAL, very lightweight which under the same thickness have better properties. Second type of laminates, the steel-composite were developed to avoid the risk of plugging the high-hardness steel plates by rifle ammunition. No more than 9 mm steel plate is required to stop standard 7.62 mm rifle ball and then the risk occurs to form a plug. For this reason it was necessary to design new panels with reduced thickness of steel and able to arrest the bullets without plugging. Last considered type of layered compositions is an alumina-aluminium laminate. This case was detailly descripted above but there should be pointed one aspect more, namely the optimum thickness understanding as the relation between thickness of both components. On the basis of the results placed in the [12] can be stated that the thickness of ceramic should be 2-3 times higher than of aluminium.

In this place must be listed other group of layered materials produced by entirely different method of joining. It is a explosively welded materials. This method allows to joint materials which cannot be joint in any other way. Nevertheless, method of explosively welding is limited to ductile materials due to extreme values of strains and its ratio. Laminates of titanium and aluminum alloys are one of the specific solution of light materials with higher ballistic resistance obtaining by explosive welding [13-14]. This laminate is probably a perspective material for aircraft and space application as shielding panels. The case described in [13] showed that the best results were achieved when the projectile impacts on the aluminium side. The purpose of used aluminium alloy AA2519 was to blunt and erode the core. In this configuration the role of titanium alloy is to support more brittle AA2519 and final arrest of the penetrating core. Sometimes in this type of layered lightweight armour materials the interlayer is added to ensure proper bonding of the main panels [Fig. 5].

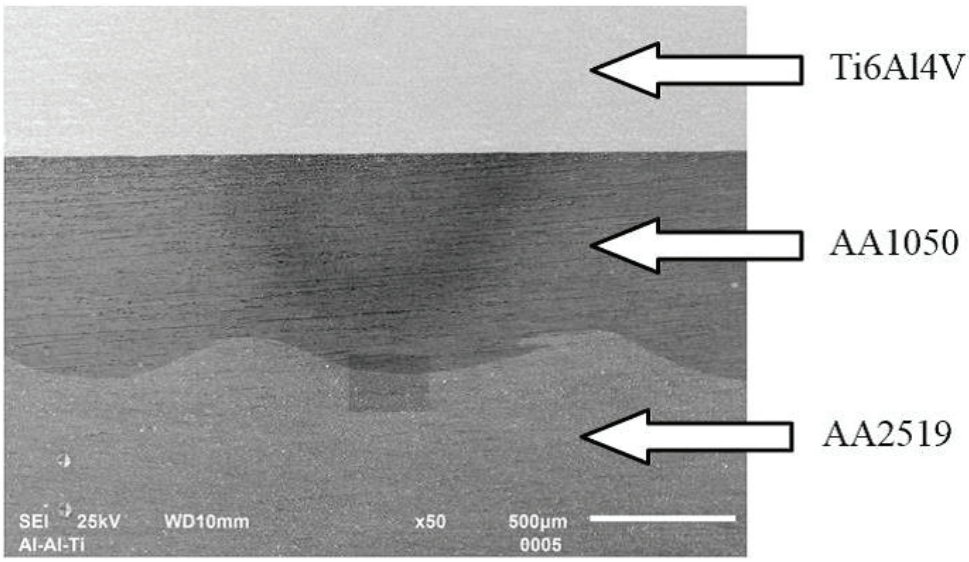

Fig.5. A cross-section of the AA2519-Ti6Al4V laminate with the AA1050 interlayer [15]

The above considered materials nowadays are developed to obtain extremely fine-grained structure up to nanoscale, including composites and armor steels. This group is common known as nanomaterials. The structure consisting of the grains or dispersive elements finer than 1 μm is characterized by the very high strength in tension, high hardness and increased capability to dissipate the impact energy by plastic strains. This materials are less brittle in comparison with classic materials which are more brittle simultaneously with the increasing hardness. Additionally, the ceramic materials more often are reinforced using carbon nanotubes due to improve their ability to carry the tensile stresses caused by bending moment or increase the resist on brittle cracking. The examples of practical utilization of nanomaterials in armor systems are showed in Fig. 6.

a)

b)

Fig.6. Application of nanomaterials in 4x4 vehicle armor (a) [16] and a nano-crystal steel in the Japanese main battle tank MTB type 10 Hitomaru (b) [17]

Special steels are still used on protective panels or elements of armor i.e. Armox or Ramor steels [18], but the grades of maraging or bainitic nanostructured steels were developed [19-20]. These grades of steel have high hardness and what is more important ultra-high strength above 1.8 GPa with good ductility. According to IBD using advanced steels, composites and ceramic materials, it is possible to achieve the same protection level as with standard materials. An armor weight reduction of more than 40% is able to reach in the case of 8x8 vehicle [16].

3. High Strength Structural Steels *HSS*

The structural steels with the tensile strength of more than 600 MPa are commonly used in military vehicles. Higher weight of the military vehicles cause that the structure must be fabricated of steels with high strength and acceptable weldability. In some structures the yield stress of those steels reach the value of 1100 MPa or even above [21]. Besides the vehicles these grades of steels are utilized in special military structures i.e. the military assault and supporting bridges, extremely loaded elements and mechanisms or the trailers for heavy vehicles transportation [22-23]. It is caused by the key benefit of weight reduction of the structure simultaneously with retaining the ability to carry heavy operational loads while driving or firing. HSS steels are used in design of the frames or self-supporting structures of the vehicles first of all than must be weldable and carry alternating loads causing the fatigue. These features are contrary to the high strength due to the fact that while the strength increases together with the hardness the ductility and weldability decrease. For this reason a production process exploiting welding technologies must be performed very carefully. Higher strength of structural steels is obtained in two ways. Firstly, the percentage of alloy additives is increased, however the carbon equivalent rises causing serious deterioration of the weldability. Secondly, advanced techniques of rolling were developed to produce the high strength structure of tempered martensite, bainite or both together with different content. This type of steel is sensitive to thermal cycles taking place during the welding. For the above reasons the appropriate material choose and one of the most important manufacturing process is welding. Serious welding imperfections can occur. Some examples of incomplete penetration and inacceptable porosity in the weldments are presented in Fig. 7.

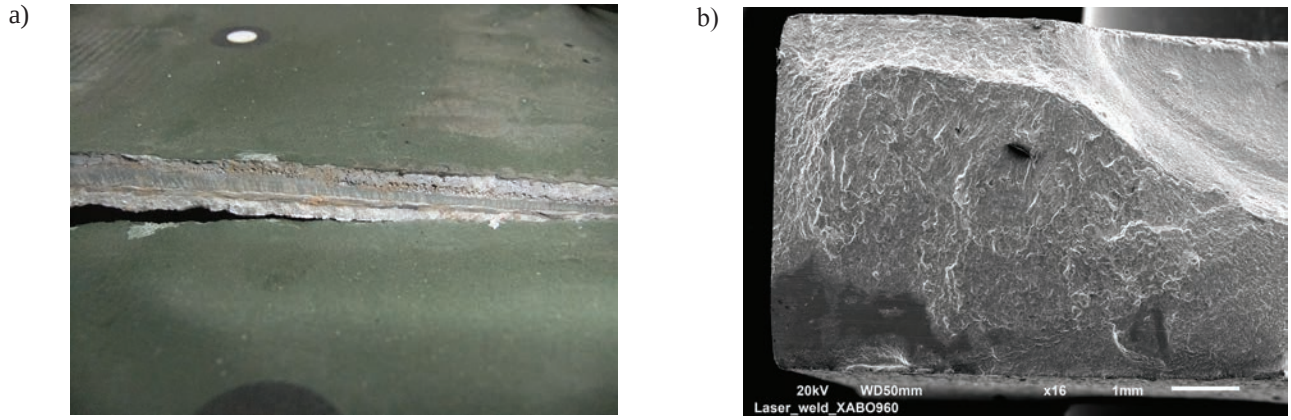

Fig.7. Incomplete penetration and porosity in the weldment high strength armor steel revealed in (a) and incomplete penetration in XABO 960 welded by laser beam (b)

Furthermore, even the welds are realized properly and any imperfections are not detected during the inspection the junctions can failure by cracking. The operational loadings cause the fatigue failures and an occasional exceed of permissible stresses can induce the overload failure. In Fig. 8 are shown the exemplary cracks of the welds at the weld face and in the fusion line.

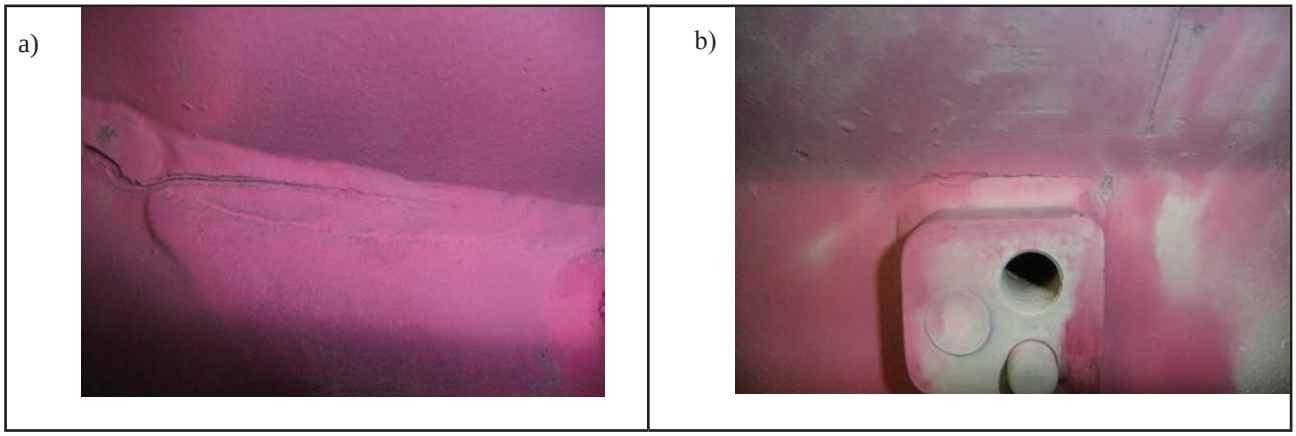

Fig.8.The cracks observed in the weldments made of high strength armor steel at the face weldment (a) and in the fusion line (b)

The above cracks are caused by a stress concentration in the place of change in shape or an invisible origin. The cracks may initiate from the site of a material discontinuity or hard particles rolled in the surface. In order to decrease the likelihood of damage first of all the construction nodes are properly shaped (Fig. 9)

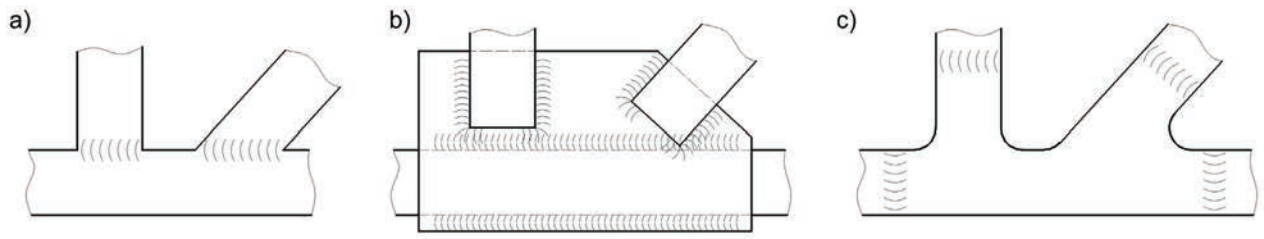

Fig.9.Exemplary different solutions for welded node from the worst, extremely notched (a), through intermediate solution using gusset plate (b) to the best shaped node (c)

Appropriate shape design is the first way to increase an ability to carry the load without damage caused by fatigue. Nevertheless, there are many other methods of modification the welded nodes made of high strength steels. The technique of the fusion line peening is one of the most popular. Using it welding technique is unchanged and an additional process is

relatively inexpensive and little time-consuming. On the other hand, some special designed stress relief holes or undercuts are realized in the sites of stress concentration.

Conclusions

A military industry has always been the most advanced among others branches. Combat equipment and armored vehicles are produced using the latest technologies, many of which are developed intendedly to achieve clear defined requirements. The safety of combat vehicles crews is the main aim to be endeavor. Advanced, very effective anti-tank ammunition and rockets cause the need to develop more resistant armors. Classic ballistic shields would have to be thicker and therefore with a heavier weight. For this reason new ballistic materials are developed to ensure adequate level of protection the crew and sensitive components of armament systems. First of all the high-tech armors have to be characterized better ratio of weight to ballistic protection level. Therefore the aluminium oxides, silicon carbides and boron carbides were introduced into the production of armor systems wherein the necessity of usage a very expensive technologies influence the higher costs. An option is to utilize laminate structures or composites, but they can be employ rather in light solutions i.e. bullet-proof jackets or armor systems of light vehicles and personnel carriers. It is slight probability that this objects would be exposed on fire of heavy armament.

New armor materials assist to reduce the military equipment weight which increase still due to fulfill the protection requirements. On the other hand the massive vehicles and another military equipment have to be supported by engineering forces equipped with assault and supporting bridges. This bridges are extremely loaded. Both mentioned examples indicate that the use of high strength steels is inevitable. Moreover, these steels make it possible to face the requirements successful and develop the construction. Nevertheless, this grade of steels is difficult to weld and many conditions should be completed to perform high quality joints. Welding imperfections can weak the junction certainly and finally the whole structure. Therefore all aspects of heavy loaded structures made of high strength steels are extremely important.

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Future Robots Using in C-IED Detection

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Abstract
In contemporary conflicts the IED and mines threats are growing. In paper the concept of using engineer robots in counter IED operation are described. To fulfil this analyses the cooperation between varied class robots are proposed.

KEY WORDS: *mobile robot, engineer robot, Unmanned Ground Vehicle, UGV, EOD/IED tasks, C-IED.*

1. Introduction

Modern military conflicts and actions, such as the conquering of Mosul in Iraq, Rakka in Syria and operations in Donbas, provide evidence to the rising role of using mine groups, mine traps, as well as IEDs. In offensive actions IEDs and mines placed on roads and main communication routes prove to be of utmost importance, especially in cars and on roadsides (including buildings in direct proximity of streets). They are, however, the main source of losses in both combat techniques and live forces.Recent years have witnessed a rapid development of engineering platforms (also known as engineering robots) and the range of their usage. It is currently predicted that they will be exploited in asymmetrical actions, conflicts of low intensity and more classical combat actions. They are mainly used in following areas:

- engineering support of patrol actions of military subdivisions;
- engineering support of combat actions in urbanized areas;
- engineering patrol and maintenance of roads;
- realization of EOD/IED tasks.

2. Investigation Results

Engineering support for patrol activities occurs mainly during asymmetrical operations. General military units patrol the area most often using full-time, armored vehicles that provide fire protection and support. In unfavorable conditions or in the case of the need to thoroughly check the terrain, they pass into pedestrian traffic. The greatest threat to patrols are booby traps. For these reasons, these patrols are reinforcing the sapper section, whose task is to recognize suspected places and objects indicated by general military reconnaissance and neutralization of detected traps. Currently during supporting infantry teams by assigned EOD specialists, light are most commonly used robots (around 10-20 kg)- tab. 1. This is due to the limited transport possibilities (limited space) of the standard AFV (BWP) - not adapted to the transport of robots. They serve mainly as reconnaissance platforms for the optical confirmation and possibly identification of threats identified by soldiers. Under favorable conditions, they can also be used to neutralize hazards by providing a destructive load. Their low payload and low battery capacity means that they are practically not used to detect and search for IEDs. In addition, their use is limited to extremely favorable environmental conditions. They are therefore used most often in urbanized areas, inside buildings and on paved roads. Their working capabilities as carriers of detection systems should be assessed as very low. The basic robots for EOD sub units are portable robots (about 75 kg - for carrying 2 soldiers) - tab.2 Their load capacity and lifting capacity allow for more effective identification and identification of threats. They have the ability to reveal hidden elements and in favorable conditions to intervene and are also capable of transferring detection systems - e.g. magnetic detectors and mini ground penetrating radars.

They have much better terrain mobility and the ability to overcome obstacles - they can be effectively used in urbanized areas and in open areas. Larger vegetation, e.g. cereals, can however effectively limit the movement of such robots. Their effective working time is about 2 hours. Hence, due to the increased demand for energy by detection systems, the patrol capabilities are limited. For the same reasons, the width of the recognized transition and the speed / velocity of recognition are also limited. As a result, their use is effective over relatively short distances not exceeding 0.5 km.

Generally, robots to support patrols of general military units are expected to be highly transport-friendly, have a short time to prepare for operation and have an effective working range of 200-400 m (nominal range 400-800 m). As the experience indicates, it is advisable to equip the patrol with two robots - a light weighing up to 15 kg and a portable one with a weight not exceeding 75 kg. The first of these is expected to implement the tasks of rapid identification and identification of threats and support activities in a very difficult area, where the robot is carried by soldiers and used only temporarily for short-term missions. The purpose of a larger robot is to perform the task of identifying the requiring ability

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to reveal hidden devices and their neutralization or transfer advanced detection and detection systems that allow for more effective protection of pedestrian patrols. The robot should have the possibility of long-lasting work enabling supporting foot patrols for a minimum of 6 h (desirable 10 h) and develop a maximum speed comparable to that of a running soldier.

Support for combat operations in the urbanized area consists mainly in detecting traps and paving passes. Portable and light robots can be used for these tasks, but their working possibilities are too small in many situations. For these reasons, it is necessary to use robots with a mass of 250-300 kg (the permissible mass is limited by the load-bearing capacity of ceilings and staircases), which have much higher lifting and thrusting forces. They are expected to be able to overcoming staircases, efficiently open doors and furniture, track, and the ability to quickly inspect rooms and warehouses. This requires a large manipulator range, high stability and high maneuverability of the robot and low energy intensity.

Currently robots adapted for military use are often used for this purpose, mainly pyrotechnic works used by police units and border guards. Due to their mass (about 300 kg) they have a considerable capacity, manipulators with complex kinematics and high degrees of freedom DOF (Degree of Freedom) - tab.3. They allow for precise diagnosis and effective IED neutralization. However, they are not adapted to fast and long-term movement and patrol operation - they are intended for intervention. Due to the mass and dimensions they are characterized by relatively low transport susceptibility - they are usually transported on special trailers. Only a few (e.g. Theodor being in the Bundeswehr's equipment) are transported inside the transporters of the EOD team.

Table 1

Light robots (about 15 kg) designed to recognize the tactical IED
on a short distance and support pedestrian sub-units

				
ROBOT	Dragon Runner 10 (QinetiQ)	MTGR (Roboteam)	AEODRS incr.1	BALSA
mass	15 kg	15 kg	15 kg	20 kg
speed	6,4 km/h	3,5 km/h	14 km/h	8 km/h
chassis load capacity	9 kg	10 kg		ok. 10 kg
width	35 cm	37 cm		50 cm
length	39 cm	45 cm		60 cm
Height (without manipulator)	15 cm	15 cm		19 cm
range of LOS teleoperation	650 m	500 m	100 m	
work time	2-3 h	2-4 h		1 h
DRIVING HEAD height of observation controlled movements magnification	on the additional mast approx. 0.3 m rotation and tilting zoom opt.	on the manipulator 0.4 m rotation and tilting zoom opt. 10x	on the additional mast approx. 0.3 m / 0.5 m on manipulation rotation and tilting zoom opt.	on the manipulator about 0.8 m rotation and tilting zoom opt.
MANIPULATOR degrees of freedom (DOF)	rotation of the boom lifting the boom raising the arm rotation of the gripper closing the gripper	lifting the boom raising the arm rotation of the gripper closing the gripper	rotation of the boom lifting the boom raising the arm rotation of the gripper closing the gripper	rotation of the boom lifting the boom raising the arm rotation of the gripper closing the gripper
range of the manipulator	approx. 0,6 m	0,49 m		approx. 0,8 m
load capacity for max. reach	approx.. 2 kg	5 kg	approx. 2 kg	approx. 2 kg

The main task of engineering patrols is to recognize the area and make transitions and clean up the area with mines and mine traps. These tasks are performed for general military units or to unlock traffic corridors. A high rate of task implementation is recommended. Used robots should be capable of detecting and quickly neutralizing road and path threats and marking safe passages. In addition, they should be able to replace sappers during land cleaning. or this purpose, they should be characterized by very high mobility, enabling access to hard-to-reach places and the ability to carry advanced detection and neutralization systems. He should be able to support the patrol for at least 10 hours (minimum 6 hours of continuous work). The desired control range is 400-800 m. The robot should be able to accompany the running soldiers. Due to the equipment being moved, the necessary working capacity and the required mobility - the total weight of the platform should be around 300-800 kg. The most complex tasks, possibly requiring whole groups of

robots, are patrolling and maintaining roads – including clear-ups of mines and clearing the roads. That introduces the necessity of recognizing and neutralizing any threats on the road, the roadsides, as well as in the closest surrounding areas.

According to the conducted analyses, it is vital to be equipped with 3 types of engineering robots in the least:

- heavy engineering-recognizing robots,
- heavy engineering-intervening robots,
- light or medium-weight engineering-intervening robots of high mobility,

and UAVs (Unmanned aerial vehicle), used for scanning areas in front of motorcades and finding general hazards. The task of the heavy engineering-recognizing robots is to find and mark points which are highly probable to be mines or improvised live bombs in either the crown of the road or its surroundings. An elementary kit of sensors/detectors should allow reckoning any hazards in traffic lanes wider than 3 m. That task should be realized by integrated detection systems, using at least 2 types of mutually completing sensors, i.e. a ground penetrating radar, cooperating with a magnet detector. Finding threats on roadsides, in roadsides ditches, in culverts, under bridges or in vehicles parked off the road should be facilitated by a special manipulator equipped with suitable cameras and sensors. The area directly surrounding the road in a strip of 50-70 m width should be controlled by a special observation system. Its task is mostly finding hazardous EFPs or remote-controlled grenade-launchers. It is advised for the robot to have systems allowing for activating live bombs in front of vehicles, as well as certain elements of electronic combat, which can protect the robot from remote-controlled live bombs.

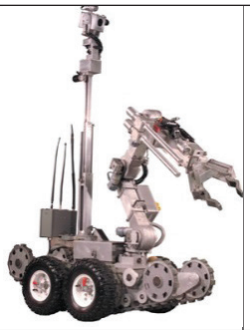
Table 2

Portable robots (about 75 kg) intended for tactical reconnaissance and support for mechanized subunits

				WO dla nowego robota armii USA
ROBOT	Packbot 510 (iRobot)	Talon IV/2 DOF (Foster-Miller)	TIGR (Roboteam)	AEODRS incr.2
mass	33 kg	52-71 kg	74 kg	75 kg
speed	9,3 km/h	8,3 km/h	-	14 km/h
bearing capacity (without manipulator)	35 kg	45 kg	150 kg	
width	52 cm	57 cm	59 cm	
length	69 / 89 cm	86 cm	91 cm	
height (without manipulator)	18 cm	28 cm	35 cm	
range of LOS teleoperation	- m	800-1200 m / 500 m	1300 m	1000 m
work time	2-3 h	2-4 h	6-8 h	
DRIVING HEAD height of observation controlled movements magnification	on the manipulator up to 2.0 m tilt zoom opt. 26x	on the additional mast approx. 0.7 m / 1.3 m on manip. rotation and tilting zoom opt. 26x	on the additional mast approx. 0.8 m / 1.5 m on manipulation rotation and tilting zoom opt. 30x	
MANIPULATOR degrees of freedom (DOF)	lifting the boom raising the arm rotation of the gripper closing the gripper	boom turnover / - lifting the boom raising the arm grapple rotation / - closing the gripper	rotation of the boom lifting the boom raising the arm lifting the gripper rotation of the gripper closing the gripper	
range of the manipulator	approx. 1,2 m	1,9 m / 1,3 m	1,5 m	
load capacity for max. reach	approx. 2 kg	- / 4,5 kg	7 kg	
maximum load capacity		30 kg / 11 kg	19 kg	

Table 3

Light robots (approx.300 kg) intended for neutralization of IED in urbanized area

				
ROBOT	Caliber Mk 4 (ICOR)	Theodor (Cobham)	Andros (AEODRS incr.3) (Northrup Grumman)	IBIS (PIAP)
mass	333 kg	375 kg	360 kg (340 kg)	300 kg
speed	3,2 km/h	3 km/h	5,6 km/h (14 km/h)	10 km/h
width	75 cm	69 cm	74 cm	88 cm
length	140 cm	130 cm	132 cm	135 cm
height	87 cm	124 cm	144 cm	125 cm
range of LOS teleoperation	1000 m	500-800 m	1000 m	1000 m
work time	5 h	-	-	ok. 4 h
bearing capacity (without manipulator)	-	350 kg	-	-
DRIVING HEAD height of observation controlled movements magnification	arm on the manipulator about 2.7 m rotation and tilting zoom opt.	on the additional mast rotation and tilting zoom opt.	on the additional mast 1.8 m rotation and tilting 72x zoom	arm on the manipulator approx. 1.7 m rotation and tilting zoom opt.
MANIPULATOR degrees of freedom (DOF)	lifting the boom raising the arm tilting the gripper rotation of the gripper closing the gripper raising the arm 2 rotation of the pyroprotor	boom turnover / - lifting the boom raising the arm grapple rotation / - closing the gripper	rotation of the boom lifting the boom raising the arm rotation of the arm lifting the gripper rotation of the gripper closing the gripper	rotation of the boom lifting the boom raising the arm arm telescope lifting the gripper rotation of the gripper closing the gripper
range of the manipulator	approx. 2,2 m	1,9 m / 1,3 m	1,4 m	1,8 m + 0,5 m telescoping
load capacity for max. reach	45 kg	- / 4,5 kg	27 kg	30 kg
maximum load capacity	90 kg	30 kg / 11 kg	73 kg	50 kg

Considering the speed and efficiency of detection systems, the robot's speed is predicted to be 5-20 k/h. A low signature of the robot is highly desirable (volume, vibrations, ground impact etc.), which will prevent from activating detonators. It is expected to allow, given favorable conditions, marking points of suspicion without the necessity of stopping the robot before a potential hazard, thus increasing the speed of tasks completion up to 15-20 km/h. Places marked by the heavy engineering-recognizing robots should then be verified by the heavy engineering-intervening robots. They should possess robotic abilities including:

- recognizing tensions (thin strings);
- recognizing antennae, cables, wires;
- recognizing mines and explosive;
- picking up or pulling out objects, using a manipulator;
- excavating objects;
- removing cars and trucks (chassis, inside, trunk);
- checking culverts and bridges;
- neutralizing IEDs, using different methods;
- wykrywanie metali zamaskowanych gruntem;
- obserwację przedmiotów nisko położonych (np. pod samochodem);
- obserwacja przedmiotów wysoko położonych nad robotem;
- odsłanianie przedmiotów w gruncie;
- podejmowanie próbek (CBRN).

Having these capabilities, a team of robots can also be successfully used as a support for the RCP, OZR and PRI group during conducting combat operations. Due to the expected high rate of action, it is advisable that the grouping has two engineering and appraisal works.

It is desirable to have 2 command vehicles to supervise such a team of robots. The dispersion of the control and control system allows to increase the effectiveness of the patrol. This gives, for example, the possibility that the mutual transfer of subordinated robots.

The command crew of each vehicle should consist of at least 5 soldiers:

commander - operator of the reconnaissance (detection and threat detection) system and UAV (unmanned aerial platform);

-the control operator of the heavy reconnaissance robot;

- operator controlling a heavy intervention robot;
- operator controlling a light intervention robot;
- driver of the command and teleoperation vehicle.

As the analysis shows, currently a number of solutions of robots of 15 kg (light), 75 kg (portable) and 300 kg (medium) robots can be found. The situation is much worse in the case of 800 kg structures. The main purpose of this size platform in these scenarios is to detect potential threats in the form of mines or IEDs and their neutralization. The most difficult task is the process of detecting a dangerous object, especially when securing the movement of troops. This is influenced by the expected high rate of action and a large area of activity. Threats should be detected on the road and in its immediate surroundings. In addition to identification, it is necessary to mark the location of suspicious objects and transfer their location to the command and control system. The detection system should enable detection of threats using a ground penetrating radar and a system confirming the high probability of finding a mine or IED. In addition, the platform should be equipped with an auxiliary detection system to detect the threat on the roadside, in roadside ditches, cars, etc. For this purpose, cameras located on the keypads are currently used. It should be assumed that the development of technology will also allow alternative, more effective systems. The reconnaissance platform should move along the road, 100-200 m before the protected group / convoy with the maximum speed and penetration detected by the system, using the ground penetrating radar of the recognized lane and if necessary checking the roadsides, road ditches and the immediate vicinity of the road. If a threat is detected, the suspect object or its hiding place should be marked. Currently, liquid sprayed by sprinklers is commonly used for this purpose. At the same time, the location information should be passed to the management and command vehicle. Regardless of the detection system, an inspection manipulator should work, which will be able to recognize and verify threats in vehicles, on roadsides, behind roadside fences, in roadside ditches, culverts, and even on trees, shelters or lorries using cameras. It is advisable to have the ability to move or lift masking elements or limit the recognition possibilities.

It is envisaged that the basic form of using such a robot will be its use in mechanized patrol. The platform will be transported on a trailer, and during the time of overcoming the threatened sections it will be controlled in the mode of teleoperation, from the steering and command vehicle. It is anticipated that it will enable the coordination of the activities of the group of 3 robots. Then, multifunctional control stations will be used. They should provide working conditions enabling the implementation of many hours of missions (patrols) without excessive operator fatigue In case of necessity to control the platform out of the scope of the steering and command vehicle and when supporting pedestrian engineering reconnaissance patrols (road or terrain), it is envisaged to use personal control stations with limited functionality. Effective implementation of the reconnaissance mission while securing the movement of troops requires from the platform:

- the high transport susceptibility (indispensable for not having to accompany the main forces and quickly reach the area of operation);
- the ability to prolong speeding over 10 km / h for a long time;
- quick transforming from transport to work position;
- effective detection of mines and IEDs located in the ground, in the recognized belt (dual detection system - basic and confirming);
- quick recognition of suspicious objects - it requires a camera with at least two degrees of freedom and a large working area of the manipulator that allows:
  - checking the interiors of standing cabins on the side of lorries;
  - checking the interiors standing on the side of passenger cars;
  - inspection of culverts (standing on the road crown), roadside ditches, and objects behind fences, walls etc.;
  - inspection of facilities located on shelters, trees, roofs, etc.
- very good visualization of the surroundings in the whole field of the manipulator's work and maneuvering the platform.

The following are critical for mission accomplishment:

- effective detection of threats by the detection system;
- high stability and stability of the detection system (ground penetrating radar);
- a very large manipulator area adapted to the anticipated, varied tasks (indicated minimization of the number of degrees of freedom to simplify the control system).

Conclusions

The battlefield of the future will be characterized by an increasing level of robotization. One should expect the introduction of entire groups of remote-controlled means, completing common tasks. For that to happen, though, there are still technical difficulties to be resolved. Those are mostly tied to mobility levels, detection systems, steering systems and manipulators. At the same time, new tactics should be developed alongside new technologies, in order to use them to their full potential.

Acknowledgements

This work was conducted within the framework of the project "Platforma średnia (klasa 800 kg)" - grant no. DOBR-BIO4/083/13431/2013. The authors are thankful for the Polish "National Centre for Research and Development".

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Static Tensile Test of rGO-PDMS Composite

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Abstract

Presented paper shows results of the tensile strength of the rGO-PDMS composite (pure PDMS doped with reduced graphene oxide (rGO). As a result, the relative elongation of the rGO-PDMS was obtained reaching 600% as compared to control samples before breaking of the composite.
Microfractographic measurements of fracture in static tensile test showed delamination in places where rGO flakes were present, what favored the initiation of breaking process.
The decrease of the Young module was observed by 8% when PDMS was doped with reduced graphene oxide.

KEY WORDS: *silocone, rGO-PDMS composite, PDMS, graphene oxide, RGO, tensile strength*

1. Introduction

Polydimethylsiloxane (C2H6OSi)n (Fig. 1) belongs to a group of polymeric organosilicon compounds. PDMS was developed in the middle of twentieth century as a replacement for natural rubber and is the most common elastomer in use today [1]. PDMS is different from other elastomers, it consists of silicon and oxygen in the form of siloxane [2, 3]. PDMS characterize with relatively low prices, softness, transparency, outstanding physical properties, chemical stability, and high gas permeability [4-7].

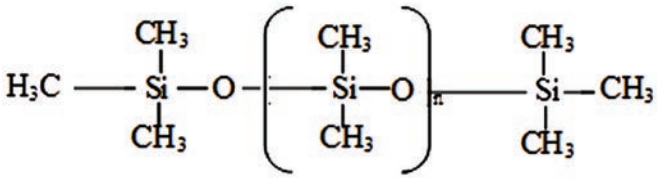

Fig. 1. Chemical structure of polydimethylsiloxane

In paper presented by S. Tazawa, el.al [8] from the results of the tensile testing, it can be found that the stress at break of the PDMS with l-phenylalanine nearly became seven times higher than that of the PDMS without l-phenylalanine. The DMA results revealed that the PDMS could maintain its storage modulus for three heating cycles, while the melting temperature was also kept at □120 °C. Moreover, the mechanical property was analyzed through two remolding cycles, and it was found that the PDMS could almost maintain its mechanical property after the heat remolding. PDMS also possessed some self-healing property, where the Young's modulus of the cut PDMS could maintain at least 70% of its original Young's modulus after contact and self-healing.

Advantageous mechanical and structural properties resulted in PDMS wide range of application in food industry [9], automobile industry [10,11] and medicine as (urology, ohtalmology, dermatology, immunology) [12].

Tino Töpper et. al.[13] showed that implementation of the soft sub-micrometer-thin elastomer membranes will become an essential component of dielectric elastomer transducers with strains comparable to human muscles, operated at the conventional battery voltages for future artificial muscles or skin implants.

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Wei Qian et.al [7] presented application of rGO-PDMS membrane for medical purposes. They showed that the rGO-PDMS composite membrane exhibited bionic performance (ordered pore structure and suitable WVTR), improved mechanical properties, good compatibility and effective antibacterial activity. In vivo experiment indicated that the rGO-PDMS composite membrane could accelerate wound healing via enhancement of the re-epithelialization and granulation tissue formation. These findings suggest that rGO doping PDMS uniquely resulted in a multifunctional material for potential use in wound dressing [7].

The goal of the conducted research in presenter paper was to determine the influence of the content of reduced graphene oxide (rGO) flakes on the structure and static tensile strength.

2. Method of Investigation

The research on functional properties was subjected to rGO-PDMS composite developed in cooperation with the Biomedical Engineering Center, Institute of Optoelectronics, Military University of Technology and Topsil Global company. Structural investigations were performed using the Quanta 3D FEG scanning electron microscope (FEI company). The experiment to determine the chemical composition was made by laser emission induction spectroscopy (LIBS) method. The laser beam was focused on the material samples causing its ablation, followed by heating and ionization of the occurring vapors and plasma generation. Created plasma was a source of strong continuous and discrete radiation, characteristic of atoms occurring in a given sample.

Tensile strength tests were carried out on the Zwick Roell Kappa 500 pulsator (Fig. 2). The maximum of the tensile strength of the vises was ±50 kN and the maximum distance of the relocation of the sample was 1500 mm. The dimensions of the rGO-PDMS samples are presented in Fig. 3.

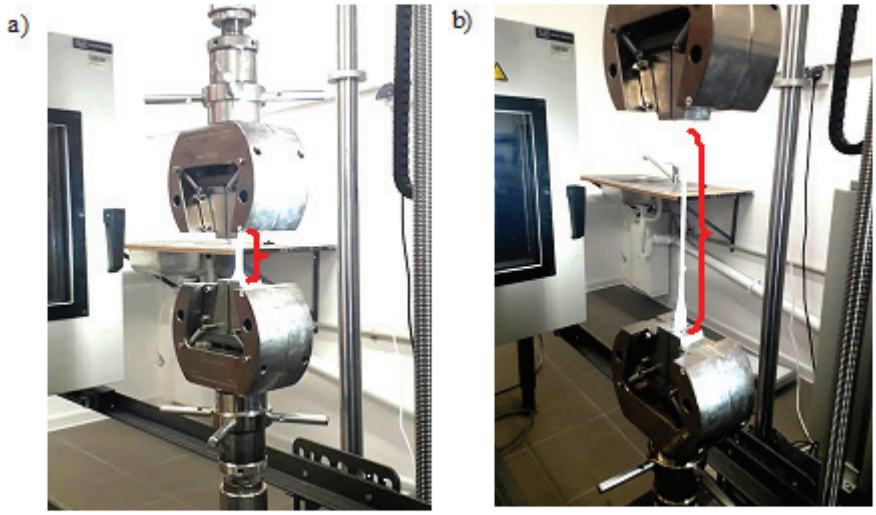

Fig. 2. Zwick Roell testing system with integrated videoextensometer, before (a) and after tests (b)

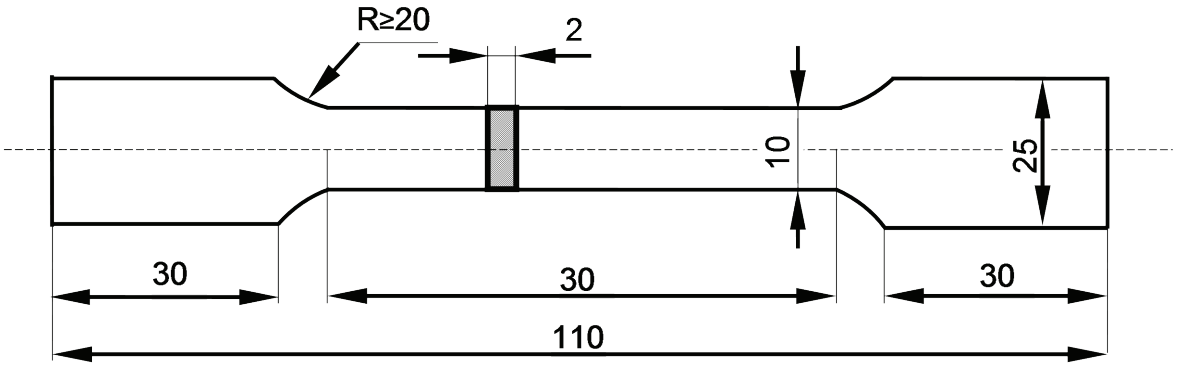

Fig. 3. Dimensions of the rGO-PDMS composite for mechanical tests

In presented experiments the electromechanical navigation of the displacement speed was implemented and was set to 100 mm/min. The test were started form preliminary loads set to 0,5 N with speed of 5 mm/min.

Spectral analysis of Raman spectra was performed on a Nicolet iS50 spectrometer from Thermo Fisher Scientific company. This device is used to measure scattering spectra in the mid-infrared range and qualitative and quantitative analysis (resolution 4cm^{-1}, the range of measurements 4000-400 cm^{-1}).

3. Structural Research

The work presents structural, spectroscopic and strength tests as well as LIBS chemical composition analysis of a rGO-PDMS composite. In the visual assessment, rGO-PDMS composite was characterized by homogeneity, however, microscopic analysis performed using optical and scanning microscope showed numerous flakes of reduced graphene oxide (rGO) (Fig. 4 a, b), also located on its surface (Fig. 4 c, d).

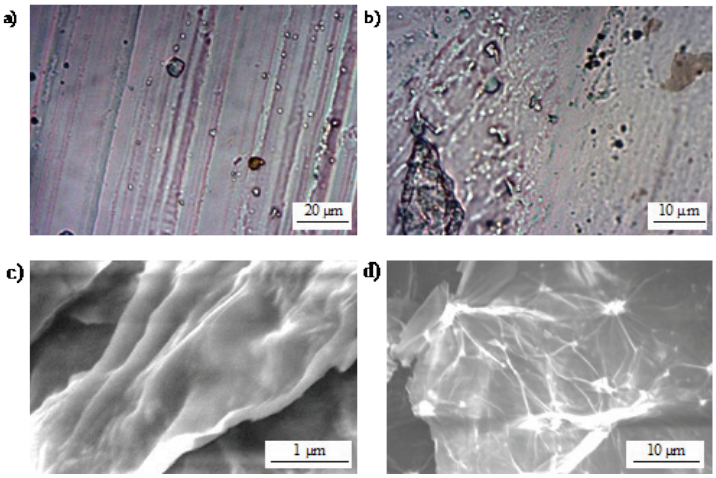

Fig. 4. Morphology of the rGO-PDMS composite surface

All analyzed by Raman spectroscopy samples were characterized by typical spectral bands in the 2900-2970 cm-1 range, derived from the C-H cyclic alkanes stretching vibrations, which are part of the siloxane structure. In the 1590, 1350 cm-1 area, rGO bands were observed what is an conformation of their presence in the polydimethylsiloxane structure (Fig. 5).

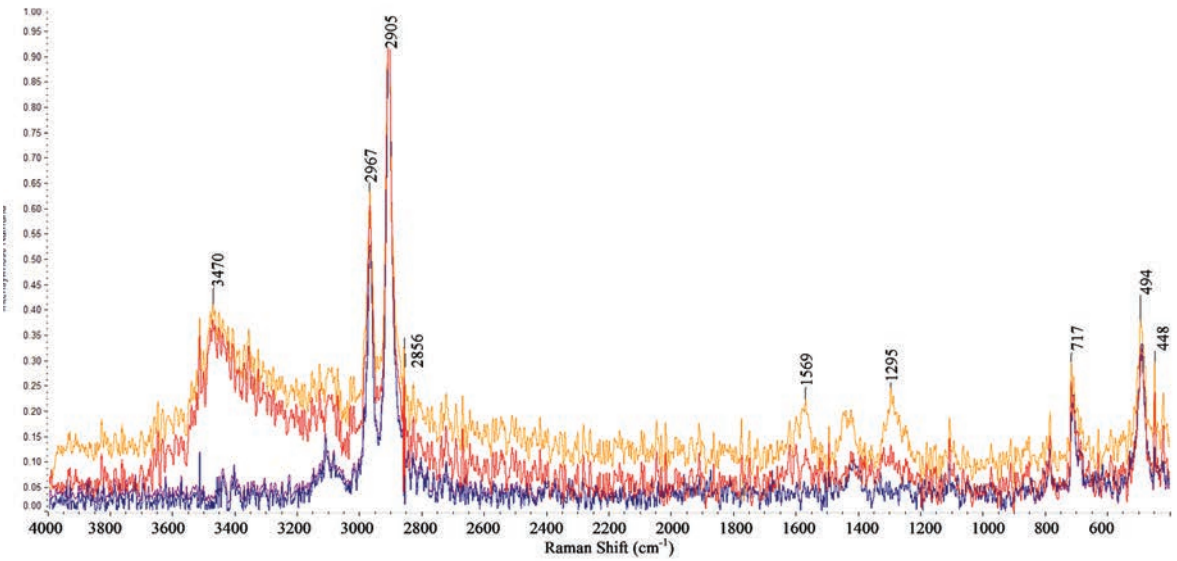

Fig. 5. Raman spectra of the rGO-PDMS composite and PDMS

LIBS spectrum of the rGO-PDMS composite was registered with use of 10 laser shots. The spectrum is dominated with molecular transition of the Si element and minor qualities of Ca, C, Mg, Na, Fe and Ti resulted from the presence of the additives which enhance structural and mechanical properties of the composite and form the storage conditions (Fig.6.).

Analysis of the chemical composition made by LIBS spectroscopy also confirmed the presence trace elements of carbon from rGO bonds.

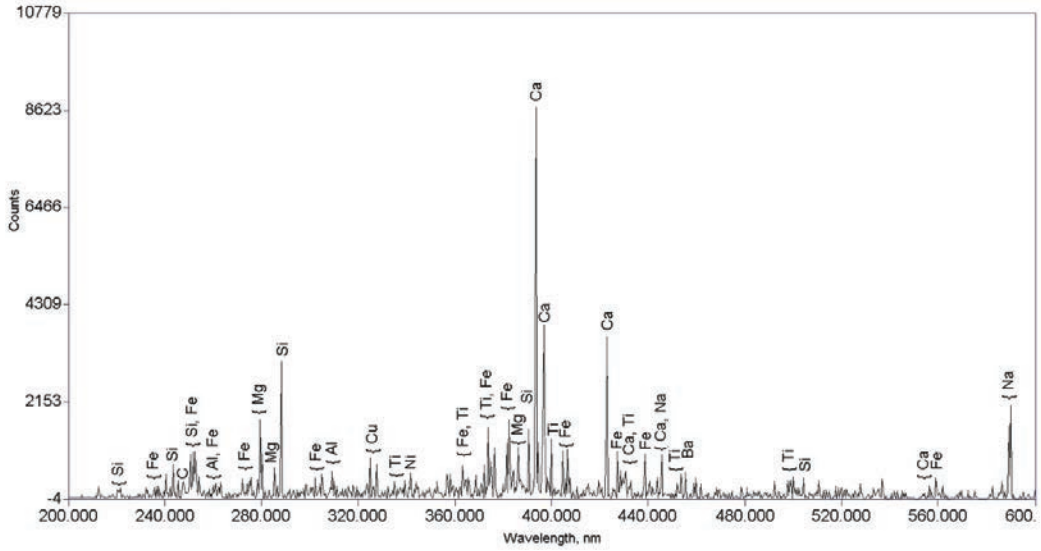

Fig. 6. LIBS spectroscopy of rGO-PDMS composite

4. Static Tensile Test

During static tensile test measurements of the axial force and displacement, which served to designate the strain-stress curve (Fig. 7). The strain was referenced to initial cross section and strain to the parallel length of the sample. The mean value of the static tensile test curve of rGO-PDMS was compared to pure PDMS. The measurements showed that doping PDMS with rGO did not influence significantly on the mechanical properties of the composite. The reduction of the Young module was observed, ranging around 8% ((EPDMS=7,19 MPa, ErGO-PDMS composite = 6,64 MPa).

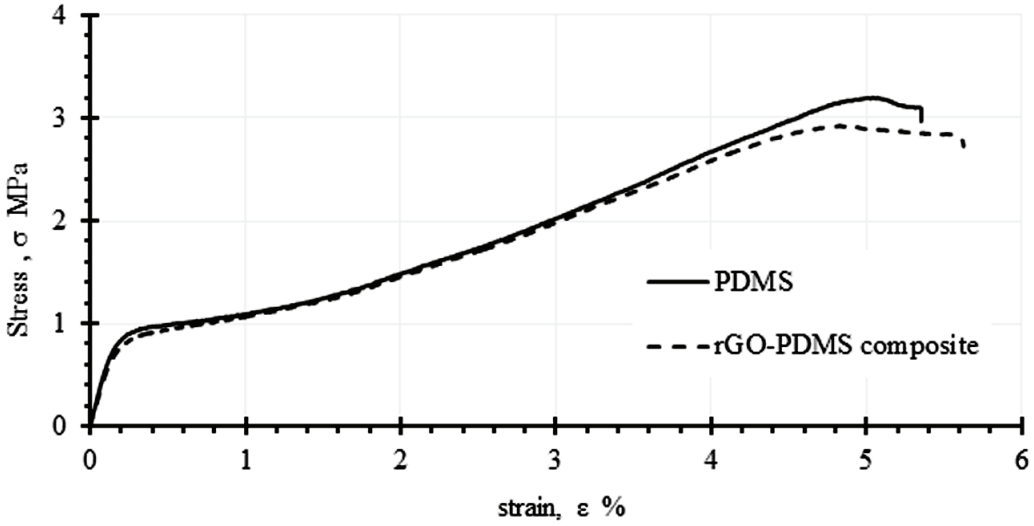

Fig. 7. Stress-strain relationship of rGO-PDMS composite and PDMS

The breaking process in both materials was observed mainly on the edge of the samples tested (Fig. 9 c, d). Topography of the fracture area was smooth in macroscopic scale (Fig. 8a). On the surface of the fracture area of the PDMS sample craters and pits were observed (Fig. 8a). The analysis of the fracture morphology of the rGO-PDMS composite revealed the presence of numerous flakes of reduced graphene oxide.

a) b)

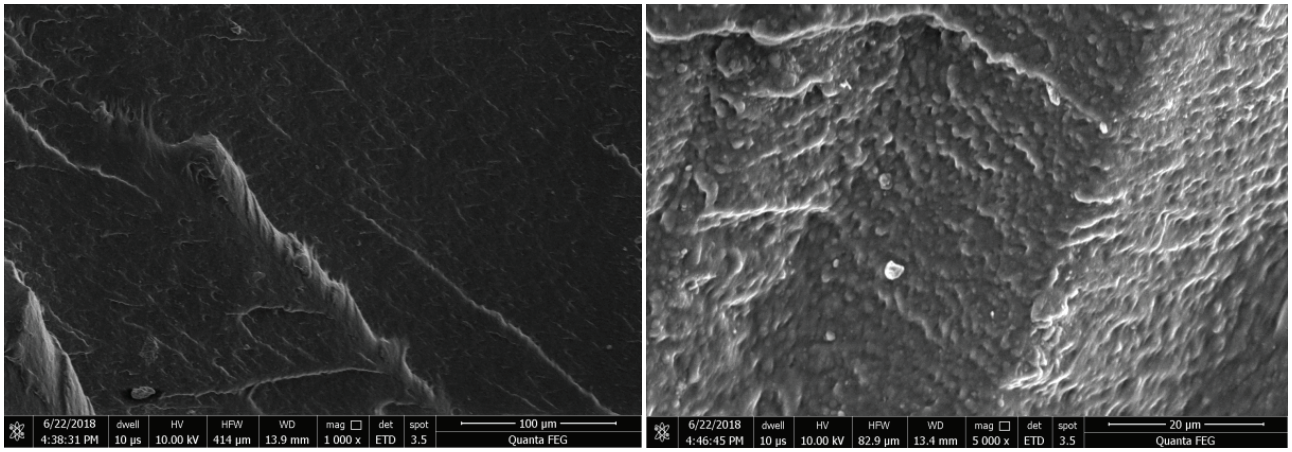

Fig. 8. Microfractography of the PDMS Surface

Despite that flakes of reduced graphene oxide were intentionally incorporated into the PDMS (Fig. 9 a-f) they didn't influence significantly the weakening of the durability of composite. On the fracture area of the composite rGO-PDMS showed week coherence with PDMS, which was shown in Fig. 9 e, f.

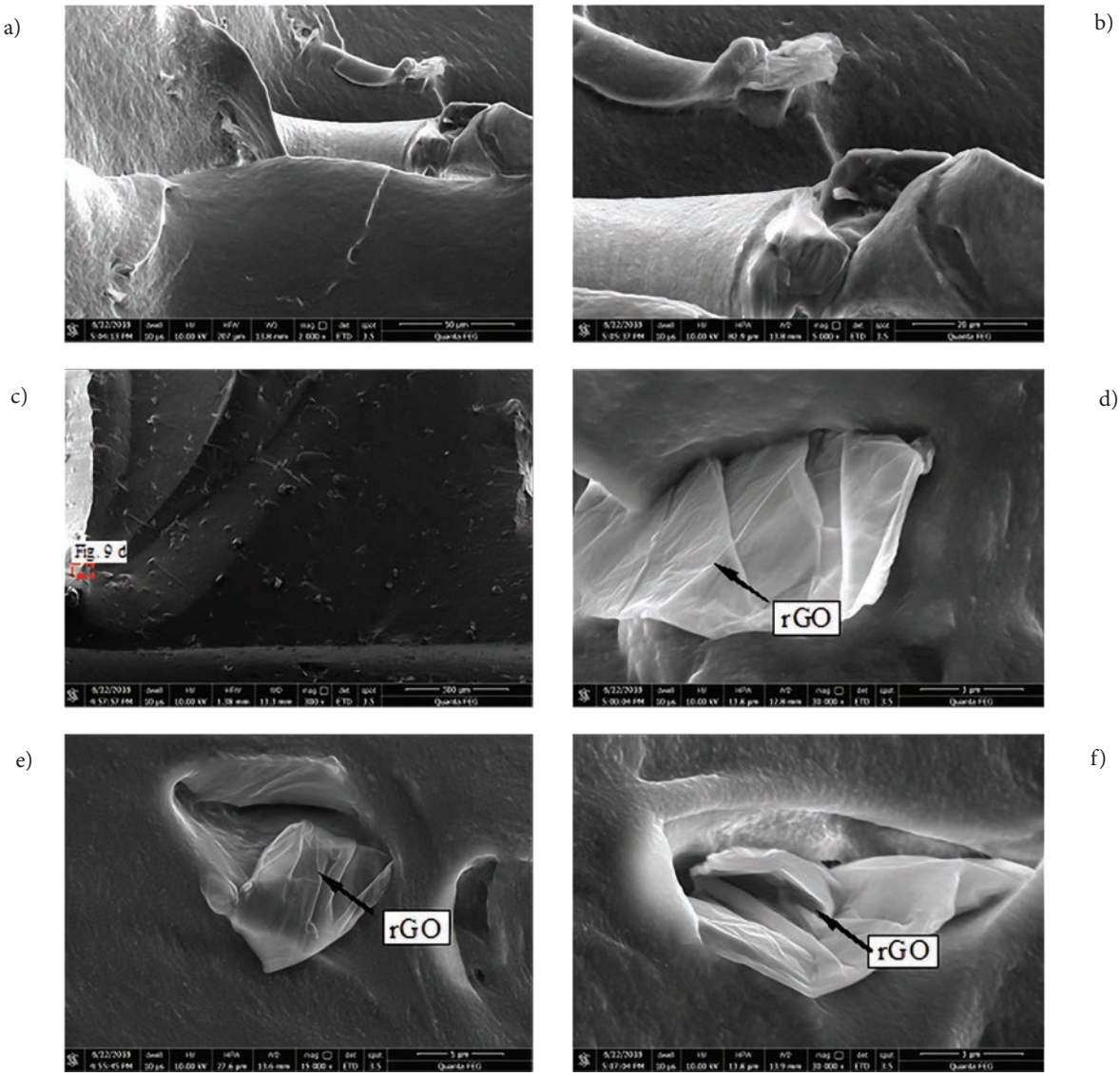

Fig. 9. Microfractography of the rGO-PDMS composite surface

Conclusions

Conducted structural and spectroscopic studies confirmed the presence of RGO in rGO-PDMS composite. The means values of the static tensile strength of PDSM as compared to rGO-PDMS composite shoved Young module decrease for about 8% (E_{PDMS} = 7,19 MPa, $E_{rGO\text{-}PDMS}$ composite = 6,64 MPa). On the fracture surface numerous flakes of reduced graphene oxide were observed. The breaking point for all examined samples was near the edge of the samples and continued the direction of the fracture towards the core of the material.

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Composites Containing Ag Nanoparticles for X-ray Protection

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Abstract

Soft X-rays assisted modification of polymeric nanocomposites containing metal nanoparticles has been performed and radiation induced changes of their physical and chemical properties have been investigated. Thin composite layers were formed on polished glass substrates applying spin-coating technique for composite deposition from solution containing metal powder additives. Synthesis of metal nanoparticles was performed directly in the deposited PMMA layer applying photocatalytic method (UV irradiation), which was followed by sample irradiation with soft X-rays. The surface morphology, composition and microstructure of samples were assessed using scanning electron microscope, energy dispersive X-ray spectroscopy and optical microscopy. Also UV-VIS spectrometry and FTIR spectrometry were applied for characterization of nanocomposites. It was found that the soft X-ray irradiation contributed to the formation of new Ag particles and their agglomeration into larger clusters within the polymer matrix causing changes of structural and optical properties of polymeric nanocomposites. Mechanisms of low-dose rate X-ray radiation induced structural changes in polymeric composites, processes promoting formation of new particles in polymers; particles growth and clusterization within polymer matrix have been discussed analyzing changes of physical and chemical properties of nanocomposites before and after their X- ray irradiation.

KEY WORDS: *polymer composites, nanoparticles, poly-methyl-methacrylate (PMMA), soft X-rays*

1. Introduction

Attention towards nanotechnologies is steadily increasing due to an extensive range of its applications in different fields of science. [1-3]. Metal nanoparticles having size of 1-100 nm play an important role in development of new nanomaterials and composites. The reason of the enforcement for nanoparticles in various applications is their fascinating properties [4-7]. Each metal nanoparticle performs different and has specific properties depending on its size, structure, shape and composition [8]. Nanoparticles aggregate easily because of their high surface energy and are quickly oxidized as well [9]. The optical properties of metal nanoparticles depend on their surface plasmon resonance, where the plasmon refers to the collective oscillation of free electrons within the metal nanoparticle. It is known that the plasmon resonant peak's position and width are sensitive to the size and shape of nanoparticle, the metal species and the surrounding medium [10, 11]. To beat the aggregation and stability problems, metal nanoparticles are incorporated in a polymer matrix forming nanocomposites.

Polymer nanocomposites are progressive functional materials [12-14] composed of nanoparticles dispersed inside of polymer matrix and covered by polymer, thus forming a skeleton structure. Produced nanocomposites combine the eligible properties of both agents [1, 15, 16]. Silver nanoparticles are the most desirable material used as polymer functionalizing agent, due to their unique properties, that are well established and extensively investigated [2, 17-22]. Nevertheless, practical applications of silver nanoparticles require their entrapment on various substrates and matrixes. In this case polymers are the primarily chosen materials due to their specific morphology, chemical and structural nature with the long polymeric chains allowing incorporation and fine dispersion of nanoparticles. However only suitable functional groups of polymers can be used as targeted reactive sites for the controlled synthesis of nanoparticles [14, 22, 23]. Use of PMMA suggests two close superiorities such as availability to carboxylate functional group for a chemical bonding with the metal ions and high solubility of PMMA in solvent like chloroform for silver chlorate reduction. Actually, there are two synthesis methods of silver-polymer nanostructures: in-situ and ex-situ. The ex-situ method involves silver

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nanoparticles formation first, followed by dispersion into a polymer matrix. And the in-situ method embraces the metal nanoparticles that can be generated inside a polymer by reduction of metallic precursor which is dissolved in the polymer or the polymerization solution. In-situ technique has been proven to give essential enrichment to the modification of the interfacial area between inorganic particles and the polymer matrix [4, 6, 18, 23-25]. Experience gained investigating silver-polymer nanostructures is of value when dealing with formation and investigation of nanocomposites containing metal particles other than Ag.

Polymer composites are appealing expectants for ionizing radiation armor applications and can be made transparent. In order to capitalize on the superior properties of polymer composites in transparent armor applications [12], novel techniques and fabrication/modification methods are needed. Modification of polymers with high energy radiation (X-rays, gamma rays, electron beam) leads to the formation of new bonds, free radicals, oxidized products, grafts, scission of main chains and cross-linking [12, 14, 21, 26, 27]. Radiation induced processes have many advantages over other conventional methods. In radiation processing of polymers no catalysts or additives are required to initiate the reaction. Absorption of radiation energy by the backbone polymer initiates generally a free radical process. With chemical initiation free radicals are produced by the decomposition of an initiator into small fragments which attack the base polymer leading to free radicals. On the other hand high dose radiation exposure of polymers leads to the degradation of these structures.

The importance of the research of radiation hardness of polymers is growing up due to the miniaturization of polymeric constructive elements and broader application of polymeric films characterized by modified surface. Functionality and exploitation characteristics of the devices are dependent on the quality and stability of polymeric materials as it is in the case of poly-methyl-methacrylate (PMMA). Radiolysis in the surface layers may significantly change the optical properties of PMMA. The impact of ionizing radiation on polymeric structure (polymer degradation) could be decreased by the formation of polymeric nanocomposites containing metal nanoparticles.

It is well known, that even small irradiation doses may cause alteration of polymer properties at least in the irradiated surface layers when not in the whole volume of the polymer, however only few investigations record the impact of low doses (Gy range) on PMMA properties and there is a lack of information on modification of the structure and properties of low dose irradiated polymer nanocomposites containing metal nanoparticles. Low dose (dose rate) X-ray radiation impact on the optical properties of thin PMMA and nanocomposite Ag/PMMA layers is assessed and discussed in the present paper.

2. Theoretical Part

UV irradiation is a widely used technique to produce electrons in the corresponding solution for reduction of metal salts is used for the synthesis of nanoparticles. Within polymer matrix produced electrons reduce metal ions into metal atoms (in present case – Ag+ and Ag0 correspondingly). The produced silver atoms nucleate and grow into silver nanoparticles inside the polymer matrix as it is shown in Figure 1 which was redrawn from [14].

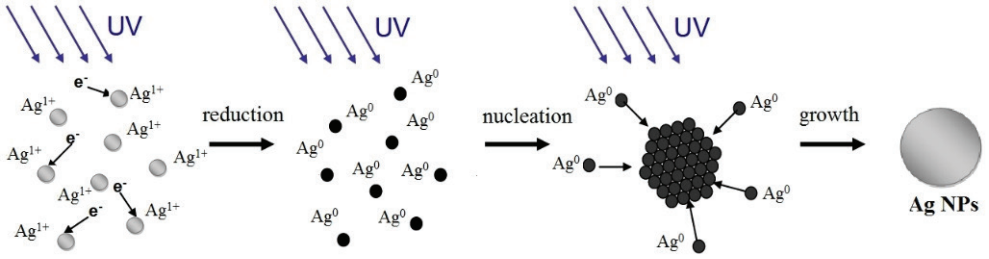


Fig.1 Schematic representation UV radiation induced reduction of Ag1+ ions to Ag0 atoms and nucleation and growth of Ag nanoparticles in polymer matrix

During the UV irradiation of the polymer, cross-linking process prevails upon polymer scission limiting the growth of the nanoparticles after a critical particle size is reached. The in-situ reduction method doesn't destroy the polymer completely, only a very small part of the polymer is degraded.

The passage of a high energy photon through matter, as it is in the case of its X-ray irradiation, stimulates a complex cascade of processes which results in the dissipation of the primary energy, eventually as thermal energy and chemical reactions. Supposing the high energy photons are the source of radiation, the energy is deposited in a highly abnormal way over a number of processes. If the energy of photons is relatively low (<35 keV) as it was in the case of our investigation, two most important energy losses in polymer mechanisms of photons were represented: Compton scattering and photoelectric effect. In the case of Compton scattering photon interacts with an electron resulting in ejection of the electron and deflection of the photon with reduced energy. The probability of Compton scattering event and the consequent energy of the ejected electron and scattered photon depend on the characteristic energy of the photon and the electron density of the material. In the case of the photoelectric effect, total energy of the photon is absorbed by a single electron. Whereas the energy of the electrons is reduced, there is increased possibility of recombination of cations and secondary electrons to form excited states. The excited-state molecules may return to the ground state through radiation

less decay, or endure dissociation reactions to form free radicals, which are supposed to be the main agents in further radiochemical reactions. Heterolytic bond decay may in addition result in the formation of charged species or very reactive intermediates. These intermediates can follow several reaction paths, which result in rearrangements and/or formation of new bonds. The ultimate effects of these reactions can be the formation of oxidized products, grafts, scission of main chains (degradation) or cross-linking. The degree of these transformations depends on the structure of the polymer and the conditions of treatment before, during and after irradiation.

The degradation effects of polymers upon exposure to ionizing can be defined as: 1) main-chain scission (degradation) and 2) crosslinking. These are parallel running processes observed in many irradiated polymers, however in certain cases the scission predominates the crosslinking, and such polymers are known as degrading polymers. PMMA belongs to polymer of this type, (Fig. 2.).

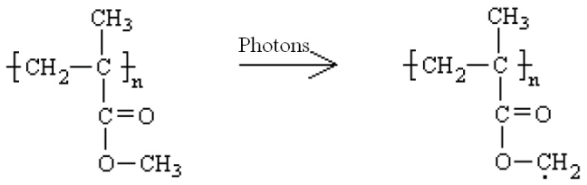


Fig.2 Photon beam induced changes in PMMA molecule

The side-chain is initially affected by the photon irradiation and the radical formed is a precursor for the main chain scission. When PMMA is exposed to ionizing radiation, like X-ray irradiation is, a free radical is generated on the ester side-chain, - COOĊH2. A number of different ways are possible for the generation of the side-chain radical:

- by direct action of ionizing radiation: - $COOCH_3 + \gamma \rightarrow$ - $COO\dot{C}H_2 + H$;
- by proton transfer of the side-chain cation: - $COOCH_3 + \gamma \rightarrow -COOCH_3^+ + e^-$; and $-COOCH_3^+ \rightarrow$ - $COO\dot{C}H_2 + H$;
- by hydrogen abstraction: - $COOCH_3 + H \rightarrow$ - $COO\dot{C}H_2 + H_2$.

Radiation induced degradation of PMMA depends on the irradiation dose rate and may lead to the deterioration of mechanical and optical properties.

Two processes affect modification of optical properties upon irradiation of polymer nanocomposites containing metal particles: possible synthesis of new nanoparticles and degradation of polymer structure due to the scission of the main chain.

3. Instruments and Methods

Poly-methyl methacrylate (PMMA) solution with metal powder (Ag) additives was prepared dissolving 0.001 M of AgClO4 in 50 ml of 1% PMMA solution in chloroform. ~1 mm thin layers of polymeric structures were spin-coated on the surface of polished optical glass using DYNAPERT PRECIMA centrifuge. Fresh films were dried in the desiccator (air humidity ~ 30%). PMMA films without additives were also produced for the comparison.

Ag/PMMA nanocomposites were produced by in-situ polymerization technique without using any external chemical reagent. PMMA was acting as a protective agent that restricts the mobility of silver ions during the reaction, and hence, agglomeration was mostly controlled. Chloroform was used as a solvent to form chemical network between silver nanoparticles and PMMA. Synthesis of Ag nanoparticles was performed using photocatalytic reduction of silver atoms directly in a thin layer of deposited polymer. UV light source (Hibridas Exposure Unit MA4, power 1200 W, wavelength 300–400 nm) was used for this purpose. Applied UV exposure time of 5 min. was sufficient enough for photoreduction of Ag ions and formation of silver nanoparticles. The successful incorporation of Ag nanoparticles was approved and properties of the fabricated layers were investigated performing UV-VIS and FTIR measurements.

UV exposed PMMA and polymeric nanocomposite (Ag/PMMA) films were irradiated to different doses at dose rate of 3.5 mGy/min using 35 keV X-ray photons generated in X-ray diffractometer DRON-3, which was equipped with a single crystal graphite flat monochromator for transmitting only a narrow Cu Kα wavelength ($\lambda = 0.15405$ nm). Irradiation of samples was performed with the aim to investigate soft X-ray radiation induced modification of their optical properties, caused by two processes: polymer degradation and formation of metal nanoparticles within polymer matrix.

Optical properties of experimental films before and after X-ray irradiation were analyzed using Avantes UV/VIS/NIR Avaspec – 2048 spectrometer operating in the wavelength range of 200 nm – 900 nm). Bonding structure of experimental samples was investigated using Fourier Transform infrared spectrometer Bruker Vertex 70, in the wavenumber range from 400 cm-1 to 4000 cm-1, with a resolution of 0.5 cm^{-1}.

The morphology of the samples and bulk composition were investigated in a scanning electron microscope (JSM-5610 LV) with attached energy dispersive X-ray analysis (EDX JED-2201; JEOL, Japan) and/or using optical microscope Optika B-600 MET.

4. Results and Discussion

UV-VIS spectroscopy is widely used for the determination of main optical characteristics of different materials that might be evaluated from absorption spectrum taking into account transmittance and reflectance of the light passing through the experimental samples. The absorption spectrum reflects the transitions of electrons from a ground state to an excited state in the molecular orbitals that are appropriate in the wavelength range of investigation. The electronic transitions observed in the UV-VIS spectroscopy generally appear as broad peaks because of the interactions of polymer molecules with each other and the solvent molecules.

The size of synthesized nanoparticles plays also an important role in the setting of the absorption spectrum in UV-VIS range, since metal nanoparticles have very specific absorption peaks in the visible region, so called surface plasmon resonance (SPR) band.

UV absorbance spectra of the soft X-ray exposed PMMA layers and PMMA + NPs (Ag) are presented in Fig. 3.

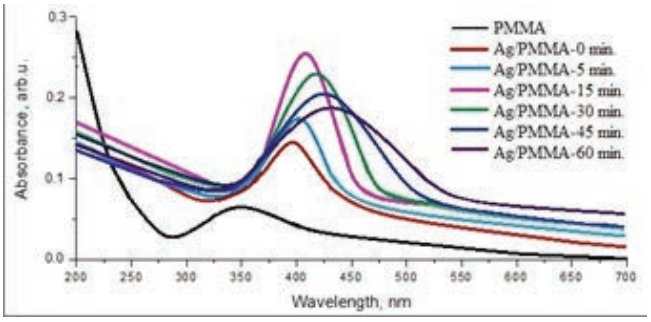
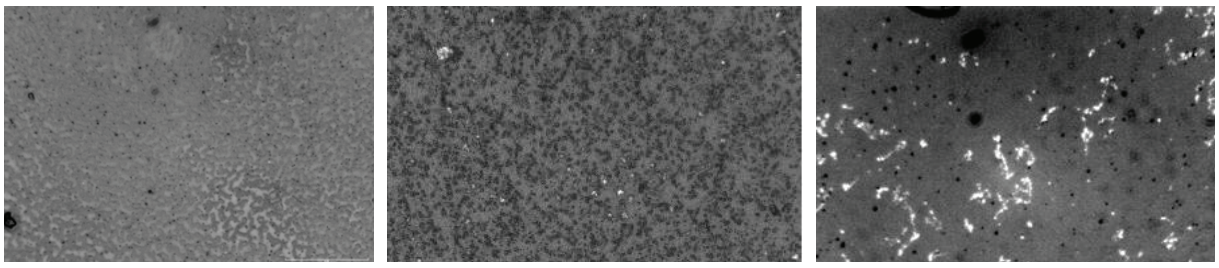


Fig. 3 UV-VIS absorbance spectra of pure PMMA and Ag/PMMA after irradiation with photons at low dose rate

Small peak observed at 436 nm in absorbance spectrum before X-ray exposure of Ag/PMMA layer indicates that a number of Ag nanoparticles are already present in the polymer composite since they were synthesized during UV preirradiation of samples. Presence of Ag nanoparticles contributes to the increased transparency of nanocomposites as compared to the PMMA. Optical transparency of nanocomposites remains stable in the whole UV-VIS region. Irradiation of experimental samples with soft X-rays shows deterioration of PMMA optical properties due to the degradation of polymer caused by scission of its main chain upon irradiation. Transparency of Ag/PMMA drops down after irradiation with X-rays. The decrease of transparency of X-ray irradiated composites is quantitatively almost the same as for PMMA thus leading to suggestion that radiation induced scission of polymer chain is the main process contributing to deterioration of nanocomposite's optical properties. Nevertheless even after X-ray exposure transparence of Ag/PMMA composites is higher than of PMMA films.

Taking into account that the silver ions can also be reduced by the radicals produced by the degradation of the polymer and that further formation of silver nanoparticles within the polymer matrix is possible, more detailed analysis of absorption/transmission spectra of irradiated nanocomposites was performed. It was found that irradiation of nanocomposites also leads the redshift of SPR peak from 436 nm to 451 nm and broadening of SPR peak. Redshift of SPR peak of metallic particles indicates an increase of metal particle size or formation of the Ag nanoclusters. This is valid also taking into account the electron mean free path effect, according to which the intensity of the SPR band should be higher for bigger particles while the critical size of the surface plasmon mode will be broadened. This is related to the energy transfer from the plasmon to single electron excitation between the quantized levels or to energy dissipation due to inelastic scattering of the transferred electrons, and leads to the strength reduction increasing the size of the metal particles. It should be noted that the exact position and broadening of SPR peak dependent on such parameters as shape of the particle, surface quality, size, and structure.

Investigation of the optical properties of polymer composites has shown that silver nanoparticles were successfully doped in the PMMA matrix. The size synthesized was X-ray dose dependent, however not particles formation but polymer chain scission was the main process contributing to the deterioration of the nanocomposite's optical properties. This suggestion was supported by the results of surface morphology examinations. Surface morphology of experimental polymer films before and after their exposure to soft X-rays is shown in Fig. 4.



a b c

Fig.4 Surface morphology of experimental films before their irradiation: a - PMMA, b - Ag/PMMA; and after irradiation to 2Gy: c - Ag/PMMA

It is clearly seen that distributed number of Ag particles are present in the PMMA matrix after its exposure to UV light (Fig. 4b). However X-ray irradiation of the experimental films to doses up to 2 Gy, degradation of PMMA surface and agglomeration of Ag particles to clusters in PMMA matrix (Fig. 4c) was observed. More detailed information on surface morphology was obtained from SEM analysis of the experimental samples. An energy dispersive X-ray analyzer (EDX) was also used in order to get quantitative information about internal content of the samples. SEM images of some irradiated polymer composites that are provided in Fig.5 indicate smooth and well-crystallized deposits of Ag NPs in nanocomposites. In addition, many nodular agglomerated grains (spheres, having diameter of 500-900 nm) that might form or are already forming Ag clusters are clearly seen in nanocomposite layer. It is supposed that a sufficiently uniform distribution of NPs and their agglomeration to some extent may contribute to the increased nanocomposite coatings hardness.

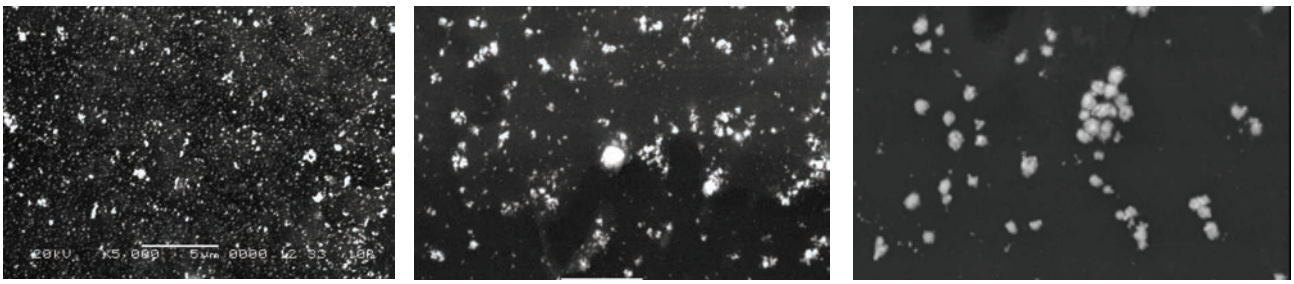


Fig.5 SEM images after films' irradiation to UV light and after film's irradiation to X-rays (0.2 Gy and 2 Gy)

The EDX spectrum and a map of chemical constituents of the nanocomposite coating are provided in Fig. 6 and Fig.7. Clearly expressed Ag peak (69.83%) indicates formation of metal NPs that agglomerate to clusters.

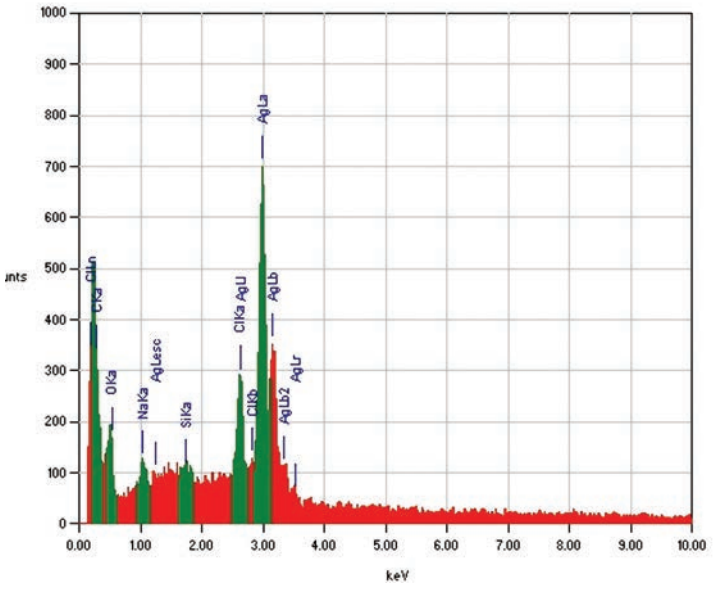


Fig. 6 The EDX spectrum of experimental sample

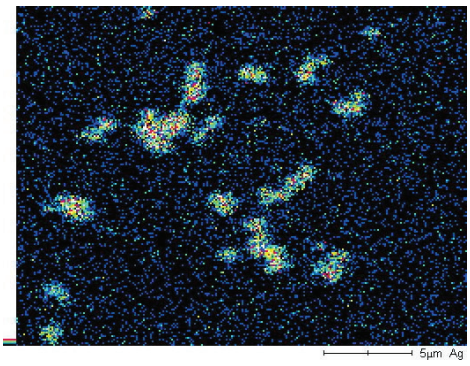


Fig.7 An EDX map of chemical constituents of the nanocomposite coating

X-ray radiation induced changes in Ag/PMMA composites are linked to the reconfiguration of their bonding structure. Chemical bonding structure of experimental PMMA and nanocomposite (Ag/PMMA) films was investigated before and after their irradiation to the doses up to 2Gy by means of infrared spectroscopy, which allows detection of functional groups and characterization of chemical bonds in a molecule [28] by producing an infrared absorption spectrum. FTIR method also provides precise information about orientation of specific functional groups within the polymer film.

The FTIR spectra before and after irradiation of Ag/PMMA films to a certain doses are presented in Fig. 8.

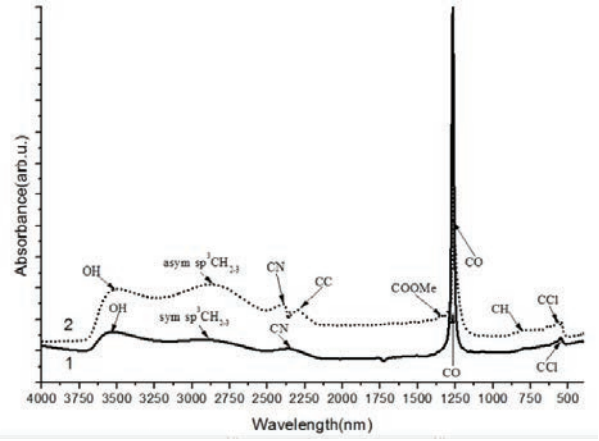


Fig.8 FTIR spectra of Ag/PMMA films before (1) and after (2) their irradiation with X-rays

The FTIR spectra of polymeric nanocomposite (Ag/PMMA) films show sp3CH2-3 (methylene) group in asymmetric stretching and bending mode at 2904 cm-1 which is shifted to lower wavelength at 2865 cm-1 for sp3CH2-3 (methylene) group in symmetric stretching and bending modes after irradiation. It is clearly seen that radiation induces defects and dangling bonds that can be easily occupied by oxygen and create C=O and O–H bonds. Broad band ranging from 3300 cm-1 – 3700 cm-1 corresponds to the valence and deformation vibrations of O-H group. The C≡N absorption peak observed at 2342 cm-1 split into two peaks 2277 corresponds to the C≡C group and 2386 cm-1 corresponds to the valence vibrations of nitrile group after irradiation of samples with soft X-rays. It is the evident that the chemical bonds of N remains in the Ag/PMMA nanocomposite structure. The connecting bonding between PMMA and Ag through C≡N and C=O influences the formation of silver nanoparticles and their size. Thus, PMMA acts as a surfactant and prevents the silver particle aggregation. We assign very intensive absorption peak observed at wave number 1269 cm-1 is due to C=O vibration, which after long modification with X-rays decreased and shifted to 1250 cm−1 to C–O stretching. The scission process dominates here and due to this the formation of Ag nanoclusters could take place. This occurrence is observed by analyzing OM images after the modification of X-rays.

In the presence of Ag nanoparticles characteristic vibration bands at ~812 cm-1, attributed to out-of-plane vibration of the C–H groups. This trend was also observed in the band at 1080 cm-1, assigned to the stretching vibrations of C–N group, which indicates that the N atoms interact with the surface of Ag nanoparticles by chemical absorption. The fingerprint region shows the C–Cl presence in the nanocomposite.

The augmentation in the intensity and appeared peaks of in the FTIR spectra of the investigated samples after 60 min. irradiation indicates that polymer chain reforms itself for the emerging groups and links. This process is part of radiation induced modification of composite structure and properties.

Conclusions

Series of polymeric (PMMA) and polymeric nanocomposite (Ag/PMMA) samples were investigated and radiation induced changes of their properties were analyzed. It was found that the polymeric nanocomposites containing Ag nanoparticles were more stable upon irradiation, however some degradation of their optical properties was observed.

Results obtained by UV–VIS and FTIR spectroscopies, OM and SEM-EDX analysis indicated that soft X-ray irradiation is suitable for in situ generation of Ag nanoparticles in PMMA matrix; however polymer degradation and metal particle agglomeration are also presented. These processes are related to radiation induced creation of free radicals and unsaturated bonds, which are responsible for possible scission processes in polymers.

FTIR analysis has proven that the interactions in Ag/PMMA films are the result of the coordination bonding between Ag nanoparticles and oxygen.

UV–VIS spectroscopy confirmed the formation of Ag nanoparticles in the polymeric Ag/PMMA nanocomposites due to their X-ray exposure. An interesting reversible peak shift effect of the surface plasmon resonance peak (SPR) was observed in the optical absorbance spectrum when the particle size was changed. It was explained as a versatile competitive result of size effect and extrinsic impact from the matrix or the surrounding medium. The mobility of Ag nanoparticles is augmented and Ag nanoparticles begin to form Ag nanoclusters. This is confirmed by the analysis of OM and SEM-EDX images.

Performed investigation shows potential application of Ag NPs containing polymer composites in the implementation

of surface functionalization strategy: analyzed and discussed soft X-ray induced modification processes in Ag/PMMA composite layers are easily transferable for the analysis of other nanocomposites containing metal nanoparticles. Also assessment of nanocomposite's behavior upon low dose rate irradiation might be of value in applications related to materials that are used in moderate radiation environment.

Acknowledgement: This research is partially funded by a grant (Reg. No. MIP-091/2012 „Optically transparent polymeric nanocomposite shields for radiation protection") from the Research Council of Lithuania.

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Heavy Robots for C-IED Operations

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Abstract

This paper the contain description of possibility of future combat engineer task robotization. The analysis is focused on most dangerous task like engineer obstacle breaching including mine fields, fence and other barriers. In the paper are described proposals of new technics and tactics for using robots and demand for their new possibilities

KEY WORDS: *military robots, unmanned ground vehicles, combat engineer tasks, improvised explosive device, C-IED operation*

1. Introduction

In recent years, the rapid development of combat engineer UGV, also called EOD robots and the scope of their range of uses has been observed. Their widespread use in the army was initiated by the conflict in Iraq due to the massive use of IEDs (Improvised Explosive Device). They were mainly used to the confirming the presence of IEDs, their identification and neutralization. Because the scope of the tasks carried out was similar to those performed by police pyrotechnics initially the pyrotechnic robots available on market were used for it. It quickly became clear that their usefulness is limited because their basic task was quick verification of the occurrence of a threat – usually the suspicious object was at a distance of 100-200 meters. Unfortunately, a long time to prepare the robot for work (Removal of transportation safety rolling off of the transport) and low speed (usually 1-2 km / h) did not provide the necessary efficiency of use. They were also not designed for intensive work in field conditions. Hence, in relatively short time the significantly lighter robots were introduced (weight approx. 20-60 kg in relation to approx. 300 kg of pyrotechnic robots) and faster (driving speed increased to 8-10 km/h) better suited to moving in a terrain. Their main purpose is recognition and identification of threats. In favorable conditions, they may also attempt neutralization. However, their capabilities in this area are much smaller than pyrotechnic robots due to the simplified manipulators construction and small lifting capacity. As a result, in American EOD subunits (*Explosive Ordnance Disposal) with the largest experience in using robots, three types of robots are widely used:*

- *MK-1 – Packbot 510 (Endeavor Robotics) with a weight depending on the version;20-25 kg;*
- *MK-2 – Talon IV (Foster-Miller) with a weight depending on the version;50-70 kg;*
- *MK-3 – Andros (Northrop Grumman Remotec) with a weight depending on the version;300-350 kg.*

Light robots (MK – 1, MK 2) are usually used in maneuvering operations, e.g. as part of RCP (Route Clearance Patrol), while robots with extensive manipulation functions (MK-3) and lifting capacities up to 27 kg on the maximum range (1,4 m) are used for neutralization IEDS in urban area on firm grounds.

Operational possibilities of these robots are too small for effective taking and neutralization UXO (Unexploded Ordnance) - what is equally important task of the EOD subunits, because the weight of bombs and missiles can be 200-250 kg, and even up to 500 kg. Taking artillery shells and mortar grenades may also require large lifting forces at maximum range, when they are in a hard-to-reach place or driven into the ground. Additional difficulties may be caused by the necessity of digging them and removal in rough terrain. For these reasons, it is necessary to develop heavy EOD robots, with high lifting capacity and high terrain mobility – capable of long -term work in as rough terrain.

2. Heavy Robots EOD

Even a cursory analysis indicates that there are machines available on the market for working in difficult terrain and having the necessary accessories, tools and lifting capacity. These are tracked mini loaders and tracked mini excavators – with its weight 2-5 t. The easiest and the cheapest way to obtain heavy EOD robots is their robotization (tab.1) - adaptation to remote control in teleoperation mode.

One of the first of such solutions was the ARTS (All-Purpose Remote Transport System) system using the Posi Track RT-50 loader with a weight of approx. 3000 kg. Thanks to the standard quick-coupling it can use about 100 commercial tools available on the market and work with tools specially designed for engineering works. It is currently equipped with the US military forces. The advantage of compact track loaders is the standard quick-coupling, great pulling power, very high maneuverability (possibility of turning back in place) and relatively high speed.

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Table 1

Characteristics of selected heavy EOD robots

				
ROBOT	Spartacus - T110 (Qinetiq/Bobcat)	Scorpion (Autonomous Solution/Bobcat)	Micro MineWolf MW50 (Pearson Enginering)	Rhino (MUT/WB Electronic)
mss	ok. 2400 kg	3300 kg	ok. 2000 kg	3000 kg
power	29 kW	24 kW	36 kW	46 kW
width	120 cm	152 cm	100 cm	200 cm
lenght (without equipment)	226 cm	198 cm	230 cm	280 cm
hight (without manipulators)	188 cm	243 cm	140 cm	130 cm
range of teleoperation LOS	1000 m	1000 m	1000 m	1300 m
speed	8,4 km/h	4,7 km/h	6 km/h	30 km/h
work time	10 h	10 h	10 h	10 h
load capacity (without manipulators)	-	-	400 kg	1000 kg
Replacement of working equipment	loader equipment with quick- coupling	excavation equipment with quick- coupling	tractor connector	loader equipment with quick- coupling manipulator with gripper
tools	grapple bucket multifunctional bucket forklift plough	bucket, gripper, hammer, drill, desruptor	excavation equipment / manipulator -bucket, gripper, desruptor flail - width 1.2 m	grapple bucket multifunctional bucket forklift plough
MANIPULATOR degrees of freedom (DOF)	lifting the boom closing the bucket tool drive	rotation of the boom lifting the boom raising the arm lifting the gripper rotation of the gripper closing the gripper	rotation of the boom lifting the boom raising the arm arm telescope lifting the gripper rotation of the gripper closing the gripper	rotation of the boom lifting the boom raising the arm lifting the gripper rotation of the gripper closing the gripper
range of the manipulator	0,7 m	4,85 m	3,0 m + 0,7 m teleskoping	4 m
load capacity for max. reach	boucket – 500 kg fork- 500 kg	200 kg	400 kg	manipulator – 200 kg fork – 1000 kg

On smooth surfaces they can reach speeds of approx. 10 km / h. In rough terrain due to the low longitudinal stability it drops to 3-5 km / h. However, the driving speed of a mini excavator in favorable conditions does not usually exceed 2-3 km / h. Their ability to overcome obstacles is also much smaller. The main advantage of mini excavators is greater manipulator work and greater lifting capacity due to the use of stabilizers supports. Therefore, they are used for tasks where a large range is necessary, and the work is of a stationary nature (low share of journeys in the implementation of the task).

Initially, the main problem of robotization was the combination of electronic remote-control systems with hydraulic drives. However, after the popularization of the Load-Sensing hydraulic drive controlled in the CAN bus system, this is not a problem. For example, all Bobcat mini-machines equipped with Selectable Joystick Controls (SJC) are currently adapted for remote control. It is only necessary to develop an appropriate system of teleoperation (table 1).

Such solutions are relatively cheap and reliable, but poorly adapted to specific engineering tasks. Hence, a number of attempts have been made to develop engineering robots that are better suited to anticipated tasks. An example is the tracked robot ACER (Armored Combat Engineer Robot) from Mesa Robotic with its weight 2040 kg, lifting arm capacity of 454 kg (1,000 lbs.) and payload capacity of 1139 kg (2,500 lbs.), driven by 62 hp turbocharged diesel engine. It can develop 10 km/h and is characterized by very good longitudinal and transverse stability. Thanks to a special quick-coupling, it can work with various tools such as paving passes in engineering constructed obstacles.

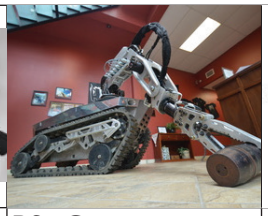
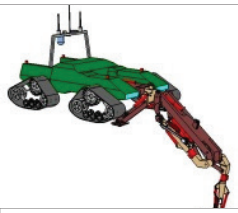
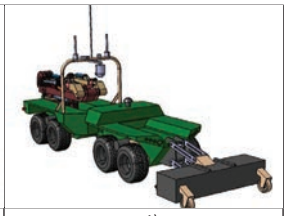
A similar purpose – making the passes in the engineering dams has the Israeli robot "Avantguard". It was designed

and made by G-NIUS. It is a platform with 8-wheel drive system, on which four mounted tracks are mounted. The torsion steering system ensures excellent maneuverability in difficult terrain conditions. The robot develops maximum velocities of 20 km / h, and it can autonomously detect and avoid obstacles. Cameras placed on a special rotary head allow observation of the terrain in the range of 3600^0. A platform with a weight of over 1700 kg has the option of mounting on its chassis such sensors as a ground penetrating radar (GPR), interference devices and thermal and infra-red imaging systems or neutralization systems with a total weight of 1000 kg.

A slightly different scope of tasks is carried out by the Israeli platform "Gardium". It allows to conduct a patrol along a road or fence in the autonomous mode (detecting intruders, navigating without access to GPS, avoiding obstacles on the road, etc.) at a speed of 7-8 km / h. It can be equipped with daylight and infrared cameras, radar, CBRN sensors, tracking detectors, road detectors and remote-controlled equipment. At a weight of 1,400 kg (length 2,95 m, width 1,8 m, height 2,2 m) can develop a maximum speed of 50 km / h (in the mode of teleoperation). It is built on the basis of a UTV off-road vehicle with a 4x4 wheeled driving system and a drive system with a CVT transmission. Its task is to detect changes in the environment indicating the activity of the opponent.

Table 2

Characteristics of selected EOD robots weighing 600-800 kg

				
ROBOT	Protector (HDT)	RS1-G2 (Howe and Howe)	BPL - intervention1)	BPL – patrol [1)]
mass	ok. 800 kg	ok. 800 kg	800 kg	800 kg
power	24 kW	-	20 kW	20 kW
width	8 km/h	8 km/h	15 km/h	15 km/h
length (without equipment)	90 cm	107 cm	200 cm	125 cm
Hight (without manipulators)	193 cm	186 cm	280 cm	380 cm
range of teleoperation LOS	107 cm	102 cm	180 cm	180 cm
speed	-	-	800 m	800 m
work time	10 h	10 h	10 h	10 h
load capacity (without manipulators)	227 kg	ok. 400 kg	450 kg	450 kg
Replacement of working equipment	excavation equipment with quick- coupling	tractor connector connection plate	2 quick- coupling - from two sides of the carrier	2 quick- coupling - from two sides of the carrier
tools	excavator bucket (about 15 dm3) loader bucket (56 dm3) flail (width 0,6 m)	manipulator - gripper, desruptor quick-coupling –fork equipment (capacity 227 kg) blade (width 1,2 m)	intervention manipulator - gripper - multifunctional bucket - ripper tooth - desruptor	inspection manipulator detection system with GPR
MANIPULATOR degrees of freedom (DOF)	rotation of the boom lifting the boom raising the arm lifting the gripper closing the gripper	rotation of the boom lifting the boom raising the arm lifting the gripper rotation of the gripper closing the gripper	rotation of the boom lifting the boom lifting arm 1 and 2 lifting the gripper 1 and 2 rotation of gripper 1 and 2 closing the gripper 1 and 2	rotation of the boom lifting the boom raising the arm closing the gripper lifting the mast of the camera
range of the manipulator	ok. 2,3 m	ok. 1,5 m	3 m	4.2 m
load capacity for max. reach	90 kg	ok. 100 kg	80 kg or 240 kg	10 kg

[1)] – under development

The Micro MineWolf robot (table 1) has a completely different destiny. It is a miniaturized version of the 9-meter MineWolf machine, mainly used for humanitarian de-mining. Its task is to intervene in the event of an IED type threat. Thanks to the quick-coupling, it can have two engineering equipment - flail and a digging manipulator, gripping and neutralization with disrupter. Despite its armor, its mass with equipment does not exceed 2500 kg. Due to its low weight and small dimensions, it ensures high transportability and can be used by RCP. Supports provide him with a large lifting capacity. However, the speed of travel and the ability to overcome obstacles are limited due to the rigid running gear.

A similar range of applications has been developed by WB-Electronic in cooperation with the Military University of Technology (MUT) robot "Rochatyniec" (Rhino) - tab.1. It is intended for interventions by means of a manipulator with a grapple or loader equipment. Thanks to the standard quick-coupling it is possible to use commercial tools for compact track loaders. The innovative suspension allows to overcome large obstacles and develop speed up to 30 km / h. It can also be a carrier of various detection systems.

Heavy interventions robots are not yet popular. Their tasks, especially confirming the presence of IED, in RCP patrols are currently carried out with large range manipulators (6-8 m) mounted on MRAP vehicles (Mine Resistant Ambush Protected) - e.g. "Buffalo". Lifting capacity of these manipulators up to a maximum range of 70 kg indicates that robots of less than 1000 kg are sufficient for this type of work- with much greater transport vulnerability. The basic parameters of such robots are summarized in Table 2. They can successfully meet the expectations in the field of digging in hard soil and taking large IEDs, placed in the ground on the route of passage of military columns. Making interventions with large range manipulators (6-8 m) placed on MRAP type manned vehicles, due to the small distance from the IED, is extremely dangerous and risky, especially when recognizing large loads. A similarly dangerous task in the RCP patrol is the operation of the IED detection system mounted on the second MRAP vehicle. For these reasons, the search for the possibility of carrying out these tasks with the help of heavy engineering robots is being undertaken. An example of such activities may be the robotization of the IED detection systems on the MRAP "Husky" (USA) [4] vehicle and Land Bike (GB) [5] vehicle - also the carrier of the detection system. There are also other possibilities to increase the scope of tasks carried out by engineering works, because they limit the risk for soldiers.

3. Expected Capabilities of Heavy Engineering Robots

The tactics of using engineering robots must be adapted to the current level of technik and technology development. Their use should be envisaged both in asymmetrical operations, low intensity conflicts and classic combat operations. The main predicted areas of application of engineering robots include:

- engineering support for patrol units of general military units;
- engineering patrolling and maintenance of roads;
- engineering patrolling of infrastructure;
- engineering patrolling of the area;
- engineering support for combat operations, especially in urbanized areas;
- road paving;
- recognition of engineering dams;
- making transitions in engineering dams.

Engineering support for patrol activities occurs mainly during asymmetrical operations. General military units patrol the area most often using full-time, armored armored vehicles that provide fire protection and support. In unfavorable conditions or in the case of the need to thoroughly check the terrain, they pass into pedestrian traffic. The biggest threat to patrols are the booby traps and IEDs. For these reasons, patrols are reinforcing the sapper section, whose task is to recognize suspected places and objects identified by general military reconnaissance and neutralization of detected traps. EOD light engineering works, which can be transported in standard military vehicles or on their armor, are used for these tasks.

These robots are expected to be highly transport-friendly, have a short time to prepare for operation and have an effective working range of 200-400 m (nominal range 400-800 m). **It is recommended to equip the patrol in 2 lightweight robots with a mass of up to 15 kg and a portable one with a weight not exceeding 75 kg.** The first of these is expected to implement the tasks of rapid recognition and identification of threats and support activities in a rough terrain where the robot is carried by soldiers and used only temporarily for short-term missions. The purpose of a larger robot is realization the task of identifying the requiring ability to reveal hidden charges and their neutralization or transfer advanced detection and detection systems that allow for more effective protection of pedestrian patrols. The robot should have the possibility of long-lasting work enabling supporting foot patrols for a minimum of 6 h (desirable 10 h) and develop a maximum speed comparable to that of a running soldier. **Support for combat operations in the urbanized area consists mainly in detecting traps and paving passes**. For these tasks can be used lightweight and portable robots but their working possibilities are too small in many situations. For these reasons, **it is advisable to use robots with a mass of 250-300 kg** (the permissible mass is limited by the load-bearing capacity of ceilings and staircases), which have much higher lifting and thrusting forces.

They are expected to be able to overcome staircases, efficiently open doors and furniture, track, and the ability to quickly inspect rooms and warehouses. This requires a large manipulator range, high stability and high maneuverability of the robot and low energy consumption. Existing pyrotechnics do not meet these requirements.

The electric drive used in robots with a weight of up to 300 kg allows for effective operation for about 2-3 hours and is very sensitive to reduced temperatures (at -200C the battery capacity of the battery falls by 50% compared to

the capacity at +200C). Hence, the ability to support activities for a long time requires the use of hybrid or combustion propulsion. As a result, the weight of a robot capable of prolonged patrolling and tasks is increased to approx. 600-800 kg. However, it allows for a significant increase in the robot manipulator capacity and the transfer of complex threat detection systems and the effective implementation of patrol tasks.

The main task of engineering patrols is to identify terrain and infrastructure, as well as to carry out passages (paving) and to clear terrain from mines and mine traps. These tasks are performed for general military units or to unlock traffic corridors. A high rate of task implementation is recommended. Used robots should be characterized by the ability to detect and neutralize threats fast on the road and the paths and the determination of safe passages. In addition, they should be able to replace sappers during land cleaning. For this purpose, they should be characterized by very high mobility, enabling access to hard-to-reach places and the ability to carry advanced detection and neutralization systems. They should be able to support the patrol for at least 10 hours (minimum 6 hours of continuous work). The desired control range is 400-800 m. The robots should be able to accompany the running soldiers.

Due to the transferred equipment needed capacity and work required mobility **- the total mass of the platform must be at the level min. 600-800 kg.**

The most complex activities that predict the use of whole robot groups are **patrolling and maintaining roads including mine clearance and cleaning.** It requires recognition (detection and identification) and neutralization of threats:

- in the road line;
- on the shoulder;
- in the immediate vicinity of the road.

Effective realization of this goal requires the involvement of specialized robots tailored for these specific tasks. Analyzes indicate that it is necessary to have at least 3 types of robot engineering:

- a heavy engineering and reconnaissance robot;
- a heavy engineering and intervention robot;
- a light or medium high-mobility engineering and intervention robot.

It is also advisable to have a portable or lightweight robot - transported inside the vehicle - adapted to penetrate hard to reach places.

These robots should move in a group that ensures effective cooperation. The task of a heavy engineering and reconnaissance robot is to detect and mark places with a high probability of locating mines and improvised devices on the road's crown and in its surroundings. The basic set of detectors / sensors should enable the detection of threat in the lane of vehicles with a minimum width of 3 m. This task should be carried out by integrated detection systems using at least two types of mutually complementing sensors – eg. ground penetrating radar cooperating with a magnetic detector.

Detection of threats on the road shoulders, in the roadside ditches in culverts, under bridges and in vehicles parked on the roadside should allow a special manipulator equipped as needed with appropriate sensors and cameras observation. Its work field and kinematics should make it possible to carry out tasks without leaving the crown of the road.

The zone of the immediate vicinity of the road in the strip of 50-70 m in width should be controlled by a special, dedicated observation system using radar, infrared or thermal vision technique. ts task is to detect threats in the form of EFP, remotely controlled grenade launchers, mines with a large radius of action and improvised devices, hidden among vegetation, suspended on trees or in buildings.

It is advisable for the robot to have systems to stimulate charges in front of the vehicle and be equipped with electronic warfare elements that protect the robot from remotely controlled wireless charges.

It is anticipated that the robot should move 100-200 m ahead of the main group, so that if a threat is detected it is possible to take alternative combat operations - at the same time not leaving the protection zone of the grouping.

Due to the speed and efficiency of detection systems, the expected speed of the robot should be 5-20 km / h. A low signature of the robot is desirable (noise, ground pressure, vibrations, etc.) that causes ignition of igniters. It is expected that this will allow in favorable conditions to mark suspicious places without having to stop the robot from potential threat and increase the speed of task completion to 15-20 km / h.

The places indicated by the engineering and reconnaissance robot should be verified by intervention works. A heavy intervention robot with high working capacity should be used on the road crown. It should be able to dig the road surface, uncover devices, remove masking objects and push suspicious objects off the road crown. The working range of the attachments should allow inspections of roadsides and ditches. Under favorable conditions, the robot should be able to neutralize detected and recognized loads. Depending on the level of threat, this robot should follow the reconnaissance robot or be transported on a special trailer or other means of transport and proceed to act if a threat is detected.

Threats detected in the vicinity of the road should be identified and neutralized by very high mobility interventions. They should be able to overcome roadside ditches, debris, collapses, logs, etc. in order to reach the indicated places, identify the threat and, if necessary, neutralize it. The robot's working capabilities should enable neutralization of EFP-type devices and active mines with a large operating range. It is advisable that he could, under favorable conditions, take over tasks carried out by a heavy intervention robot operating on the road's crown. For these reasons, its speed should reach 15 km / h.

Command and control systems should be grouped together in a command and teleoperation vehicle. They should enable effective teleoperation of all robots, mutual transfer of information and cooperation and coordination of tasks by the commander.

In high risk or need for purification broad lanes, it should be possible to connect and cooperation of the two sets of robots. It is advisable to supplement the system with an unmanned flying vehicle (rotorcraft, helicopter) - supporting a

group in situational awareness and control. The system should have inclusive capabilities:

- detection of tension (thin lines);
- detection of antennas and wires;
- detection of metals masked with soil;
- detection of explosives;
- CBRN detection;
- observation of low-lying objects (eg. under a car);
- observation of objects high above the robot;
- taking or removing items with a manipulator;
- uncovering objects in the ground; - excavating items;
- checking cars and trucks (chassis, interior, luggage compartment);
- checking culverts and bridges;
- IED neutralization by various methods.

As a result, the crew of the command and teleoperation vehicle should consist of at least 5 soldiers:

- commanding officer - the operator of the reconnaissance (detection and threat detection) system and the UAV (unmanned aerial platform);
- operator controlling a heavy reconnaissance robot;
- operator controlling a heavy intervention robot;
- operator controlling a light intervention robot;
- drivers of command and teleoperation vehicles

The engineering and patrol platform while working with detectors should not intervene but continue the mission of detecting threats. Critical for the implementation of the intervention mission are:

- a very large manipulator area adapted to the anticipated, varied tasks (indicated minimization of the number of degrees of freedom to simplify the control system);
- large lifting and pulling forces developed by the manipulator with high resistance to overload (this requires the use of hydrostatic drive and high stability);
- ability to overcome roadside ditches and other terrain obstacles and rubble;
- the ability to dig and loosen the ground;
- the ability to quickly engage the necessary to accomplish the task of complementarily working tools.

Conclusion

Robotization of C-IED tasks is now a necessity due to the threats. The currently used mobile and light EOD robots are not able to effectively complete all the necessary tasks. The conducted analyzes clearly show the need for introduction of heavy robots. They are useful both during removal and neutralization of UXO, as well as during the detection, identification and neutralization of IEDs. To ensure high work efficiency it is necessary to have specialized robots forming groups. It should include patrol and intervention robots.

Patrol robots should detect threats and confirm them under favorable conditions. The treats may be in the lane (usually buried in the ground or hidden in ducts and culverts), shoulders (usually masked with various objects), in vehicles set by the roads, hidden behind or inside of infrastructural objects (junction boxes, walls, fences, ground floors, etc.) and near the road – in the case of using EFP - 50-70 m from the road. The main task of the patrol platform is the detection of mines or IEDs located in the ground, on the route of marching and their marking and determining the location.

It can also verify the threat by using a patrol (reconnaissance) manipulator. The type of taken actions will depend on the tactical situation. One of the possible solutions is also not taking action and avoiding (driving around) the dangerous zone. One of the main problems for the patrol robot detection system is the lack of unambiguous characteristics of the searched objects. While in the case of mines - produced serially and in accordance with the conventions – there may be a number of characteristic shapes and the content of ferromagnetic materials, as in the case of IED, both shape, construction, material is not standard. In any case, they can take other forms and are very easily modified and adapted to local conditions which definitely makes them difficult to detect and practically eliminates the possibility of process automation. For their common feature can only be considered their considerable dimensions - comparable or much larger than anti-tank mines. The initiating systems are very diverse and are often found outside the main explosive device hence, there are often different types of wires connecting individual elements of the IED.

For these reasons, the platform should effectively detect anti-tank mines and large objects hidden in the ground. The ability to detect wires, especially those connected to electronic remote-control systems is also indicated.

Intervention robots should be able to confirm the presence of danger on the road crown and in its vicinity, thanks to the ability to quickly reach the indicated point and the ability to remove masking materials by lifting them, pulling away or digging.

In case of confirmation of occurrence, they should be able to neutralize the threat. UGV activities should be coordinated within the robot groups. Because platforms should support the activities of motorized or mechanized sub- units performing tasks also in pedestrian line, they ought to be characterized by high terrain mobility.

Acknowledgment

The work presented in this article has been supported by the Polis National Center for Research and Development – (Grant No. DOBR -BIO4/083/13431/2013).

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Proposal of the Composite Footbridge for the Military Application

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Abstract

The article presents the methodology of modeling a footbridge structure made of a composite material. A lightweight composite footbridge is proposed, which may find application for small-span crossing of the rivers and other terrain obstacles for military purposes. The construction is characterized by lightweight, easiness of assembly and universal application in various location and conditions. The numerical model of the structure was developed based on a 6-meter prototype, for which a reinforcement was proposed and a detailed numerical analysis was carried out for the 18-meter version.

KEY WORDS: *laminated composite materials, footbridge, hand – operated assembly*

1. Introduction

The durability of composite materials, their competitive price and easiness of design and shape forming cause that many attempts have been made to apply them successfully to the construction of bridges [1,2]. One of the possible applications of this type of material, without the necessity of its assembly with elements ensuring spatial stiffness of the structure, is the construction of footbridges. Limitation to pedestrian traffic is dictated by operational safety due to the low construction weight and the susceptibility of this type of material to the formation of deformations and displacements of the structure. In the case of applications for car or railway traffic, it would be necessary to use an assembly with rigid elements, for example a reinforced concrete deck plate. The carried – out, initial numerical calculations and engineering analysis show that it is possible to use this type of construction while performing certain modifications in relation to the prototype solution. This solution, as a prototype with a 6-meter span, was developed by the Aircraft Repair and Production Department from Bielsko-Biała [3] - Fig. 1.

Fig. 1. The prototype of the composite footbridge section [3]

The application of this type of footbridges is justified for the performance of fast crossing over terrain obstacles of small spans. In particular, it is possible to utilize them in military operations to increase the mobility of troops. Moreover composite footbridges can be used in small municipalities and everywhere where small watercourses or other obstacles such as excavations hinder pedestrian traffic. The analyzed spans of composite footbridges is sufficient for the temporary overcoming of pedestrian difficulties and inconveniences also in urban areas in the case of tedious excavations and earthworks as well as road infrastructure repairs.

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The methodology of modeling a lightweight, composite footbridge structure is presented in this paper. The numerical model of the structure was developed based on a 6-meter prototype, for which a reinforcement was proposed and a detailed numerical analysis was carried out for the 18-meter version.

2. Numerical Model of the Composite Footbridge

Based on the results of the analysis of the 6 meters span prototype, a 18 meters span model of the composite footbridge was developed. Compared to the prototype section, two reinforcements and improvements were proposed. The first modification consists in stiffening the extreme section by using a wider floor beams at the ends of the structure - Fig. 2. The second reinforcement in the form of two internal half-frames is proposed to ensure greater stability of the structure. These is achieved by increasing the thickness of the girders' cross braces and reinforcing the section of the bridge deck - Fig. 3. This was done both by extending the two deck fins to the end of the lower horizontal beam as well as increasing their thickness.

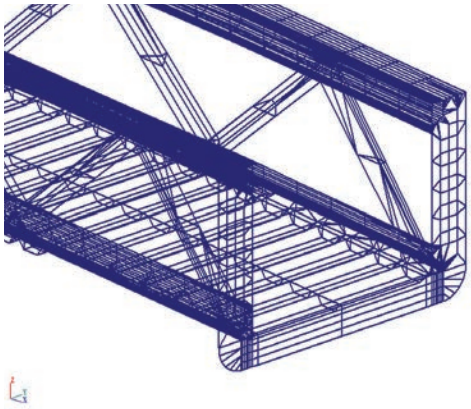

Fig. 2. The improvement of the prototype in the form of application a wider floor beams at the ends of the structure

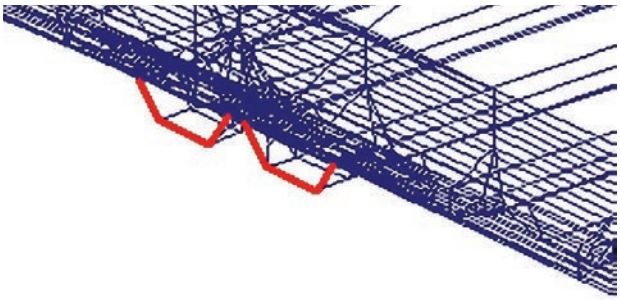

Fig. 3. Reinforcement of the middle section of the footbridge

After developing the design of the reinforcement of the original 6-meter section of the prototype bridge, the conceptual design of the composite footbridge with a span of 18 meters were carried out. The structure consist of three sections of a 6-meter. The axis of the bridge deck describes an arc having a radius of 90 m, which give a 0.45 m preliminary rise of arch. Deck has a width of 1.60 m. The height girders is 1.16 m (measured to the level of the deck).

The numerical model has been developed as a 3D, deformable, shell finite element model described on the cylinder axis - Fig. 4.

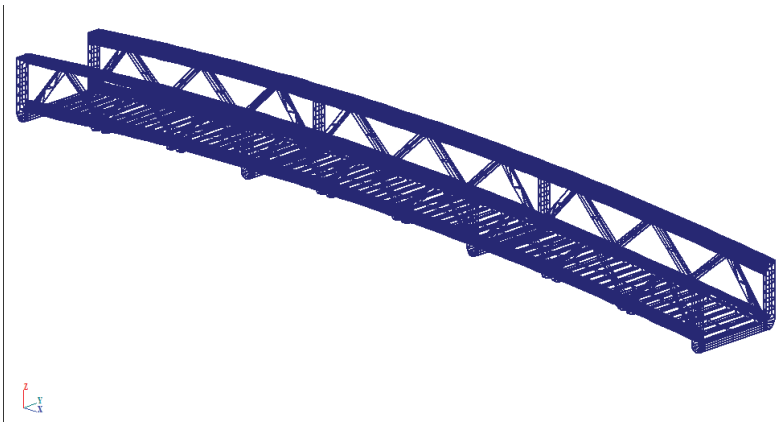

Fig. 4. Numerical model of an 18-meter span footbridge

The basic system of computational loads for bridges and a system of characteristic loads for checking serviceability limit states were used for calculations. The following loads were applied:

- deadweight of the footbridge, generated automatically by the software,
- the weight of the pavement on the deck in the form of a uniformly distributed load on the deck,
- the load of pedestrian crowd according to EC1[4] for simulating soldiers' passage,
- wind load according to wind pressure recommended in [5].

Using the appropriate coefficients, all loads were combined into normative combinations for the DA 2 calculation approach.

3. Results of the Numerical Model Calculation and its Analysis

The results obtained in the numerical model were compiled in the form of the stress distribution maps in the main elements of the analyzed composite footbridge. The first is the most strenuous top flange of the truss girder. Figure 5 shows the reduced von Mises stresses in this element, while in Fig. 6 the principal stresses along the compressed fibers are presented. These values are very similar to each other, which is the effect of adopting an arched scheme of the spar girders.

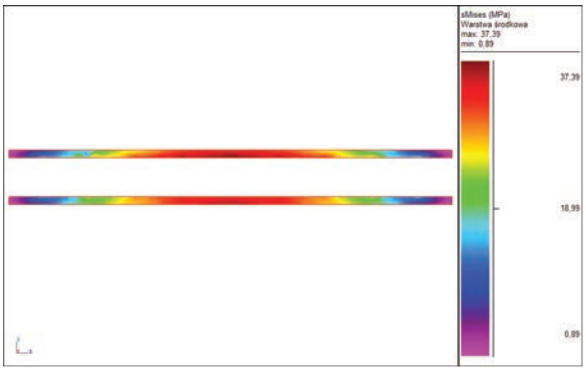

Fig. 5. The reduced von Mises stresses in the top flange of the truss girder

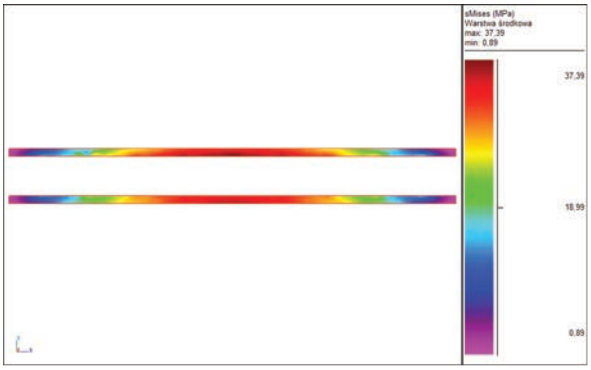

Fig. 6. The principal stresses in the top flange of the truss girder

The obtained values of stresses do not exceed the permissible value, i.e. 400 MPa in any of the analyzed elements of the composite footbridge structure. The maximum material effort is less than 10% of the limit values. More unfavorable values are obtained for serviceability limit states. The obtained values of horizontal displacements from the crowd load of pedestrians are presented in Table 1, while horizontal displacements for wind load amounts to 0.5532 cm.

Table 1

Maximum vertical displacements of the footbridge structure

Node number	Vertical displacement [cm]
15773	- 6,5401
15766	- 6,2433
614	- 6,2312
15781	- 5,8314
15758	- 5,6340
15789	- 5,0091
731	- 4,9421
15707	- 4,5820
15728	- 4,5808
15695	- 4,5759

According to the Polish standard [6], the displacement values are about 65% of the admissible values, which indicates the proper design of the construction itself and effective transverse stiffening of the prototype. Considering the stiffening elements, the maximum effort was obtained in the lattice girders. Fig. 7 shows a map of the maximum principal stresses of the reinforced deck rib, while in Fig. 8 the maximum stresses in the reinforced flanges of the central module are shown.

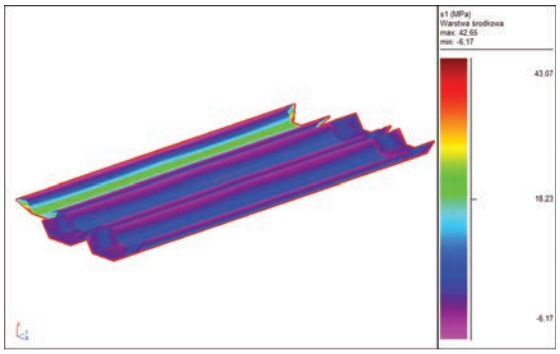

Fig. 7. The principal stresses in the reinforced deck rib

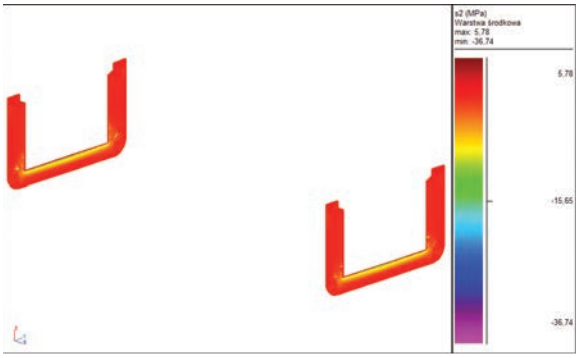

Fig. 8. The principal stresses in the reinforced flanges of the central module

Conclusions

The proposed solution for the improvement of the composite footbridge fulfills requirements of the standard values of loads in relation to pedestrian traffic. This is proven by carried out numerical calculation as well as the analysis made in this paper. Subsequently, it is proposed to produce reinforced constructions, to operate them under the load of pedestrians and to observe the practical use of these solutions, in particular for military applications to increase the mobility of troops. The operational value of the proposed solution is the long-term durability and life-cycle of the footbridge in the original technical condition without the use of any anti-corrosion protection. However, it should be emphasized that the analysis omits unrecognized fatigue conditions of material behavior under operating load.

The application of composite materials in bridge construction brings tangible results, especially in reinforcing existing concrete bridges [7]. Currently, the practical application of composite materials in main elements of engineering structures is more often observed in the area of civil engineering [1, 2, 8, 9]. The proposed structure, apart from being used as a typical footbridge, is also possible to be used as working platforms and crossings for temporary overcoming of small terrain and water obstacles, particularly by military troops. Additionally, it enables safe crossing of excavations in the case of earthworks for civilian pedestrians. That types of footbridges also ensure the continuity of pedestrian communication and make it possible to minimize the troublesome bypasses of places inaccessible to pedestrian traffic.

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Analysis of Engineer Obstacle Negotiation Possibility with Grouping Robots

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Abstract

This paper the contain description of possibility of future combat engineer task robotization. The analysis is focused on most dangerous task like engineer obstacle breaching including mine fields, fence and other barriers. In the paper are described proposals of new technics and tactics for using robots and demand for their new possibilities

KEY WORDS: *combat engineer robot, mine field, engineer obstacle crossing, robot team*

1. Introduction

Overcoming the engineering obstacles is an extremely difficult, complex and dangerous task, because the barriers are assumed to be protected (defended) by enemy fire and they consist of a variety of obstacles including:

- minefield barriers;
- wire obstacles, fences, picket holdfasts, steel hedgehogs, concrete blocks, etc.;
- ground fortification barriers – antitank ditches, sidehill cuts, embankments and flooding.

Their breaching and clearance them requires ability to: making the lines in minefields by the explosive method; minesweeping; marking them; making lines in embankments and crossing ditches.

Combat engineer equipment. Because of the opponent's influence to making lines there are normally used manned, heavily armored tracked vehicles equipped with different attachments, tools and kits. The most popular are:

- mine-clearing line charge;
- mine plough, mine clearing rollers, flails;
- manipulators and excavator attachments;
- dozer and loader attachments;
- assault bridges.

Usually attachments and tools are grouped together creating specialized vehicles built on the basis of MBT (Main Battle Tank). Most commonly mine ploughs are grouped with mine-clearing line charge forming overcome mine barriers vehicles (mine-clearing vehicles) while manipulators and dozer or loader attachments create the vehicles making lines in other barriers.

Making line in extensive engineering obstacles therefore requires: mine-clearing vehicle, breaching vehicle, earthmoving vehicle and assault bridge vehicle. The weight and the size of these vehicles is dictated by the need of the crew protection and it is not necessary for most of these tasks from point of view demanded capabilities and their stability. However large weight and dimensions limit their agility and mobility. Introduction of the remotely controlled combat engineer robots allows to reduce their weight, improve terrain mobility and also reduce the risk for crews [2,3,6].

Due to the impact of the opponent, manned - heavy, heavily armored tracked vehicles equipped with various attachments, tools and kits tools are used as standard. The most popular are:

- long devices - carried directly on armored vehicles or on towed trailers - they are used for explosive destruction of mines and dams with the use of explosive material with a length of 100-170 m moved to the minefield by means of rocket engines, their disadvantage is insufficient length in the case of erratic fields is too small width of the passage which in the case of mines with compensation of the pressure wave is at the level of 2 m and the lack of the possibility of precise extension or lengthening the passage by means of subsequent devices (no flight control of the rocket);
- **mine clearing plow**– expanding the passage made by the explosive method - depending on the ground conditions, the following can be used:
  - excavations (sandy and loamy soils) - older solutions are rutting plows, but nowadays they with full trawling width are becoming more and more popular - they allow to make passes by removing layers of land from mines without causing detonation - with a speed of 5-6 km / H
  - pressure (all types of land including stony and overgrown with perennial vegetation) - usually rutted - allow to pass at speeds of up to 8-10 km / h, which shortens the exposure of the crew, but causes detonations of trawled mines;

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- flail (recommended for sandy and loamy soils) - they traverse full-width passages - however, the trailing speed of 0.4 km / h (maximum 1 km / h) limits their operational use;

- manipulators with a lifting capacity of approx. 2000 kg - used for fencing works - are usually equipped with grippers or bucket shovels with additional jaws for gripping - they also enable laying of fauns for backfilling of antitank ditches;
- bulldozer blades or buckets - used for fencing works and making passes in earth dams, in particular in earth gelding and ditches.

In order to overcome ditches, attack bridges are used to overcome narrow aqueous obstacles, however, their standard span of 20-25 m, does not correspond best to the needs related to crossing trenches with a width of approx. 5 m - hence the span structures of length 7-8 m, which are much lighter and easier to handle.

Usually attachments and tools are grouping to create specialized vehicles built on the basis of MBT (Main Battle Tank). Most often, the trawls are grouped with longitudinal devices, creating wagons for overcoming mining dams (trailing vehicles), while manipulators and attachments, bulldozers or loaders, create vehicles paving the passages in the remaining dams. Some of the combat engineer vehicles are additionally equipped with means for throwing loads, used to destroy dams and fortifications.

In the engineering dam's fortification objects are also used, such as antitank ditches or earth embankments. To overcome them the assault bridges carried on heavy tracked vehicles and pioneering vehicles equipped with plowshares are used. The efficiency of using pioneering vehicles built on the basis of MBT tanks for making passages in embankments or for backfilling of trenches is usually low because they are usually equipped (due to the visibility and angle of the driveway) with 2.5-3 m3 shares. As a result, despite of the mass of 45-60 thousand kg they have working capacity similar to track dozers weighing only 15 thousand kg. For these reasons, to ensure high efficiency of earthworks, it is necessary to use heavy armored fortification machines.

Execution of the passage in extended engineering dams therefore requires the use of a trawler vehicle, a pioneering vehicle, a fortification machine and an assault bridge. The weight and size of these vehicles is dictated by the need to protect the crew and is not necessary for most of these tasks. Large weight and dimensions, however, limit their maneuverability and mobility. Eliminating crews will allow tasks to be carried out by smaller, more mobile robots and increase the security of their implementation.

2. Problems and Limitations of Robotization.

The limitation of robotization mainly depends from the current level of technology development [1,4,5,7]. Contemporary robots can successfully carry out repetitive activities – however they are not capable of autonomous actions requiring the robot to acquire new information, their analyses and decision making. These processes require the development of artificial intelligence. Currently used robots in order to fulfill unique tasks, requiring decision making must be controlled by man. If they work in direct operation's environment it is a sufficient solution to use remote control - the operator directly assesses the environment and controls all movements or its sequences. In case of operation at the greater distance or the occurrence of danger to the operator – the teleoperation is used. This means that the operator makes decisions and controls the robot based on the image obtained from the robot cameras. The remote control, especially teleoperation limited the operator's perceptual abilities in the area and of robot environment and location assessment and its working movements due to:

- delays occurring in the transmission path of the control signals;
- delays in image path of the robot's surroundings;
- limited viewing angle of the teleoperation system cameras;
- usually lack of stereovision - allowing quick distance assessment;
- too low image resolution due to the limited bandwidth output;
- no fillings of longitudinal and lateral inclinations of the robot and accelerations acting on the robot;
- no fillings contact between the robot and the ground;
- no fillings of vibrations and noise - allowing to assess the condition and load of the robot.

Limiting barriers requires the development of tele-presence technology. In addition, the relatively small teleoperation range of ground platforms, which currently does not exceed 1-1.5 km (due to the need for image transmission with delays not exceeding 0.1-0.2 seconds) limits both the scope and methods of task implementation (however, it is sufficient to carry out paving tasks).

Teleoperation creates new opportunities to carry out tasks. Lack of direct threat to the operator enables the use of new, different technologies, techniques and tools - the use of which is not expected in the case of vehicles and manned machines. Hence the design, applied solutions, mass and size of robots can differ significantly from manned platforms. They can also perform tasks in teams that complement each other's capabilities. As a result, eliminating a person from the immediate danger zone allows not only to reduce the risks, but also to increase the effectiveness of tasks in the danger zones, provided that the techniques and technologies for their implementation are changed.

3. Possibilities of Making Transitions in Engineering Dams using Robots

Analysis of tasks and tools necessary to perform passages in engineering dams indicates that most works can perform robots much smaller and lighter than manned platforms, because they do not require very large lifting forces and pull

(large mass of manned vehicles results mainly from the need to provide space and protection for soldiers).

An example of this can be the basic task when making passes in dams - moving long loads along the foreground and making explosive passes. This task can be carried out by robots weighing only 5-6 thousand. kg (Fig. 1) able to carry long devices, the weight of which does not usually exceed 2 thousand. kg. They can also, thanks to special mechanisms, remove the springs or tensioning cables remaining after detonation - Fig.2 - reducing the risk of accidental blocking of the running gear and stopping vehicles when crossing the passage made.

Fig.1. Lengthened devices require a robot with a maximum total weight of 7-8 thousand. Kg (concept)

Fig.2. The robot can ensure the removal of traces of the long-term load (concept) that are dangerous for the movement of tracked vehicles

Fig. 3. Remote controlled pressure concept (concept) with hydropneumatics suspension can plow the entire width of the transition at a speed exceeding 10 km / h

Another task after the detonation of the lengthened devices is to expand the passage using the plow. Due to the high speed of trawling and high efficiency of work on different substrates and leaving intact the structure of the ground, a popular solution is the use of pressure plows.

Classical pressure plows are usually rutted trawls and do not traverse the entire width of the passage. They are pushed by heavy, armored tracked vehicles with a large amount of tractive power, hence their weight, rolling resistance and rolling resistance are of no great importance. The length of plowed sections does not usually exceed several hundred meters, and the speed of travel does not exceed 8-10 km / h.

Modern pressure trash with pneumatic tires, hydropneumatics suspension and pneumatic wheels are characterized by significantly lower rolling resistance and steering, and thus do not set too high requirements for tractors (pushers). Hence, lighter tractors with smaller working resistances can plow the entire width of the lane at higher speeds. Under favorable conditions on smooth surfaces can plow even at a speed of 20-30 km / h.

The effectiveness of plowing at speeds exceeding 8-10 km / h depends primarily on the plowing system used. It should ensure an even distribution of pressure on all wheels, despite significant longitudinal and lateral irregularities and prevent dynamic displacement of the wheels from the ground and bouncing of the trawl under the influence of the excursions of kinematic inequalities. In this respect hydropneumatics suspensions cooperating with pneumatic wheels placed in 2 rows are the most effective for fully covering the width of the trawling lane (Fig. 3). Such systems, with a plowing width of 4.5 m, are characterized by a weight of the order of 5000 kg and low rolling resistance at the level of 0.03-0.1 of gravity depending on the type of the trawl substrate. Taking into account the resistances of elevation in the path (inclinations up to 150), these total resistances of movement may reach 0.3-0.4 of the gravity force. This requires the use of tractors (pushers) with a weight of 10,000 kg. The minimal weight of the plow is therefore at the level of 15 thousand. kg and is 3-4 times smaller than the weight of manned plowing vehicles. Such a solution ensures full width of trawling and high rate of transition without the need to expose the crew.

Fig. 4. Cutting the palisades requires a scythe carried by robots of the order of 3 thousand. kg (concept)

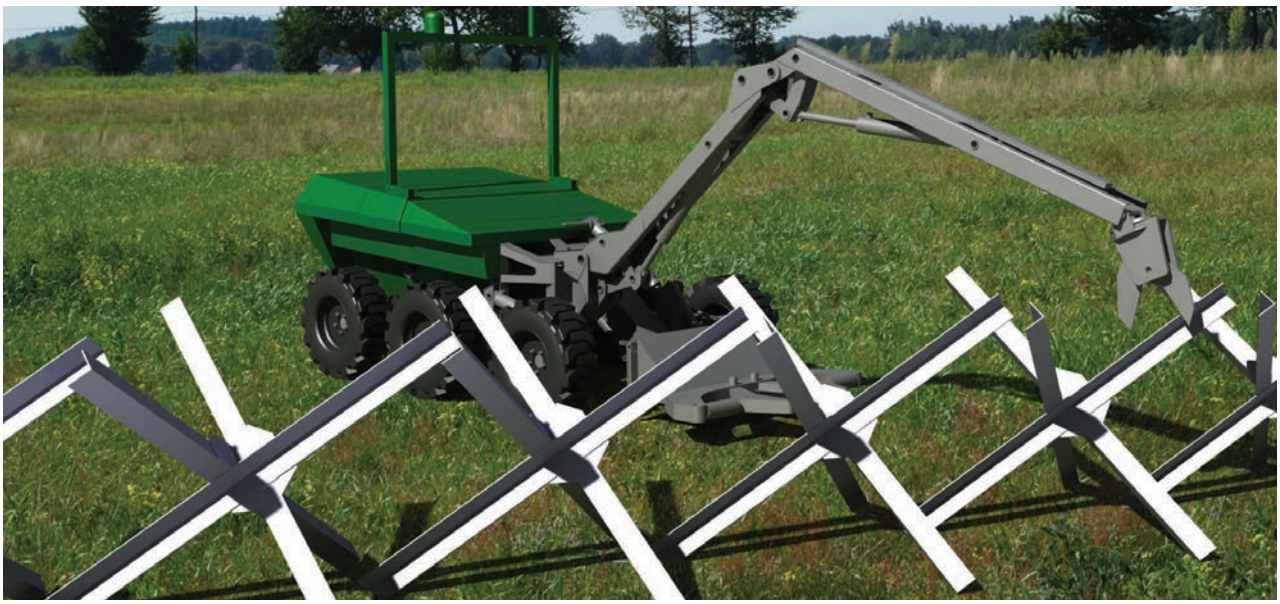

Fig.5. Destroying steel dams does not require the use of very heavy robots (concept)

Transitions in wire barriers, beam post obstacles and steel dams can be carried out using robots with a weight of 3-4 thousand kg using commercial tools with hydraulic drive available on the market - Fig.4 and Fig.5. These tools are now standard equipment for skid-steer loaders and mini-excavators and their range enables the implementation of diverse tasks without the need to engage in very heavy equipment.

Moving spans with a span of approx. 8 m and load capacity of the order MLC 70 also does not require the use of heavy equipment (Figs. 6-8), because the mass of the span is at the level of 3 thousand. kg. Depending on the adopted spanning system, the necessary weight of the robot to ensure an adequate level of stability and mobility is at the level of 4-6 thousand kg.

Fig. 6. A robotic bridge to overcome narrow obstacles - span in the transport position (concept)

Fig. 7. A robotic bridge to overcome narrow obstacles - span prepared for placing on the obstacle (concept)

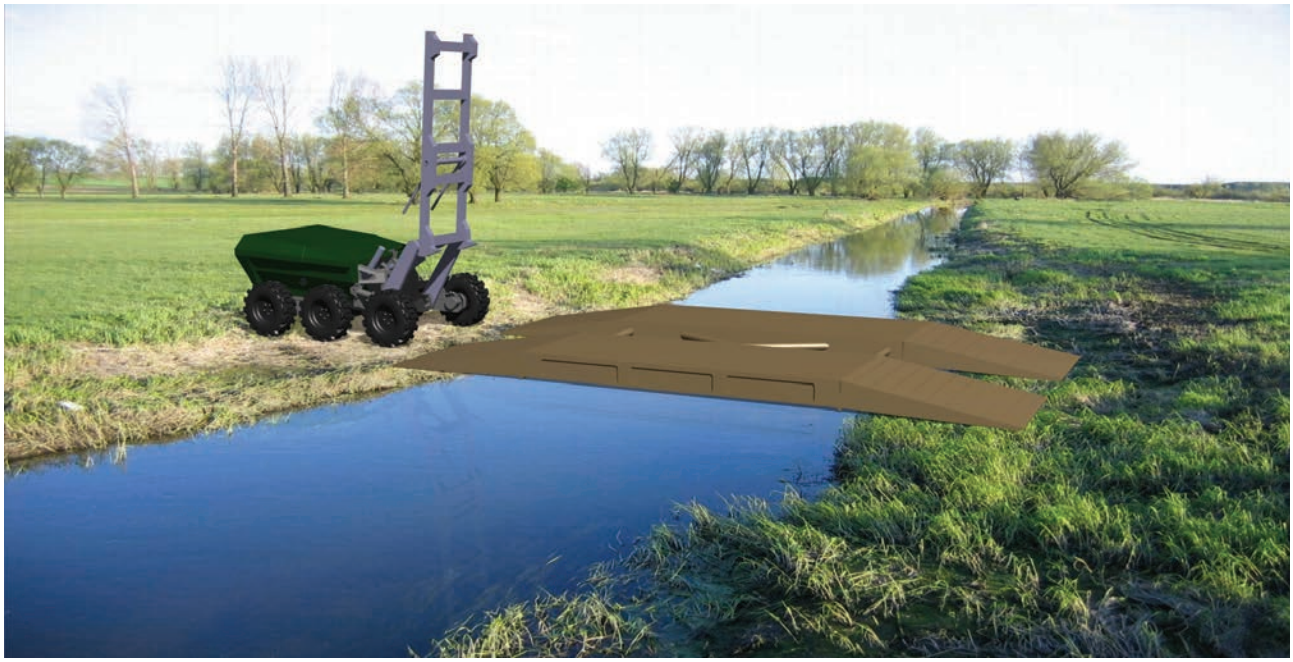

Fig.8. A robotic bridge to overcome narrow obstacles - span after placing on the obstacle (concept)

Fig.9. Light, small and fast high mobility robots are able to effectively support masking activities and destroy fortifications and barriers (concept)

The task of destroying defenses, damming up the dams, can successfully carry out light high mobility robots - Fig.9 - with an unladen weight of about 150-200 kg and a load capacity of 80-100 kg and medium robots with a capacity of approx. 300 kg and own weight of 600 -800 kg. They can also be used to mask activities by transferring grenades and smoke systems and destroying wire barriers and fences. Medium-sized robots are better suited for these tasks because they can be equipped with a larger assortment of tools and attachments and have considerable lifting and pulling forces. With high mobility, low magnetic signature and low pressure on the ground, they should easily penetrate enemy minefields, destroy firewalls with explosive devices and put smokescreens.

A grouping of robots to carry out the passages in engineering dams can therefore consist of relatively light robots including (Fig.10):

- robots - carriers of Bgalore torpedoes;
- pressures plowing robots;
- robots for fencing works;
- robots - carriers of bridge spans;
- robots for destruction and masking.

If necessary, they can be supported by heavy, robotic earthmoving machines. They are necessary in the case of the necessity of making passes in earth dams, such as shielding shafts and, if necessary, removal of very heavy objects or vehicles that terrace the passage made. Robotization of such machines is not currently a major technical problem, because

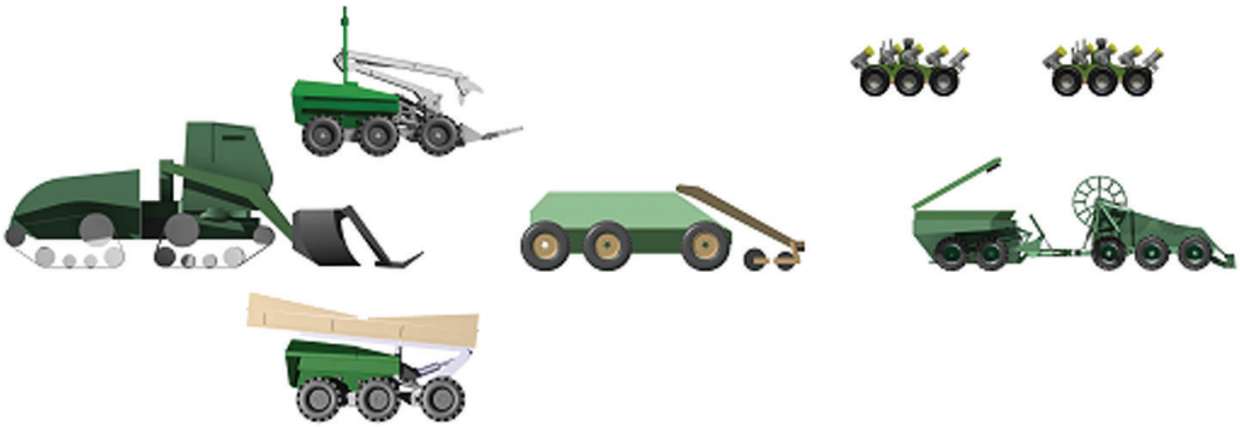

Fig.10. A grouping of robots to perform transitions in engineering dams

most modern machines are currently controlled by electronic information systems that manage both the hydrokinetic drive system as well as the control and hydrostatic drive of work tools. By default, CAN buses are used for this purpose.

Conclusion

The use of robots to overcome engineering dams has a wide range of development opportunities because they do not impose high demands on the autonomy of operation. In addition, the required coverage does not exceed the capabilities of modern communication systems. To perform the task robotic manned vehicles can be used. However, they are characterized by very large dimensions and masses, which limits their maneuverability. The necessity of moving a few machines along the narrow strip that is removed increases the likelihood of their getting bogged down. They are also not designed for teleoperation. This significantly limits their working possibilities.

Presented concepts and conducted analyzes indicate that eliminating crews (people) from pioneering vehicles allows achieving high efficiency of tasks using much smaller robots. However, this requires searching for new methods and technologies for the implementation of tasks. Complex tasks require the use of teams / groups of cooperating specialized robots and coordination of their activities. Therefore, it is necessary to develop new, more effective teleoperation and telepresence telepresence systems as well as new broadband communications systems, robot control systems and combat situation display systems.

Acknowledgment

The work presented in this article has been supported by the Polis National Center for Research and Development – by grant DOBR -BIO4/083/13431/2013.

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Protection Systems against Unmanned Aircraft Vehicle Evaluation

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Abstract

The purpose of this investigation is to present the protection systems used against the low, slow, and small (LSS) unmanned aerial systems (UAS) capabilities. The results of a market survey are included that highlights potential commercial entities that could contribute some technology that assists in the detection, classification, and neutralization of a LSS UAS. In order to accurately select a protection system which will later be used by all Lithuanian Armed Forces units the nine existing protection systems were analyzed. The analysis was done under the technical specifications for acquisitions and the detailed requirements of the measures were set out on the basis of the Operational Requirements Document.
This article provides the existing protection systems against unmanned aircraft vehicle (PSAUAV) technical conditions analysis with the aim to help to make the choices in defining a protection system that can be adaptive to contemporary and future needs for the Lithuanian Armed Forces. The numerous requirements and expectations for nine PSAUAV were analyzed by statistical software package SPSS version 20. There were used the experts' evaluation methods based on experts' surveyed sample analysis. The Kendall's coefficient of concordance (W) was selected for quantitative assessments of experts' decisions data analysis. In addition for PSAUAV technical conditions evaluation was used the hierarchical clustering.

KEY WORDS: *Unmanned Aircraft Vehicle, multidimensional database, hierarchical clustering, Kendall W*

1. Introduction

The chosen investigations have become currently relevant because the activity of unmanned aerial vehicles (drones) in the world is increasing over the last 10 years. The unmanned aerial vehicles are one of the fasters growing and most exciting technologies anywhere in the world. There are many companies that predict the UAVs market variations. These companies for market analysis used the different sources of information and methodologies, but their forecast analysis proves that the market of the UAVs is growing [1]. More than eighty countries produced the unmanned aerial vehicles for the different purposes, but there are only about twenty-five countries which producing military UAVs [2]. Some examples of commercially available LSS UAVs, a glider type UAS, commercially popular quadcopters, and a jet turbine based high-velocity UAVs are shown in the Fig. 1.

The challenges of detecting low, slow, and small (LSS) unmanned aerial vehicles (UAVs) becoming an important capability for the maintenance of security. Consumer grade LSS UAVs are becoming increasingly complex, and represent a diverse new threat which must be addressed by physical security systems of the future. The conclusion is drawn from internal discussions and external reports are the following; detection of LSS UAVs is a challenging problem that cannot be achieved with a single detection modality for all potential targets. For security purposes, the UAVs were categorized by their mass and typical capabilities that are associated with each class, as shown in Table 1[3]. There we can see that the first class UAVs includes anything less than 150 kg, while second class extends to the larger types between 150 and 600 kg. This upper class is, for now, generally restricted to military aircraft.

The UAVs had been used only for military purposes until a few years ago, but now the features and capabilities of technology used for military, commercial and civilian purposes UAVs becoming very close. For this reason, the UAVs have recently joined to the other common things which can become suddenly lethal weapons. Classification of LSS UAVs, especially classification in the presence of background clutter (e.g., urban environment) or other non-threating targets (e.g., birds), is under-explored. However information of accessible technologies is sparse, numerous of the current possibilities for UAS detection seem to be in their beginning when compared to more established ground-based air protection systems for larger and/or faster threats. In addition, there can be mentioned that all companies currently providing or developing technologies to combat the UAVs safety and security problem are certainly worth investigating, however, no company has provided the statistical evidence necessary to support robust detection, identification, and/or neutralization of LSS UAVs targets.

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Table 1

Categorization of UAVs by their mass and typical capabilities [3]

Class/Weight	Category/ Weight	Operating Altitude	Operation Radius	Carrying Payload
I (<150 kg)	Micro (<2 kg)	to 90 m	5 km	0.2-0.5 kg
I (<150 kg)	Mini (2-20 kg)	to 900 m	25 km	0.5-10 kg
I (<150 kg)	Small (<150 kg)	to 1500 m	50-100 km	5-50 kg
II (150-600 kg)	Tactical	to 3000 m	200 km	25-200 kg

Military conflict in Ukraine has shown the growing use of such aircraft in military and civil conflicts. The UAVs have been becoming a real threat and weapon in present-day asymmetric warfare, terrorist attacks or malicious uses. Due to the capabilities and size of various drones, their shoot down has become difficult. Units of the Lithuanian Armed Forces, military exercises, the military equipment of Lithuania and its NATO allies attract more and more attention from the people. Such factors have led to the intensive use of drones over military areas and other restricted areas.

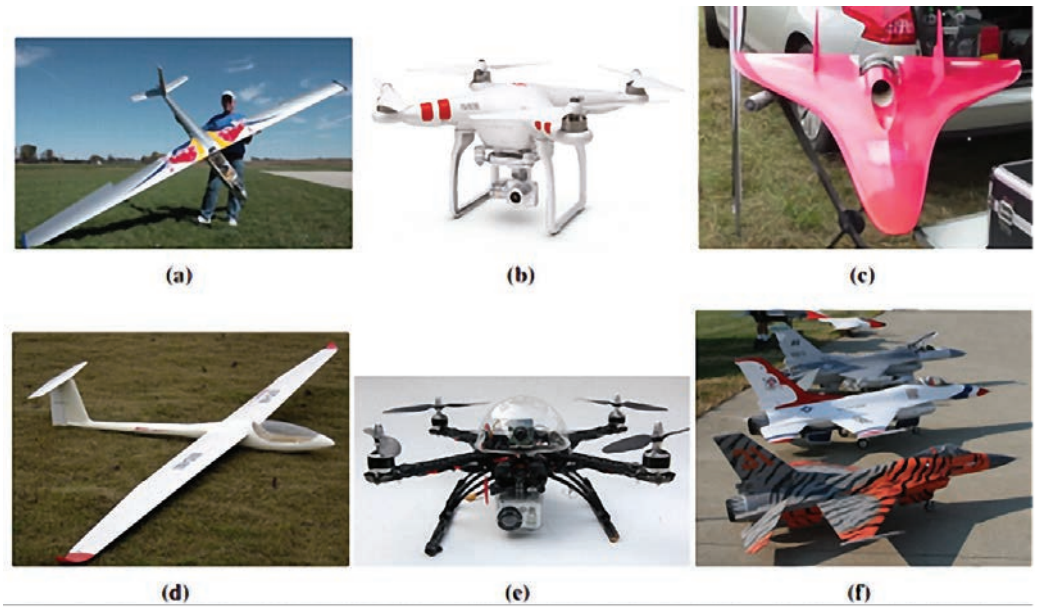


Fig. 1. Commercially available LSS UAVs (a) and (d) show two variants of a glider type UAS, (b) and (e) show commercially popular quadcopters, (c) and (f) show jet turbine based high-velocity UAVs [3]

Airborne threats coming from the drones have revealed a security loophole in the Lithuanian Armed Forces.

Ultimately, the appropriateness of the methods for qualification or neutralization of LSS UAVs targets within the wanted setting is what will order their use and/or implementation in future ground-based aerial defence systems or LSS UAVs qualification systems. Also, the use of UAVs ammunitions and missiles for security or safety protection is obviously not ideal in a heavily populated civilian environment. On the other hand, these methods may be appropriate for engaging targets on a hostile battlefield. The decision for use of such devices must be heavily influenced by the inherent risks in each (e.g. collateral damage or ineffectiveness), and whether the consequences of those risks are determined to be acceptable. However, Lithuanian Armed forces do not have any safety protection system that can effectively fight against hostile drones. This study was provided on an existing nine protection systems used against remotely controlled mini-unmanned aircraft systems engineering analysis with the goal to help to make the decisions in defining a system that can be adaptive to the Lithuanian Armed Forces current and future needs.

2. Combat Concept and Protection Systems

The UAVs which have the possibility to perform hazardous, malicious or unwanted actions are considered threats. This includes devices intending to carry out a hostile mission, being operated by an unsafe individual, or crossing into a sensitive area. UAVs threats must be appropriately dealt with by security systems, where the type and extent of mitigation techniques depend on the situation and environment. The three steps of protection against UAVs was clarified by the Ministry of National Defence (MND). The following combat concept developed by MND was chosen as background for on how to combat the unmanned aerial vehicles (drones). The MND concept was separate into three combat modules:

- Module I – Detection. The first there is necessary to collect some phenomenological information captured by a sensor.
- Module II - Identification / Tracking. The received data in the detection phase analysis, with the goal being to separate real targets from highly clustered, noisy background data. This step of the analysis is performed solely by a human.
- Module III - Neutralization. Once a target is positively identified in the previous step, additional action must be taken to deny mission success, including the potential for target neutralization. An overview of detection methods, drone neutralization options, specific blocked frequencies, and the main weapon - the jammer.

In order to accurately select a protection system for the Lithuanian Armed Forces (LAF), which will later be used by all LAF units and full fill security-compliant requirements. The working group under the Lithuanian Force Planning Department prepared the ORD documentation by the weightier criterion for acquiring security measures against unmanned aircraft vehicles. The analysis was done under the military purposes which are described in detail in the Operational Requirements Document (ORD). The existing nine protection systems such as *Blighter Surveillance Systems*/UK; *Aquila Defence Group*/ Switzerland; *HENDSOLDT*/ Germany; *Bukovel*/ Ukraine; *Elbit Systems*/ Israel; *NT Service*/ Lithuania; *Radio Hills Technologies*/ USA; *MOOG*/ USA; Rohde&Schwarz/ Denmark, were analyzed. Technical specifications for acquisitions are drawn up and the detailed requirements of the measures are set out on the basis of ORD.

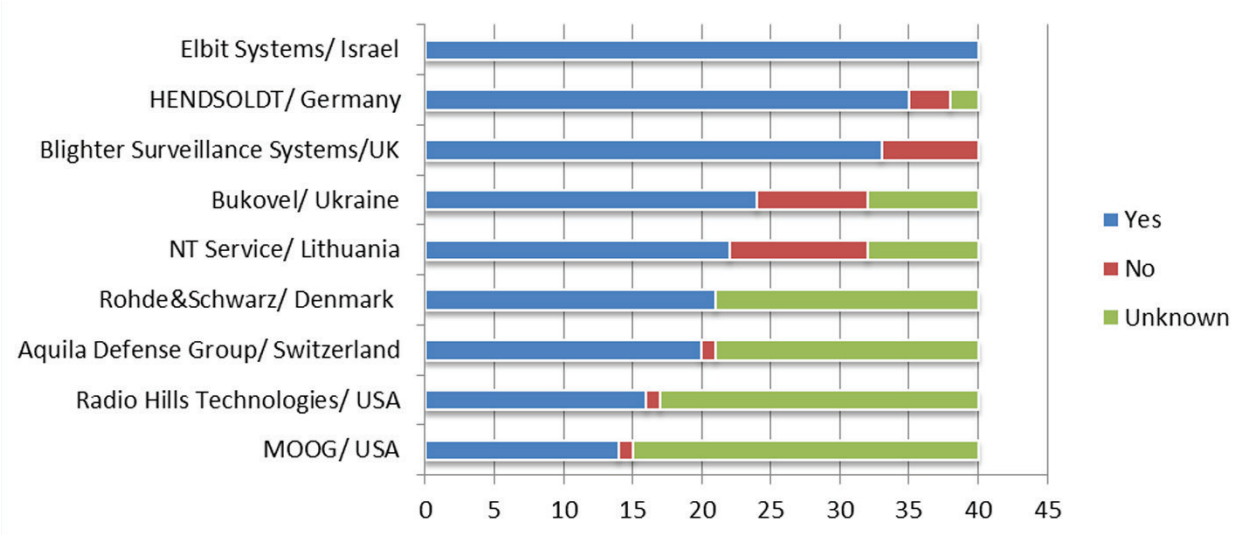


Fig. 2. The evaluation of capabilities of the each of nine systems

The technical information about nine existing protection systems (EPS) was composed after deep analyses of the ORD documentation where were jagged all requirements for the protection system which can be used in the Lithuanian Armed Forces. The nine EPS technical documentation analysis helped to disclose the characteristics and/or capabilities on the each of these systems. In addition, the nine chosen systems were statistically evaluated by the following three combat modules for unmanned aerial vehicles. All analysis was done by the separating essential functionality for each of the nine ESP with summarizing the main requirements in accordance with three principles: accuracy, reasonableness and completeness. For example, the anti-poverty task force distinguishes three key functions: detection, identification and neutralization.

According to the ORD requirements, the protection system that was searched for LAF needs had to have the jammer. It seems that the chosen system has to be able to use for tampering blocking, transmitting, blocking, or otherwise kinetically manipulating the UAVs. The ORD documentation precise requirements make it possible to choose the most appropriate protection, to determine the detailed technical requirements for military equipment and to properly understand the request for information received by enterprises. This analysis showed the Lithuanian Armed Forces needs and helped to identify the most appropriate device. In this survey, the detailed possibilities of nine EPS were compared with the respect to the minimum of main parameters (forty parameters were evaluated). The receiving result is presented in the graphical visualization in the Fig. 2. All forty criteria for each of nine EPS were evaluated as follows: if the EPS system meets the criteria under consideration – "YES", if not – "NO", in other cases where the manufacturer did not mention anything about the assessed requirement it was weighed as "Unknown". In the Fig. 2, security measures of each nine EPS are ranked according to the criteria of the "YES" criterion from the most suitable to the least. Moreover, this graphical analysis discloses the possibility to see one more tendency: the more systems meet the requirements, they have the less the unknown and unavailable system components that are specified in the ORD requirements. We can also notice another trend that if the "NO" criteria increase, the "YES" criterion decreases. The statistical analysis showed that all of the forty criteria were met by the Israeli company Elbyt Systems, the second system meeting the highest criteria is HENDOLDT with 35 requirements. The United Kingdom system remains in the third position of the chart with only 33 matching requirements.

Having analyzed the existing protective systems measures which were on interest for the Ministry of Lithuania National Defense, there were clarified their possibilities, advantages and disadvantages. Due to the fast-paced technology,

there is no ideal system or product against UAVs. All analyzed systems and products do not have a final solution that can be effective in the future. Therefore, for Lithuanian Armed Forces there was very important that the manufacturers must provide for the possibility of continuous updating of equipment, the introduction of new components to adapt to newly emerging threats. There was clarified that the commercial equipment designed to fight against civilian aircraft is ineffective against modified and/or military aircraft. For these reasons, the research was extended with additional multidimensional data analysis. The mathematical background and the results of these analyses are presented below.

3. Investigation Methods and Mathematical Background

The goal of comprehensive investigations was to analyze selected nine EPS and identify groups that are similar to each other by technical features but differ from EPS parameters in other groups. It can be intellectually satisfying, profitable, or sometimes both to manage this without statistical analysis because it can't be known who or what belongs in which group and a number of groups can be known only after clustering analysis. The SPSS statistical package has three different procedures that can be used to cluster collected data [16]. From the methodological point of view, there was chosen the agglomerative hierarchical clustering analysis and similarity of groups was measured by Euclidean distance, which is suitable for only continuous variables and has a possibility to choose a statistic that quantifies how far apart (or similar) two cases (two EPS) are. Using collected technical parameters data set and agglomerative hierarchical clustering with selected a median method for forming the similar groups. In this way from nine EPS, there were realized the EPS with similar protection promises against a remotely controlled unmanned aircraft systems.

In addition, was conducted the experts' opinion evaluation analysis based on experts' surveyed sample. The Kendall's coefficient of concordance (W) was selected for experts' data assessment. The statistical software package SPSS version 20 was used for the collected experts' opinions data analysis [16].

3.1. Mathematical Background for Agglomerative Hierarchical Clustering Analysis

The hierarchical clustering method determines the overall structure of interconnections of all clusters and also helps to select the optimal number of clusters. The agglomerative hierarchical clustering method is divided into combining and dividing methods. All methods are assessing the proximity by objects. In this analysis, there was used the straightforward way to assess two objects' closeness by drawing a straight line between them. This type of distance is also referred to as Euclidean distance or straight-line distance and is the most commonly used type when it comes to analyzing ratio or interval-scaled data. In the mathematical point of view it can be described by the equation:

$$Dist(x, y) = \sqrt{\sum_{i=1}^{n} (x_i - y_i)^2}, \qquad (3.1)$$

where x_i and y_i are the cases measurement vectors. Some analysis of clustering methods can be conducted with any kind of similarity or distance measure between cases, but there are three methods: Ward's method, Centroid method and Median method, which use squared Euclidean distances:

$$Dist(x, y) = \sum_{i=1}^{n} (x_i - y_i)^2. \qquad (3.2)$$

In this case, was selected a squared Euclidean distances measure of similarity or dissimilarity (equation 2) and chosen a median clustering algorithm. This method takes into consideration the size of a cluster, rather than a simple mean [16, 17]. With the median method, the two clusters being combined are weighted equally in the computation of the centroid, regardless of the number of cases in each. This allows small groups to have an equal effect on the characterization of larger clusters into which they are merged. The investigation results are presented in the fifth section below. All analysis was following the agglomerative hierarchical clustering mathematical background [16, 17].

3.2. Mathematical Background for Experts' Data Assessment

Simulations were done by SPSS and are presented in the section 5 to compare empirically the classical χ^2 test of the coefficient of concordance.

There are two ways to found for computing Kendall's W statistic, but they lead to the same result. S or S' is computed first from the row-marginal sums of ranks R_i received by the objects:

$$S = \sum_{i=1}^{n} (R_i - \overline{R})^2$$

or

$$S' = \sum_{i=1}^{n} R_i^2 = SSR. \qquad (3.3)$$

S is a sum-of-squares statistic over the row sums of ranks R_i . $\overline{R}$ is the mean of the R_i values. Following that, Kendall's W statistic can be obtained from either of the following formulas:

$$W = \frac{12S}{p^2(n^3 - n) - pT}$$

or

$$W = \frac{12S' - 3p^2n(n+1)^2}{p^2(n^3 - n) - pT}, \qquad (3.4)$$

where n is the number of objects, p the number of judges. T is a correction factor for tied ranks (Siegel 1956, p. 234; Siegel and Castellan 1988, p. 266; Zar 1999, p. 446):

$$T = \sum_{k=1}^{m} (t_k^3 - t_k) \qquad (3.5)$$

in which tk is the number of tied ranks in each (k) of m groups of ties. The sum is computed over all groups of ties found in all p columns (judges) of the data table.

Kendall's W statistic is an estimate of the variance of the row sums of ranks R_i divided by the maximum possible value the variance can take; this occurs when all judges are in total agreement; hence $0 \leq W \leq 1$. To derive the formulas for W given above, one has to know that the sum of all ranks in the data table is $p\ (n+1)/2$ and that the sum of squares of all ranks is $p^2n(n+1)(2n+1)/6$. Friedman's χ^2 statistic is obtained from W using the formula:

$$\chi^2 = p(n-1)W. \qquad (3.6)$$

This quantity is asymptotically distributed like chi-square with (n -1) degrees of freedom. This allows us to test W for statistical significance. The results get after our investigations are discussed in the fourth section below.

4. Experts' Data Analysis Results

There were questioned the ten experts. The nine of the interviewed experts are officers or soldiers and only one is the civilian expert. All experts belong to the same group which was arranged for the fighting against the UAVs. Almost all experts have higher education, only one has the higher non-university degree. The six of experts' are in this team for only one year, the two are about two years and only two of them were with experience of five years. The age of questioned ten experts varied from 25 to 40 years. The detailed characteristics are known for the author, but will not be presented in this paper. All of these experts have a lot of competence and knowledge working with UAVs, but in the different field.

For this research was selected the list of sixteen technical specifications which broadly define three steps to UAVs threat. The technical criteria codes used in experts' data statistical analysis are presented in Table 3 and the brief description can be presented like this:

- Five technical criteria for UAVs detection: CR1, CR2, CR11, CR13, CR16;
- Five technical criteria for UAVs identification / Tracking: CR3, CR4, CR12, CR15, CR14;
- Six technical criteria for UAVs neutralization: CR5, CR6, CR7, CR8, CR9, CR10.

The data collected from questioned ten experts were analyzed by SPSS package, the inferential statistic was tested and the null hypothesis of equality of concordance coefficient to zero was verified. But there was impossible to make the conclusion, that all ten experts' opinions are close because the experts' assessments describe Kendall's concordance coefficient (Wa =0,174) and p-value (0,037). In addition, the analysis was repeated with the four experts' group. The six experts' were eliminated from the continual analysis of the reason that they work in the experts teem only one year. The surveyed four experts opinions were very similar, this was shown by Kendall's concordance coefficient, which was high enough (Wa =0,580) and p-value (0,007).

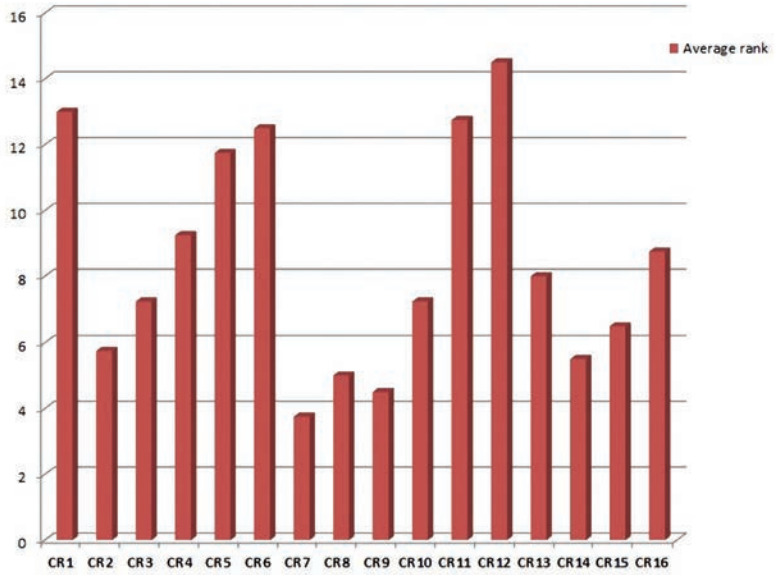
The continual analysis result when the preselected group of four experts according to their specific experience was used allowed us to use the expert judgment for decision making. In this way were determined the most important technical criteria, which can be clarified as the main technical parameters for existing protection systems.

Table 3

The protection system technical criteria evaluation analysis

Technical criteria		Four experts				Ten experts			
		Mean	Std. Deviation	Min	Max	Mean	Std. Deviation	Min	Max
CR1	Detection distance	13,00	3,464	8	16	11,6	4,351	3	16
CR2	Detection angle	5,75	4,50	2	11	6,4	4,695	1	14
CR3	Data Capture	7,25	5,058	3	13	7,8	5,633	2	15
CR4	Data Analysis	9,25	5,123	4	15	7,9	5,238	3	16
CR5	Operator location setting	11,75	0,957	11	13	10	4,922	1	15
CR6	Neutralization	12,50	3,512	9	16	11,1	4,677	5	16
CR7	Alternative neutralization techniques	3,75	3,403	1	8	5,5	3,504	1	12
CR8	Neutralizing Targets	5	2,828	1	7	6,3	3,773	1	12
CR9	Ability to remotely control system	4,5	1,291	3	6	7,3	3,529	3	12
CR10	Autonomous system operation	7,25	3,403	4	12	6,7	4,029	1	12
CR11	System Mobility	12,75	2,217	10	15	10,5	3,598	4	15
CR12	Identification of UAVs	14,50	2,38	11	16	10,9	4,818	2	16
CR13	Ability to connect the additional modules	8,00	4,32	4	14	9,3	3,592	4	15
CR14	Personnel quantity	5,50	4,041	2	9	6,8	5,095	1	15
CR15	Preparation for operation time	6,50	5,00	1	13	7,7	4,27	1	14
CR16	Possibility to update the system	8,75	4,193	3	13	10,2	4,158	3	16

Source: Author's



Source: Author's

Fig. 2. Result for technical criteria ranking by experts' opinion

According to the experts' opinion five of sixteen criteria were marked as important (Fig. 2). The first important feature for existing protection systems was chosen the CR12 – Identification of UAVs (evaluated in 58 points of 64), the second in the queue was CR1 – Detection distance (evaluated in 52 points of 64), the third was CR11 – System Mobility (evaluated in 51 points of 64), the fourth was CR6 – Neutralization (evaluated in 50 points of 64) and the fifth was CR5 – Operator

location setting (evaluated in 47 points of 64). Moreover, after this analysis by following experts' recommendations for protection system capabilities to fight against unmanned aircraft vehicles, we can conclude as the most important possibilities were selected two: the Identification of UAVs and the Detection distance.

This research continues with the additional statistical analysis, which solves in part research goals and objectives. The statistical software package SPSS version 20 was used to perform the agglomerative hierarchical clustering analysis [17]. The results are presented in the next section.

5. Agglomerative Hierarchical Clustering Results

As was mentioned above, the agglomerative hierarchical clustering analysis was used to group by similarity nine existing protection systems. The two of EPS were manufactured in USA: Radio Hills Technologies and MOOG. The others – mass-produced: in the Israel (Elbit Systems), in the Germany (HENDSOLDT), in the Ukraine (Bukovel), in the Switzerland (Aquila Defense Group), in the Denmark (Rohde&Schwarz), in the Lithuania (NT Service) and one – in the UK (Blighter Surveillance Systems). All parameters for the hierarchical clustering analysis for these nine existing protection systems are well known for author, but in safety reasons aren't detail in this article.

Table 4

Dissimilarity matrix for nine EPS

Protection System	Squared Euclidean Distance								
	1:Blighter Surveillance Systems	2:Aquila Defence Group	3:HENDSOLDT	4:Bukovel	5:Elbit Systems	6:NT Service	7:Radio Hills Technologies	8:MOOG/ JAV	9:Rohde&Schwarz
1:Blighter Surveillance Systems	.000	4.953	12.959	20.020	18.112	7.297	14.105	16.827	6.593
2:Aquila Defence Group	4.953	.000	19.113	25.389	14.351	5.557	12.063	25.139	4.718
3:HENDSOLDT	12.959	19.113	.000	27.774	22.193	14.170	9.397	14.593	13.605
4:Bukovel	20.020	25.389	27.774	.000	26.084	18.308	22.783	36.462	18.434
5:Elbit Systems	18.112	14.351	22.193	26.084	.000	17.994	22.068	36.666	13.431
6:NT Service	7.297	5.557	14.170	18.308	17.994	.000	4.775	14.194	.894
7:Radio Hills Technologies	14.105	12.063	9.397	22.783	22.068	4.775	.000	13.210	5.009
8:MOOG	16.827	25.139	14.593	36.462	36.666	14.194	13.210	.000	16.764
9:Rohde&Schwarz	6.593	4.718	13.605	18.434	13.431	.894	5.009	16.764	.000

Source: Author's

As for Lithuania Armed Force's future plans, the parameters were specified with respect to all requirements which are enumerated by the Ministry of National Defence of Lithuania in the ORD. In this way for each protection system constructed to fight against hostile drones were collected the eight measures.

Table 5

Agglomeration Schedule

Stage	Cluster Combined		Coefficients	Stage Cluster First Appears		Next Stage
	Cluster 1	Cluster 2		Cluster 1	Cluster 2	
1	6	9	.894	0	0	2
2	6	7	4.668	1	0	4
3	1	2	4.953	0	0	4
4	1	6	7.045	3	2	5
5	1	3	10.819	4	0	6
6	1	8	11.914	5	0	7
7	1	5	23.185	6	0	8
8	1	4	19.995	7	0	0

Source: Author's

The agglomerative hierarchical clustering analysis helped to identify similar groups by technical criteria parameters such as RF scanner; radar, an acoustic sensor, the thermal sensor, the electronica optical sensor, the detecting module, the identification module and neutralization module. All chosen variables in this analysis under consideration are measured on different scales and levels. There is the possibility to resolve this problem by standardizing the data prior to the analysis. There are available different standardization methods in the hierarchical clustering procedure in SPSS. The variables can be standardized in different ways. There is the possibility to compute for variables standardized scores or divide by just the standard deviation, range, mean, or maximum. This resulted in all variables contributing more equally to the distance measurement.

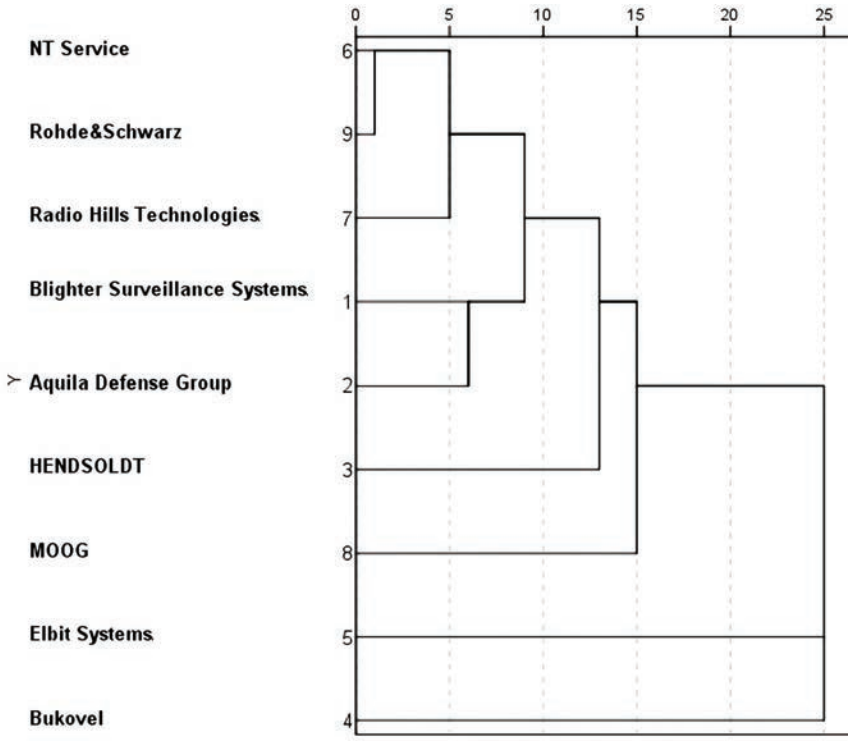
Table 6

Cluster Membership

Case	4 Clusters	3 Clusters	2 Clusters
1:Blighter Surveillance Systems	1	1	1
2:Aquila Defense Group	1	1	1
3:HENDSOLDT	1	1	1
4:Bukovel	2	2	2
5:Elbit Systems	3	3	1
6:NT Service	1	1	1
7:Radio Hills Technologies	1	1	1
8:MOOG	4	1	1
9:Rohde&Schwarz	1	1	1

Source: Author's

There was chosen the simple z standardization for this analysis. This method rescaled each variable to have a mean of 0 and a standard deviation of 1. The data standardization was used, by the reason to reduce or inflate the variables' influence on the clustering solution. In addition, the median algorithm was selected for clustering. In this analysis, each of clusters pair being combined was weighted equally in the computation of the centroid, regardless of the number of cases in each. One of the results get after this analysis is the dissimilarity matrix for nine EPS which is presented in Table 4.



Source: Author's

Fig. 3. The dendrogram using median linkage between groups

To get the squared Euclidean distance between each pair of EPS, there were squared the differences in the eight scores that were assigned to each of the nine EPS pairs. There were weighing the 72 scores for each EPS. The distances get after calculations are shown in Table 4, the proximity matrix. The presented distance matrix is symmetric. All of the numbers on the diagonal are equal to zero since an EPS does not differ from itself. The smallest difference between two EPS to 0.894. This is the distance between Denmark (Rohde&Schwarz) and Lithuania (NT Service) protection systems. The largest distance in the proximity matrix equals to 20.020 and occurs between the UK (Blighter Surveillance Systems) and the Ukraine (Bukovel) EPS.

There was used the possibility to choose the different clusters number in the agglomerative hierarchical cluster analysis. In purpose to accurately represent collected data, there were determined by this analysis two, three and four clusters which grouped by similarity different EPS. The cluster membership analysis results are presented in Table 6. There you can see how similarly constructed clusters are when was created additional clusters.

The agglomeration schedule which can help to make the decision about clusters number is presented in Table 5. The distance statistic value was used to form the cluster because for this analysis the median method was applied. The figures in the column labelled Coefficients indicate how unlike the clusters being combined are. In this research was used the dissimilarity measures, so the small coefficients indicate about fairly homogenous clusters are being attached to each other and large coefficients indicated that dissimilar clusters are combining [17].

The visual representation of the distance at which clusters are combined is shown in the dendrogram (Fig. 3). The dendrogram is read from left to right. The observed distances are rescaled to fall into the range of 1 to 25, so you don't see the actual distances; however, the ratio of the rescaled distances within the dendrogram is the same as the ratio of the original distances. The first vertical line, corresponding to the smallest rescaled distance, is for the NT Service (Lithuania) and ROHDE & SCHWARZ (Denmark). The second vertical line corresponds to the NT Service (Lithuania) and Radio Hills Technologies (USA). What is presented in the plot in the Fig. 3 is the graphical view of information that is accessible in the agglomeration schedule, Table 5. By this way there are possible to conclude, that in the last two steps, fairly dissimilar clusters are combined: the Elbyt Systems (Israel) and the Blighter Surveillance Systems (UK) with 23.185 distance coefficient; the Blighter Surveillance Systems (UK) and Bukovel (Ukrainian) with 19.995 distance coefficient. The Elbyt Systems (Israel) and Bukovel (Ukrainian) are the furthest away from other clusters. This is due to the fact that their technical characteristics are significantly better than the EPS in the first cluster.

Based on the obtained results we can conclude that after agglomerative hierarchical clustering analysis which was done on nine existing protection systems inattention to eight chosen technical criteria measures, four fairly different clusters were identified:

- the first cluster can be presented as *Blighter Surveillance Systems* (UK), *Aquila Defense Group* (Switzerland), *HENDSOLDT* (Germany), *NT Service* (Lithuania), *Radio Hills Technologies* (USA) and *Rohde & Schwarz* (Denmark);
- the second cluster considers only one EPS – *Bukovel* (Ukrainian);
- the third cluster considers only one EPS – the *Elbyt Systems* (Israel);
- the fourth cluster considers only one EPS – the *MOOG* (USA).

The results of postponed hierarchical clustering analysis let us realize which EPS belongs in which group and additional was disclosed a number of similar groups (clusters). To manage this without hierarchical clustering analysis it can be intellectually satisfying.

Conclusions

The analysis of precise requirements listed in the ORD documentation makes it possible to choose the most appropriate protection, to determine the detailed technical requirements for military equipment and to properly understand the request for information received by enterprises. In addition, the ORD analysis showed the Lithuanian Armed Forces needs and helped to identify the most appropriate device.

The detailed capabilities survey of nine EPS with the respect to the minimum (forty parameters were evaluated) of main parameters let us clarify nine existing protective systems possibilities, advantages and disadvantages. All criteria were encountered by the protection system Elbyt Systems which is mass-produced in Israel, the second system meeting the highest criteria was HENDOLDT (Germany) with 35 requirements. The United Kingdom system Blighter Surveillance Systems remains in the third chart position with 33 matching requirements. Moreover, there was realized that all analyzed existing protection systems and products had the weakness. Also was realized that no one of nine EPS does not have a final solution that can be effectively used in the future.

The research on existing protection systems shows us that due to the fast-paced technology, there is no ideal system or product against UVAs. The manufacturers didn't provide for the possibility of continuous updating of equipment, installing new components to adapt to newly emerging threats. Also can be mention, that the commercial equipment designed to fight against civilian aircraft is ineffective against modified and/or military aircraft.

With the assistance of a specific experience group of experts were marked as important only five of sixteen criteria: the CR12 – Identification of UAVs (evaluated in 58 points of 64), the CR1 – Detection distance (evaluated in 52 points of 64), the CR11 – System Mobility (evaluated in 51 points of 64), the CR6 – Neutralization (evaluated in 50 points of 64) and the CR5 – Operator location setting (evaluated in 47 points of 64).

The agglomerative hierarchical clustering analysis results showed the closest and the remote protection systems used for aircraft unnamed vehicles which can be pointed for Lithuanian Armed Forces demands. In purpose to accurately represent collected data, there were determined by this analysis two, three and four clusters which were grouped by different EPSs' similarity. The precise classification was met only in the four cluster group.

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Design of Electromagnetic Rail Powered Missile for Penetrating Missile Defense System

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Abstract

Replacing chemical propellant and using electric power that generate the muzzle power to propel the rocket is done since 1846. There were productive research conducted to achieve velocity of 2000-3000 m/s, which cannot achieved using conventional propellant. These velocities are capable of penetrating the armor vehicles and high-density materials. Research is conducted to increase the velocity and stealth technology to penetrate missile defense system. However, the advanced technology capable of detecting from small drone to high velocity missile. This research give the conceptual design of the two-staged missile capable penetrating the defense shield using only kinetic energy by unconventional propulsion system. One stage act as the prey to the incoming missile and other system enter the shield with its velocity higher than any other interceptor missile. This missile uses Lorentz force to propel the projectile towards the target.

KEY WORDS: *Electromagnetic rail; EMR missile; Interceptors; Infrared signature, Lorentz force; Missile defence system; Projectile*

1. Introduction

The defense territory if shielded by missile defense system (MDS). This system monitor the incoming cruise missile, drones and other aerial vehicles. As the missile launched from enemy territory reaching the missile defense system shield, the heat signature of the exhaust captured by infrared (IR) satellite and the trajectory is sensed by the MDS radar. The velocity and flight path are measured using missile defense radar, counteract will be initiated using interceptor missile. Thus entering MDS is difficult and sometime impossible with the advanced MDS.

The design of new kind of missile varying velocity and without heat signature can counteract the interceptor missile launched from MDS batteries. Destroying any part of the MDS is crucial part in the penetration. Based on the case study on the conventional missile defense system working the electromagnetic rail powered missile is designed to counter and enter the shield to destroy the target.

2. Working Principle

The concept of launching the projectile towards the target from the second stage of the missile using electromagnetism is basic principle.

The construction of this missile has conventional first stage with solid propellant and unconventional second stage, which act as a launcher for second stage.

The electromagnetic launcher works on principle of Lorentz force. When a current **I** is flowing right angle to the magnetic field **B**, the force **F** will generate right angle to both the current and magnetic field. ℓ is the length of the armature.

$$F = I \cdot \ell * B$$

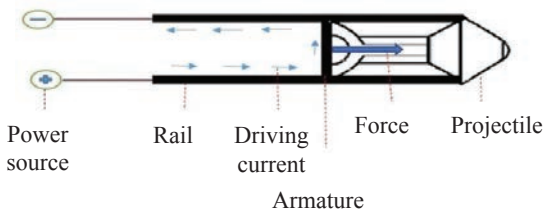

Fig.1. Current flow in the rail of the missile

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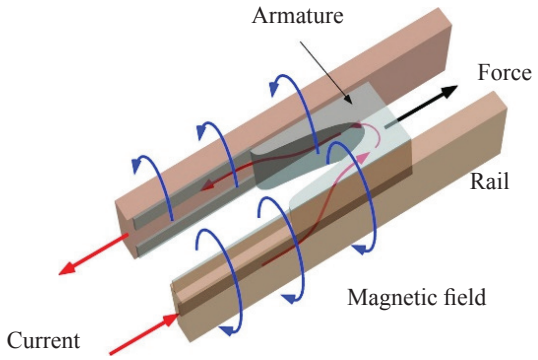

Fig.2. Lorentz force1

In the basic design rail is kept parallel to each other and longitudinal axis of the missile. As the length, extend from the solid motor to near nose cone. The rail made of conductive material such as copper. The power source of the launcher is capacitor bank, which transfer the energy required to propel the projectile.

Power source is the crucial part of the launcher that depend on the amount power applied is proportional to the propelling power. Larger current need to be applied to push the projectile for longer distance with higher kinetic velocity as the penetration of MDS required faster heatless motion.

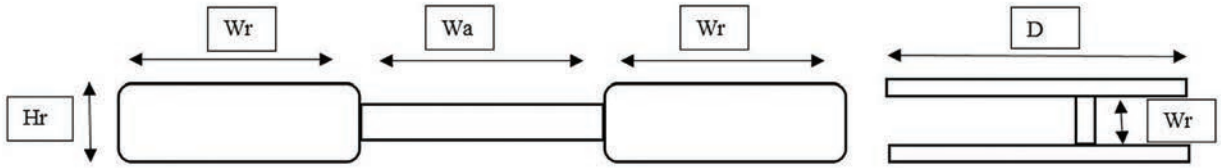

Fig.3.Schematic diagram of electromagnetic rail

Wr = width of the rocket rail;
Hr = height;
D = length of the rail;
Wa = distance separating rail.
The expression for the change of muzzle velocity over the time:

$$\frac{dy_{muzzle}}{dt} = \sqrt{\frac{L'D}{m} * I} \qquad (1)$$

L' = inductance gradient;
D = length of the rail;
I = current;
m = armature mass.
Equation (2) gives the kinetic energy applied on the projectile:

$$KE_{muzzle} = \frac{1}{2} m \frac{dy_{muzzle}}{dt} \qquad (2)$$

$$= \frac{1}{2} L'DI^2$$

3. Missile Design

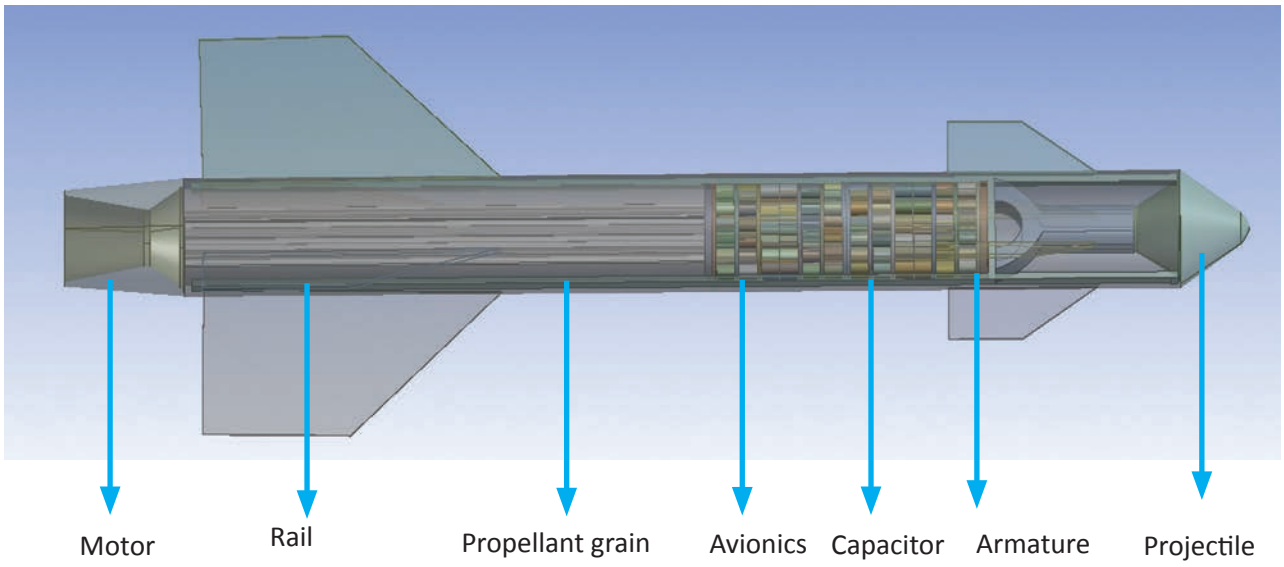

Fig.4. Parts of the missile

First stage: First stage of missile is conventional solid propellant motor uses Ammonium perchlorate based composite propellant. The grain geometry is internal burning tube and slot. The aluminium casing is used to reduce weight and insulation is done to separate the rail from the casing and fuel. Ignitor kept on the top of the first stage and avionics system proceeds the first stage.

Second stage: Second stage consists of copper rail running parallel to missile longitudinal axis; the high-power capacitor bank store all the power need to propels the projectile. The high-density armature, which slides in the gap between the rails. Armature completes the circuit and allows the current to flow in the circuit.

This current flow create the force to push the projectile. The injection system is employed to give initial push of the projectile otherwise, it creates arc and heats up the system. Projectile is made of rigid material such as titanium and the shape of the projectile is aerodynamically modified to thin sharp edge shape gives better performance and reduced drag during the motion. As it is not caring any control, propulsion, guidance system it can be thin enough to deflect the radar waves. As it completely rely on kinetic energy, it does not produce any heat signature.

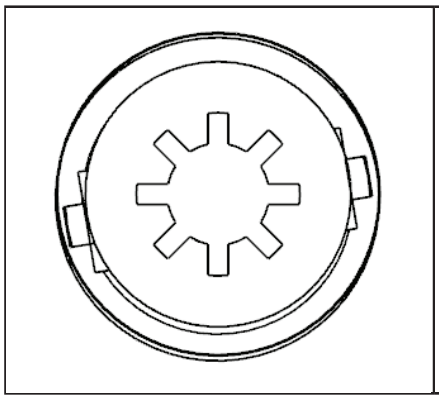

Fig.5. Grain geometry

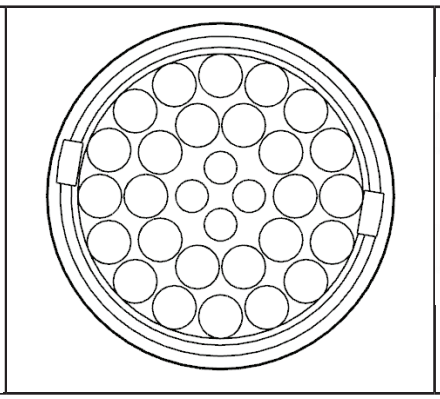

Fig.6. Arrangement of capacitor

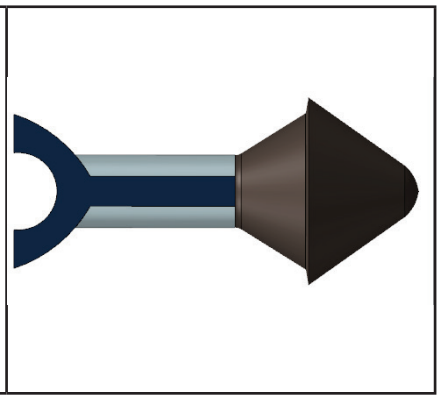

Fig.7. Projectile

Fins are used to control the stability and maneuver of the missile trajectorie at first and second stage.

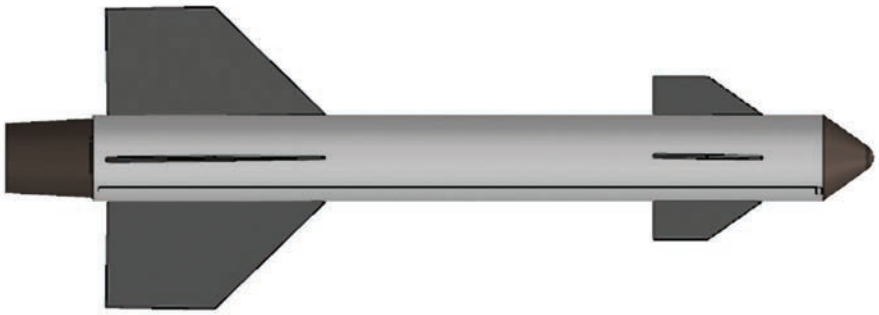

Fig.8. Side view of missile

Table 1

Missile specifications

Total length	14000 mm
Diameter	1300 mm
Mass	12000 kg
speed	830 m/s
Missile range	400 km
Rail length	13250 mm
Projectile length	400 mm
projectile range	60 km
Projectile speed	1500 m/s

4. Mission segment

Mission profile designed to destroy the particular element of the missile defence system. Multiple launch required to destroy the complete MDS. Critical elements of MDS is satellite, radar, interceptor batteries. Mostly the radar and batteries are the target for this kind of missile.

Missile is launched from the ground and the variant can be launched from aircraft. After the launch of the missile, the heat signature is captured by the infrared satellite and sends the signal to MDS system.

The MDS radar detect the trajectory of the incoming missile and signals to launch of interceptor missile. The interceptor is targeted towards the incoming missile. The velocity of interceptor coincide with the missile.

Missile approach warning system (MAWS) in our missile detect that the missile is locked with interceptor. Based on MAWS the control system alter the attitude of missile and point towards the target.

The injection system pushes the projectile. The high-energy current in the rail creates high kinetic energy that pushes the projectile towards the target. There is no propulsion system is used on the projectile so it does not produce any heat signature. The aerodynamic shape keeps the projectile hidden from radar detection. Due to its thin body, it produce less drag and move faster. The motion completely rely on kinetic energy to hit-to-kill target.

The interceptor missile hit the incoming missile but the projectile already ejected from the missile and travel higher speed then the initialisation of another interceptor missile. The electromagnetic propulsion gives higher muzzle energy than any other missile so the projectile can travel much faster.

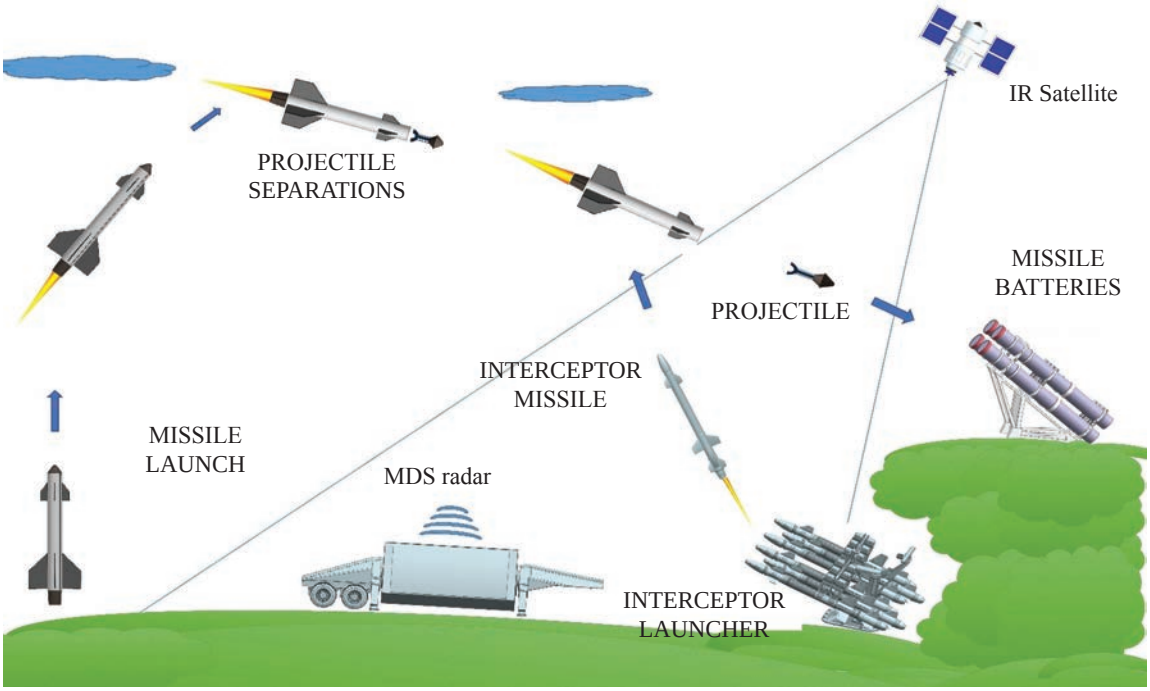

Fig.9. mission profile

Conclusions

The following results of our design:

- Hyper velocity projectile launched towards target by electromagnetic rail mounted on the missile;
- Trajectory is controlled by the control surface.
- Projectile travels on velocity produced by the electromagnetic rail avoids heat signature;
- Thin surface avoids aerodynamic drag and gives the additional stealth from radar signal.
- The first stage of missile act as prey target for the interceptor missile.
- Projectile escapes from interceptor missile and hits the target.

Acknowledgements

The design of this missile is inspired from the US navy railgun project designed by BAE SYTEMS and GENERAL ATOMICS. Authors thankful to Kaunas University of Technology online library and IEEE journals.

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Small EU Initiatives in the Process of Pooling and Sharing of Military Capabilities

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Abstract

The defense budgets of the Member States of the European Union are rising due to the current economic situation and change in the level of security. The goal of approaching two percent of gross domestic product will probably be reached within one decade. However, the positive trend in the development of the defense budget will not allow small states to acquire the exact numbers of military techniques in the numbers that imply a continuous increase the capacity of national armies.
Pooling and sharing is one of the approaches that will allow the required capabilities of national armies to benefit the European Union, or the North Atlantic Alliance. Deepening co-operation in the field of acquisitions will put pressure on coordination of activities, alignment of legislation and, above all, overcoming national and common. Obviously, given the current combat experience, the issue of armed forces has already been partly solved and pooling & sharing implementation is a political issue.

KEY WORDS: *pooling & sharing, smart defence, Visegrád Group, EU battle group, strategic cultures, the clarity of intentions, trust and solidarity, a common acquisition process, common development in defense capabilities*

1. Introduction

The Pooling & Sharing project basically relies on activities related to arms and services procurement pooling, joint research background, such as sharing through the partial or full integration of the power structures, the introduction of training facilities or the establishment of joint units; and specialization. There are some practical examples of P & S in Europe: the France-UK Treaty of November 2010, which is a bilateral agreement on P & S; the vast experience of the Visegrád Group (Czech Republic, Hungary, Poland and Slovakia) and the Weimar Triangle (France, Germany and Poland). The above-mentioned cooperation examples can be more appropriately labelled as small initiatives for which the P & S model partially applies. The most important example of the "pooling" of EU Member States' troops is the creation of the capabilities of the EU Battlegroup.

Notwithstanding these initiatives, however, the functioning of the EU P & S agenda depends on two fundamental factors that have not been fully implemented yet. The first important area is the effective liberalization of the European arms market, which will create more competition among national defence industries, where the necessary condition is the removal of national barriers, and the Europeanisation of a part of the defence budget. The other still missing area is a significant improvement in EU defence cooperation that would lead to the adoption of a concept of reduced diversification level in military equipment and technology in Europe.

1.1. Method of Investigation

The methods of scientific knowledge used here based on the need of acquiring data, creating new knowledge, and continuously building on the previous knowledge and contexts of processes. Due to the amount of available book resources, the need for the ability to implement the knowledge gained due to the changes in the implementation of logistical support and the implementation of private and public sector partnership projects on a global scale has emerged. [1] The logical chain of inductive understanding [2] based on the collection of data from different sources in order to find regularity in the data obtained for the preliminary conclusions.

The historical-comparative method is based on the ability to find the same evolution of structures in the commercial sphere and subsequently implement them in the process of the armed forces in the implementation of logistic support at tactical and strategic distances. The dates of involvement of the Armed Forces of the Visegrád Group in the European Union Battlegroups were used.

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1.2. Investigation Results

The Visegrád Group states, by taking a decision to create the V4 EU BG, sent a clear signal of their interest in consolidating the EU's position on the international scene [3], and the joint contribution was a practical expression of the support of the Common Foreign and Security Policy.

The creation of a joint V4 formation without the participation of a European "big" player demonstrates the maturity of states [4] and at the same time declares the ability of sub-Central European countries to cooperate within the complex political and military issues that the EU BG is building. State-of-the-art is also supported by the experience gained in previous combat groups together with experienced Union Member States. The positive development of the V4 EU BG was also the ability to offer a position to the Lead State where the Poland republic assumed responsibility for the planning, creation, training and certification of V4 EU BG, while the other participating countries respected PR authority and its responsibility towards the EU. Positive is also the finding of a consensus on the precise distribution of contributions and individual modules so as to eliminate possible shortcomings, particularly in the area of technical or logistical deficiencies [5].

2. Smart Defense and EU Pooling and Sharing Capacity

The financial crisis has profoundly affected the European defense budgets and, as a result, the EU's ability to act as a global security provider. It can be said that differences in military spending between EU Member States and lack of coordination are detrimental to EU security cooperation. A possible solution was the acceptance of NATO's intelligent defense alliance, Smart Defense, which uses the processes of sharing and pooling military capabilities. The aim of the new approach is to promote collective capacity building and to balance budgetary constraints.

Thus, in 2011, when Europe was not faced with an imminent threat, the political arguments for increased military spending were not relevant. It is not surprising that states tried to increase efficiency by supporting bilateral or multilateral forms of cooperation with other states.

The NATO Summit in Chicago in May 2012 in its conclusions recommended Member States to reduce costly national programs and seek effective solutions by pooling and sharing resources. Achieving synergy results requires improved understanding of mitigation measures, fulfillment of mandatory requirements by all actors in the distribution chain, and continuous updating of applicable regulations and directives [6]. The P & S concept is not new, but the new one was a combination of the financial crisis and the lessons learned from the Libyan campaign, which called for a more equitable settlement of the European contribution to NATO's ability to develop a "smart" way to cope with growing defense demands through multilateral cooperation.

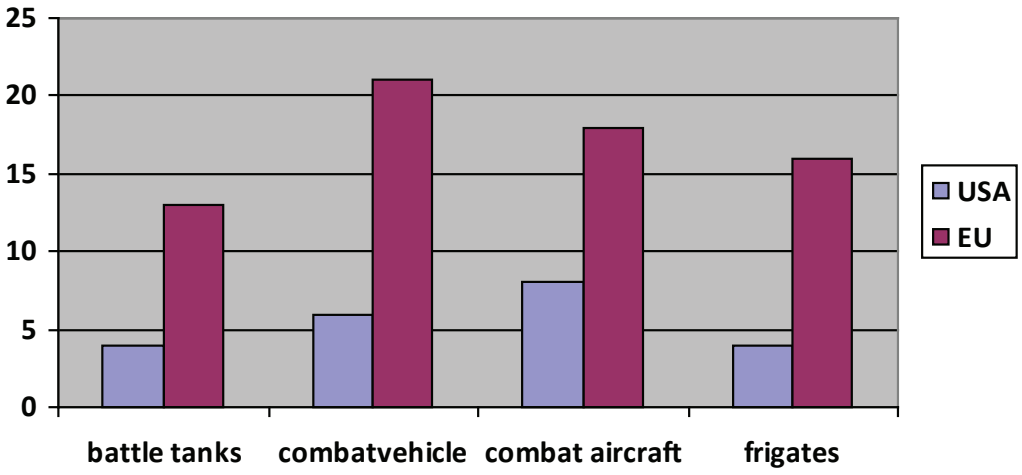

Fig. 1. Different combat platforms between the US and the EU

Implementation of a robust EU P & S agenda depends on two fundamental factors still needs to be realized. The first is the effective liberalization of the European arms market, which results in greater competition from defense industries that will remove national barriers and the current Europeanization of the defense budget. The second is to achieve a state where national states have diversified military hardware and services that will be able to communicate with each other through technology.

Thus, the critical mass of the EU's defense capabilities is not "big enough" and national capacities are still largely uncoordinated, especially with regard to the acquisition of new technologies. It can also be said that the achievement of the 2010 target on capacity building, based on capacity building, does not reach positive trends and public procurement projects are rather declared as threats to national markets and rivalry. The success of P & S processes is the EU Battlegroups,

which represent capacity development, although they have never been deployed, and cannot improve and to innovate mechanisms by creating new capacities.

Economic protectionism and geopolitical aspects could be the answer to clarification the geometry of defense cooperation that prevents defense integration. The result is slow progress in the development of capabilities. The Military Budget therefore represents mandatory spending, 50%, operating (30%) and development spending (20%) [7].

3. The Process of Pooling and Sharing Capacities

The unfavorable combination of the financial crisis, which was reflected in the military budgets of the European states, with the already mentioned insufficient military capabilities of the EU, put pressure on the EU around 2010 to seek practical solutions for the elimination of the unfavorable situation.

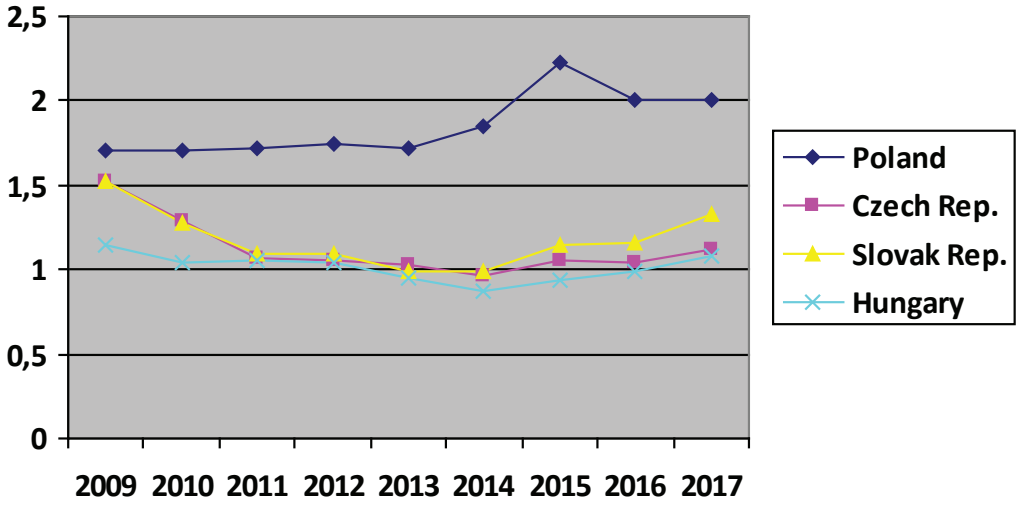

Fig. 2. Development of the defense budgets of the Visegrád Group states [8]

However, pooling and sharing can currently be defined as an expression of EU security efforts and newly defined threats to eliminate the deficiencies of EU Member States in the area of military capabilities Deep knowledge about the capabilities of their own security systems, environments and relationships between them enables decision makers to make decisions with the least degree of risk [9]. The concept was based on the assumption that the use of P & S will increase the interoperability of EU Member States' armies. At the same time, the P & S concept allowed us to identify and eliminate the duplication of military capabilities of European states where national profiling should be reflected in the efficient use of allocated resources. The P & S concept assumes a wide range of military initiatives, ranging from military education, through joint exercises to participation in the EU BG, to accelerate the process of achieving the required military capabilities [10].

The newly established military cooperation trend was to enable European states to maintain and develop national military operational capabilities and, by implementing 3E, to increase operational capabilities while increasing efficiency, sustainability, interoperability and profitability.

Sharing of Military Capabilities "implemented in the context of multinational defense cooperation is based on the implementation of shared selected military activities within national structures and capabilities of forces, which are not integrated into a single international mechanism. This means that the process of command and control, including control, is the national responsibility of the armed forces. Operational costs are also subject to a breakdown based on the national share of participation. Participating Member States continue to maintain national sovereignty over the control of national forces.

The concept of "pooling", however, in the framework of multinational cooperation, the sharing of military capabilities is a much more complicated and complicated mechanism than a "sharing", given the fact that command and management of shared military capabilities is partly subordinated to national governments, even though defined national capabilities have been integrated into a multinational structure. However, the concept of pooling requires less personnel and operational logistics costs in the process of integrated and coordinated planning.

The most appropriate example of pooling is the construction of multinational safety purpose structures – EU BG or NRF. Multinational command and control structures are established within the purpose of the structures, but participating states retain control over their units, national contributions.

Safety is one of the most important values of every society. If it is not assured of safety, they cannot develop further activities. The national security as a reference object can contribute significantly in various sectors of security and membership in the international community [11].

The need to ensure availability has to be based on the "Availability of National Capabilities Agreement" from the very beginning of the implementation of the P & S processes that require the following activities:

- Analysis of interests and required military capabilities through a consensual solution.
- Identify the range of available military capabilities.
- Performing comparisons of required changes in capacities and structures.
- Substitution of missing competences through a sharing project or so-called "sharing roles".
- Excessive military capabilities that should be phased out in developing national programs due to inefficient development.
- All capabilities should then be analyzed to find out how to use the pooling project and the "sharing role" [12].

Implementation of P & S projects also raises concerns about the so-called "rejection of shared capacities", which could result in the efforts of one of the participating States being thwarted when other states in a shared unit refuse to grant national contributions to shared capacities. Different national economic strengths can also raise concerns about the fact that economically less advanced states or states with limited national defense capacity will paradise free-riding using the concept of P & S, exploiting the benefits of cooperation without sufficient reciprocity. [13,14] However, the current form of the P & S project is, overall, a new direction of mutual cooperation between EU Member States based on a rational approach to solving security dilemmas, while setting the trend to eliminate duplicity, eliminating ineffective military capabilities. The implementation of pooling and sharing projects presupposes a certain level of military cooperation between Member States, based on regional, subregional platform.

4. Subregional Military and Defense Co-operation

The concurrent efforts of EU Member States and NATO to find common solutions to defense can result in new and diversified forms of sub-regional, multinational military and defense co-operation reflecting the unfavorable development of financial capabilities and military capabilities. It can be stated that the objective of cooperation of defense-led states is not the interest in creating new structures beyond the existing but above all reduction of operational costs at national level through co-operation and sharing that will allow national states to support the selected military capabilities defined by the White Paper on Defense. [15]

The above described effort corresponds to the P & S military capability project. A relatively new project does not allow for precise definition of success criteria, but on the basis of experience in defense cooperation, it is possible to identify some factors that allow not only the creation but also the sustainability of security cooperation. The factors identified so far are: geographical proximity, similar geographic size, comparable military power, similar strategic culture, historical political cooperation, and political will of state officials.

In the field of foreign policy criteria, which create the prerequisites for the construction of sub-regional military and defense cooperation between Visegrád countries, it is possible to include:

- Similarity of strategic cultures.
- Trust and solidarity.
- A comparative structure of armed forces and quality in all dimensions.
- Similarity of the defense industry.
- Clarity of intentions. [16]

The signing of the new Visegrád Declaration of May 2004 confirmed the efforts of the V4 states to continue in further cooperation on subregional activities and initiatives to strengthen identity of the Central European region. At the same time, the commitment was confirmed joint co-operation of the Visegrád Group countries in CFSP / ESDP development, strengthening of Euro-Atlantic relations and the relationship between the EU and NATO. The meeting provided another significant incentive to step up mutual cooperation at the sub-regional level in the military-defense area. However, the state declaration of the State representatives did not positively respond to the real development of military cooperation. The reduction in the level of practical military cooperation of V4 countries in the military field, which was only a declaration of a "common platform", lasted from 2004 and took the form of manifestations of the Visegrád group's common positions. Military cooperation between the V4 countries, after accession to the EU and NATO, was largely a political consultation, but it allowed the V4 states to realize a "subregional lobby" in interpreting the Visegrád Group's interests.

The new form of military relations of the V4 states was based on the autonomous behavior of the members and was manifested mainly by the participation of states in many NATO expedition operations, the EU / CSDP and the so-called "coalition of willing". Relationship flexibility was also reflected in the acquisition and upgrading of the national armed forces.

5. Construction and Readiness of V4 EU BG in 2016

Operational readiness for deployment of V4 EU BG was from January 1 to June 30, 2016, with post-operative readiness on 1.7. - 30.10. 2016. The formation of the Visegrad countries – Poland, the Czech Republic, Hungary and Slovakia (V4 EU BG) was shared. More than 3,900 soldiers from four countries had a 24-hour emergency room during which they could be sent to resolve a crisis situation anywhere up to six thousand kilometers from Brussels.

In approving the impact of the forces and resources of the V4 EU BG, the V4 parliaments agreed to the force of the

force for a 6-month standby, but in the future, 120 days from the day of deployment needed to be calculated, requiring a 6 months extension of consent to the force + 120 days.

Of the total of over 3900 soldiers of the V4 EU BG. Poland, as the lead country, allocated 1,868 people, the Czech Republic earmarked 728 people, Hungary sent 639 people, and Slovakia sent 466 OS members. Poland has provided a major part of the combat maneuvers for V4 EU BG, Hungary has provided engineers and CIMIC, Slovakia with a Weapons of Mass Destruction UnitWMD. On the V4 EU BG, members of the OS of Ukraine also had to participate in 19 persons.

Poland, as the lead country, declared the creation of the V4 EU BG with operational readiness in the first half of 2016 as early as 19 April 2012 at the EU BG Coordination Meeting in Brussels. Subsequent signed documents, "Cooperation in Developing Capabilities, Solidarity in Sharing Responsibilities" and "Joint Statements of the V4 Ministers of Defense" have enabled the development of joint combat group capabilities in training, and the development of capabilities and their sharing.

The efforts of the V4 countries to harmonize the V4 EU BG Exercise (LIVEX V4 EU BG) with the Trident Juncture Strategic Exercise (TRJE15) proved to be a good solution, and the V4 representatives agreed on the need to link LIVEX V4 EU BG and TRJE15 and, at the same time, V4 territory.

The members of the Army of the Czech Republic were responsible for logistics and health care, where they held the position of the leading country. The Czech Army's logistics ensured the construction of a common ammunition depot, the transport company and the national support element. The Combat Command has established JLSG HQ- Join Logistics Support Group Headquarters for Logistics Coordination. The preparation of the logistics module culminated in the international certification exercise Capable Logistician 2015.

The specialty of preparing the health element was based on the Multinational Medical Modular Approach (Multinational Medical Module Approach). The principle of the principle is based on the use of whole or certain parts of the health modules of the participating states (personnel, infrastructure, and instrumentation) for the creation of a joint medical unit. The ACR's medical staff provided V4 EU BG with the construction of a multinational field hospital (ROLE 2E) on the basis of the 7th field hospital with the active participation of the V4 modules. Capacity testing was carried out by the Medical Man 2015 Certification Exercise.

The armed forces of the Slovak Republic contributed to the V4 EU BG as follows:

- ROLE 1 mechanized company with logistic support for up to 150 people.
- RCHBO Company with its own logistic support unit with a capacity of up to 140 people.
- 12 people, in two teams, for the removal of explosive devices.
- Military Police team of 15 people.
- Movement management team of 10 people.
- ROLE 2 medical team up to 25 people.
- Representatives in the Joint Operations Headquarters for 40 persons.
- Transport company for up to 100 people.
- Intelligence, Survey, and Electronic Combat for 10 people.
- Representatives in teams of psychological operations of 8 people.
- A national support element of 50 people.
- Representatives to the headquarters of a support logistic group of 10 people.

The national certification of the RCHBO module took place in 2015 so that the V4 EU BG certification exercise could take place in the second half of 2015. The Republic of Hungary contributed to V4 EU BG facilities with a ROLE 1 medical collateralized facility with a plurality of logistical support of up to 230 people, units in the CS structure of 127 people, with the structure of the engineer company comprised of 100 people. The contribution to the CSS units reached 75, the largest part being predestined for the health module in an account of 49 people. The Republic of Poland, which provided 1 868 people in total, was represented in all major structures V4 EU BG as follows:

- HQ members of 447 people.
- Mechanized Company, Logistics Company, Command and ROLE 1 Medical Unit, up to 400 people.
- ISR group of 63 people.
- Connecting company up to 65 people.
- Military police platoon up to 40 people.
- Support units, engineer unit, CIMIC and PSYOPS units for up to 130 people.
- JLSG units up to 270 people.
- RSOM process control units up to 460 people.

Conclusions

From the point of view of the system of management and administration of the V4 Defense Ministry processes, processes of conceptual design must be created. Achieving set goals requires the following processes:

- Set Supply Chains, Define Assigned Resources Using and Processes.
- Set control objectives based on the strategic objectives of defense departments.
- Ensure / create a functional organizational and communication model sharing information to control the objectives of the management and its fulfillment.
- Set up monitoring of goal fulfillment to ensure process management and management is in the planned direction.

Analyzing the data obtained has led us to conclude that significant variability exists for each material category. This may reinforce the belief that storage management in different displacements achieves low standardization levels and requires the adoption of decisions aimed at centralizing storage management with significant limitation of distribution sites and potential staff cuts while maximizing the use of information technology. Frequency and time consuming inventory inventories are also different depending on the location of the dislocation. The research of the future network and the follow-up logistics services led, among other things, to the development of a versatile packing line facility capable of completing the required types of material, depending on customer requirements. This enables the required material to be completed up to the level of the battalion task force without the need to increase the capacities of the employees.

The establishment of the V4 Planning Group (V4 PG) laid the foundation for more intensive cooperation in the defense planning process. The main task of V4 PG is to seek and propose areas of cooperation with the aim of developing mutual competencies. A prerequisite for the active influence of the V4 PG is the periodicity of meeting when the members of the working group should meet at least twice a year as part of the EU and NATO activities. An important consensus should be the fact that the country pays the costs of the capacities and capabilities it offers.

Due to the requirement to achieve certification of the training units, it would be advisable to set up the number of trainees to a level of up to 1 500 people, using the necessary number of support devices and selecting weapon systems according to the scenario of the operation.

It can be predicted that further development of the P & S project will be implemented in the following areas [17]:

- Common logistics.
- Medical treatment capacities.
- Training in air traffic control.
- Radiation chemical and biological protection.
- Training of helicopter pilots.
- Multinational military experiments.
- Training against improvised explosive devices.
- Joint construction of armored vehicles and ammunition.
- Equipment and armaments of soldiers.
- Integrated command and control systems.

Acknowledgements

This work was done within the framework of the UoD research project "Support for ACR Aviation Activities in Local Conflicts ".

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Cybersecurity in the Context of Criminal Law Protection of the State Security and Sectors of Critical Infrastructure

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Abstract

The protection of state security by the legal standards of the criminal law is one of the key, the legally protected interests including the cybersecurity in the sectors of critical infrastructure transport (road, air transport, ship, and rail), electronic communications, energy, information and communication technologies, post, industry, water and atmosphere, health. Today's empirical empowerment confirms that the security is a significant multidimensional factor of the quality of society and citizen's life, which we have to systematically examine, forecast and ensure. The contribution presents the defined security interests of the state in the framework of new strategic documents of the Slovak Republic in the comparison with the current standards of the criminal law for the protection of state security within the material and non-material components of the defence potential of the state.

KEY WORDS: *cybersecurity, legal norms, criminal law, protection, protected interests, state security, cooperation*

1. Introduction

The protection of state security by the legal standards of the criminal law is one of the key, the legally protected interests including the cybersecurity in the sectors of critical infrastructure: transport (road, air transport, ship, and rail), electronic communications, energy, information and communication technologies, post, industry, water and atmosphere, health. An important period of strengthening the security and defense capabilities of the Slovak Republic is the practical implementation of the provisions of the New Cyber Security Act of 30 January 2018 [1]. The draft of law on the Cyber Security and Amendments to some acts no. 69/2018 Coll. was prepared by the National Security Office of the Slovak Republic in cooperation with the Deputy Prime Minister for Investment and Informatization. We also regard the cyber-security issues as an important part of protecting state security within the material and immaterial components of defense and protection.

The resilience of networks and the stability of the information system is a prerequisite for a smooth and the uninterrupted functioning of the EU internal market and a prerequisite for the credible international cooperation. Networks and information systems play a crucial role in free movement and are often interconnected and connected to the Internet as a global tool. The disruption of the network and information systems in one Member State therefore affects other Member States and the EU as a whole, explained the key issue the National Security Authority [2].

2. Method of Investigation

This problem cannot be solved by one country in a comprehensive way, but a rigorous and professional international co-operation that relies on high-quality national capabilities.

The New Act transposes into the Slovak legal order a European directive on measures to ensure a high common level of network security and information systems in the Union (NIS). The NIS Directive is the first pan-European legislative regulation on cyber security that aims to strengthen the competences of the relevant national authorities, increases their mutual coordination and constitutes safety conditions for key sectors as a methodological guide for Member States. This article uses the historical and content legal analysis to explore the issue.

3. Investigation Results

The experience of the security community confirms that the level of protection was heterogeneous and incompatible due to the mutual inconsistency of the current legal norms in which the cyber-security issue was solved partially in the conditions of the Slovak Republic, thus failing to reach the required level of EU member states. As a result, there is no

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adequate level of cyber security against existing threats, resulting in irreparable losses and disruptions in the credibility of organizations and the state. The goal of cyber security is therefore to minimize the potential for such threats and, in the event of the consequences, to minimize their impact, which is a prerequisite for both public administration and the private sphere.

The article presents:

- Analysis of selected praxeological problems;
- The legislative solutions of selected problems of cyber security;
- The cybersecurity as part of the security interests of the state protected by the criminal law standards.

Already during the legislative process LP-2017-407, commenting on the draft law, 706 comments came, of which 236 were essential. From the analysis of the draft legal standard and from the comments, the following selected key outputs resulted:

– The proposal has repeatedly identified vague legal concepts which it does not itself define and which are not settled in the current legislation. A request was made for the law-bearer to reduce the uncertainty of these concepts in accordance with the applicable Legislative Rules of the Slovak Government in order to prevent later interpretative problems in the application of the Act after its approval;

– The uncertainty of terms brings other problems in application practice;

– The draft law was objected. "In order to ensure fulfillment of the tasks under this Act, the Office may conclude a cooperation agreement with a natural person or a legal person. The cooperation agreement must include a specific form and terms of cooperation. The cooperation agreement is not necessarily a public contract ". It completely disrupted any security measures of the basic service provider in the area of personnel and physical security. According to the proposal, any person who will have an agreement with the Authority will have the power to learn about any information. If the applicant remains in a position to conclude a cooperation agreement, it is necessary to specify the specific conditions that a natural person or a legal person as a contracting party must fulfill, including a requirement to demonstrate security and technical standards, qualifications and skills in cyber security. Also, a written agreement should specify the extent of the information that such a person will be entitled to acquaint himself, with the basic service operator and a duty to keep confidential about the facts that that person has become aware of when implementing such an agreement. Also, if the agreement is not excluded from mandatory disclosure of contracts under Act No. 211/2000 Coll. as subsequently amended, the non-disclosure of this Agreement constitutes a breach of this Act. However, in the case of unpublished contracts, exist the obligation to disclose information on its conclusion (the so-called notification obligation);

– The continuing problem is to reach a compliance with other applicable legal standards in the case of new legal standards;

– The draft law was objected that "The officers of the Office shall, in relation to the performance of the control and to the extent necessary for its execution, to enter the communication and information systems to the level of the System Administrator, including the authority to temporarily change the Hardware or Software Configuration". The proposed wording of § 29 par. 6 of the draft law provides inadequate competencies to the Office's officers, including inappropriate interventions in communication and information systems. Under § 3 par. 4 of Act 275/2006 Coll. on the information systems of the public administration of the obliged persons, who are administrators of the information system, are obliged to ensure the smooth, secure and reliable operation of the public administration information systems in their administration, including organizational, professional and technical security, and to provide the public administration information system against abuse. In the event of a change in the hardware or software configuration, the assurance of these obligations may be compromised or directly impaired. At the same time, may violation of the provisions of Act no. 122/2013 Coll. on the protection of personal data, since the entitlement to enter the information system at the level of the system administrator may result in the disclosure of the personal data of the persons concerned, provided that personal information is processed in that information system. If the proposed wording of Article § 29 par. 6 of the Cyber Security Act will not be abolished, the IS administrator cannot ensure the fulfillment of the obligations imposed by Act no. 275/2006 Coll. The draft law would also determine who will be responsible for malfunction or disruption IS functionality after changing the hardware or software configuration, and who will bear the adverse consequences associated with it, including damages caused to third parties;

– Definition of a cyber security incident in § 3 (f) of the draft law largely overlaps with the facts of the offenses set forth in § 247 - § 247d of the Criminal Code. However, the bill does not refer to criminal obligations in this provision or elsewhere, it does not refer to obligations in criminal proceedings and does not look at several places, such as the necessity of providing evidence (the response to a security incident should be conducted in such a way as to avoid devaluation evidence of subsequent criminal proceedings). This is a complexity of the assessment of the proposed regulation[4].

Legislative solution of selected outcomes and problems:

– In order to ensure fulfillment of the tasks under this Act, the Office may conclude a written cooperation agreement with a natural person. The cooperation agreement must contain the specific form and terms of the cooperation and the natural person must be entitled to have access to classified information of the relevant classification level if required to do so;

– When exercising control over observance of the provisions of this Act and its implementing regulations, the Office shall proceed according to the basic rules of the control activity stipulated by a special regulation. For the purpose of performing the control, the basic service provider and the digital service provider have the rights and obligations of the audited entity under a separate regulation. The Office will check the Digital Service Provider if it is reasonable to suspect

that the digital service provider does not meet the requirements of this Act;

– A cyber security incident is any event that has a negative impact on cyber security due to a disruption of network and information security or a breach of security policy or a binding methodology, or which has the following consequences:

1. loss of data confidentiality, destruction of data or compromise of system integrity,
2. limit or deny the availability of a basic service or digital service,
3. high probability of compromising basic service or digital service activities, or
4. threats to security of information.

4. Cybernetic Security as Part of the Security Interests of the State Protected by Criminal Law Standards

The Slovak Republic in the process of guaranteeing security, creating a security strategy, building its security policy and creating an adequate security system is based on historical experience, available scientific analyzes and forecasts of the security situation in the world, Europe, the Central European Space and its territory [5].

Company attention has always focused on two basic areas of security, namely internal security and external security, and the corresponding sources of threats that have been basically presented by natural and civilization sources of threats or combinations of them. It is precisely the area of civilization threats associated with armed violence that has become an area of great development in mankind's historical development which has provided humanity with instruments of self-destruction, destruction of the world, and human civilization. The state uses the available tools of the security system to eliminate them, in the context of collective defense and safeguard of protected interests, in individual security sectors.

The protection of state security by the standards of criminal law is one of the key, legally protected interests. Today's empirical empowerment confirms that security is a significant multidimensional factor of the quality of society and citizen's life, which we have to systematically examine, forecast and ensure.

The Slovak Republic is currently experiencing a new stage of defining security interests from its autonomy, which mirrors the newly formed Security Strategy of the Slovak Republic under the authority of the Ministry of Foreign Affairs and European Affairs of the Slovak Republic and their implementation in parallel strategic documents such as the Defense Strategy of the Slovak Republic and the Military Strategy of the Slovak Republic, in charge of the Ministry of Defense of the Slovak Republic. The paper presents an introductory part of the first stage of the scientific assessment of the problem - the identification of security interests in the newly proposed Security Strategy of the SR (2017) and relevant standards of criminal law.

5. Discussion to Protect the Security Interests of the State

5.1. The current, initial situation

We perceive the security strategy as the theory and practice of the functioning of the State - the Community of States, aimed at achieving general and long-term security objectives. The previous approaches and opinions as well as the basic postulates of security and defense are contained in the Security Policy Documents, discussed and approved by the National Council of the Slovak Republic in September 2005 - "The Security Strategy of the Slovak Republic" and the "Defense Strategy of the Slovak Republic"[6]. Country Strategy Documents were in the process of updating to respond to changes in the security environment by all available means of the Slovak Republic, based on the "Strategic Defense Assessment" in 2011 and a broad professional and layout debate. A key pillar of our direction was the "Strategic Concept of Security and Defense of North Atlantic Treaty Organization Members", adopted by the Heads of State and Government in Lisbon in 2010, to replace the 1999 Strategic Alliance concept. "The strategic concept must offer freedom with regard to the foreseeable development but with sufficient precision to be useful to Allied officials responsible for policy implementation."[7].

The security interests of the Slovak Republic are based on the principle of guaranteeing the security of the citizen in accordance with international legal standards and constitution and fundamental civil and democratic values. The Slovak Republic recognizes and protects the values of freedom, peace, democracy, the legal state, law, and justice, pluralism, prosperity, solidarity, respect for human rights and freedoms[8].

Slovakia's security interests are based on the following values:

- Guaranteeing the security and protection of the fundamental human rights and freedoms of citizens;
- The guarantee of territorial integrity, sovereignty, the integrity of borders, political independence, identity;
- Democratic state establishment, legality and market economy;
- Economic, social, environmental and cultural development of society;
- Transatlantic Strategic Partnership, allied security;
- The effectiveness of the international organizations to which Slovakia is a member, supporting the expansion of NATO and the EU;
- Developing good partnerships and forms of cooperation with countries with which we share common interests;
- Promoting the spread of freedom and democracy, respect for human rights, rule of law, international order, peace and stability in the world.

5.2. New Reality

The new Security Strategy defines the security interests of the Slovak Republic, the basic objectives of the SR's security policy and the ways of their implementation in the various areas of Slovak security. Strengthening the interconnection of security interests with the expression of objectives, procedures and tools of the Slovak Security Policy in key areas of security in their enforcement, in line with a comprehensive approach to security (integrated action of a wide range of instruments). It also takes into account the limits of international organizations to address current issues, giving greater importance to regional organizations based on a common value basis and capacity development of the SR[9].

The expert community notes that, in view of the continuation of the draft of the Security Strategy of the SR of 2017 on the Security Strategy of the Slovak Republic in 2005, there has been no significant shift in the determination of security interests. The preservation of state existence, sovereignty and integrity, the development of democratic foundations and the rule of law, sustainable development and security remained almost identical in terms of text and order. Compared with the 2005 Slovak Republic Security Strategy, a good environment, cultural development and safe cyber space have been added. The security, stability and capability of the EU and NATO as a security interest have remained (this has brought about the continuation of the integration core - the response to the changes in the EU). If the Transatlantic Partnership in the 2005 Slovak Republic's Security Strategy was the fifth, in the document of 2017 is the penultimate one and it is included in the area of security and stability in the European Neighbourhood. [10]. The debate on the new Security Strategy of the Slovak Republic is expected by the end of 2017.

5.3. Material and non-material components of the defense potential of the state

The scientific examination of the material and non-material components of the defense potential of the state constitutes the starting platform for the assessment of the current scientific problem of criminal law protection of state security[11]. The historical experience of many war conflicts and the defense of autonomy, civil liberty and ideals of democracy as well as national values have confirmed the synergistic effect of bringing together material means of defense and patriotic conduct and determination to bring sacrifices for their freedom, the nation and the state. Even military science (defense and military science) considers military force and military potential to be a sum of the real material and spiritual possibilities of society, military coalitions that it uses to lead a war or other external or internal activities, in accordance with their security interests using armed forces.

Among the forms of development of unity of material and spiritual components of defense we can include:

- Facts that develop parts of the social consciousness, activity and commitment of citizens to actively engage in defensive activities;
- Facts that directly or indirectly create optimal conditions for defense and defense activities.
- The core of the material components of the defense potential of the state and its regions consists mainly of economic potential, military-economic potential, scientific potential, and military-scientific potential. Material potential is the source and foundation of the spiritual forces of the citizens and the armed forces. Spiritual elements are not the passive reflection of the material elements, nor their mechanical consequences. They always play an active role in changing the military force, in the efficiency of its use, increasing or decreasing the size or effectiveness of the material elements. While the material elements of the military force act on the enemy immediately physically and morally psychologically, the spiritual elements act primarily morally and psychologically.

5.4. Identification of criminal law protection of state security in the legal order of the Slovak Republic

Key instruments of criminal law protection of legitimate interests in the subject matter of investigation are the criminal law standards set out in a specific part of the Criminal Code[12], such as:

- Criminal offenses against property (primary legal regulation the fourth chapter of a special section of the Criminal Code: in the area of cybernetic security § 247-247d; property rights and interests are also protected in some other sections of a special part of the Criminal Code
- Criminal offenses against the Republic (legal regulation the Chapter 7 of the Criminal Code: § 311-320).
- Criminal offenses against the defense capacity, against civilian service, against service in the armed forces and against the defense of their homeland (legal regulation of the tenth chapter of a special section of the Criminal Code: § 379-392).
- Crime offenses against peace, against humanity, terrorist offenses, extremism and war crimes (legal regulation of the twelfth chapter of a special section of the Criminal Code).

Further scientific work within analyzing and assessing the potential of tools of criminal law protection of selected, legitimate interests in the subject matter, including cybernetic security of the state, will be the second and third stage of assessment and legal argumentation [13], the investigation of security law, the use of relevant legal case- as well as the experience of building the National Competence Center for Cyber Security of the Slovak Republic with the professional support of the "consortium" of the national ecosystem of cyber security from the academic, research and IT environment of the Slovak Republic (the Knowledge Alliance of Cyber Security of the Slovak Republic).

Conclusions

The following results of our investigation were obtained:

The protection of state security by the criminal law standards is one of the key of the legally protected interests, and the cyber security is an important and indispensable part of it. Today's social empiricism confirms us that security is an important multidimensional factor of the quality of society and citizen's life, which we must systematically examine, forecast and ensure.

The importance of the topic and the use of the national defense potential is mirrored in the latest initiative under the ongoing structured EU security and defense cooperation - PESCO, with the emphasis on the cooperation and strengthening the cybersecurity capabilities. Due to the topicality and multidisciplinary, the solution of the problem will be supported also in the form of a national research project with partners. The priority is given to the security in the critical infrastructure sectors such as the transport (road, air, water, and rail transport), electronic communications, energy, information and communication technologies, post, industry, water and atmosphere, and health.

Acknowledgements

This work was conducted within the framework of the Establish a national risk assessment and management of the security risks strategy. The authors are thankful for the cooperation provided by the Ministry of Foreign Affairs of the Slovak Republic.

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Security Management in the Air Transport: Example of an Interdisciplinary Investigation of Special Security Questions

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Abstract

Security management in the air transport is understood as an integral part of the activity and the decision-making process of the managers of the air operator and the security service, assigned to manage the security risks in the following dominant areas. The scientific cognition, investigation and complex education in the field of the situational security management within the range of a multidimensional relation "Human – Technique – Environment" in the transport that is perceived as a complex adaptive ergatic system within the context of available resources, it represents a creative activity in the field of security, quality and effectiveness of processes of the personnel education, performance and flight operation provision.

KEY WORDS: *Security, air transport, investigation, security questions, airport security, flight safety*

1. Introduction

The scientific cognition, expert education, education to professionalism and a challenging practical training of the personnel of the transport and specialized services providing and supporting its activity is rightfully in the center of our attention. The ambition of the experts is therefore to contribute to the development of the scientific investigation and education in the field of the security management in the transport (flight safety, security of persons and property, logistics and in the protection of the environment) [1].

2. Method of Investigation

The essential philosophy of the security management in the field of the air traffic service is a systematic approach to security risks and threats of the air transport. The most important component in the whole system of the security of flights is the management of the security of flights of the participants of the air traffic service. *The security of flights* is perceived as an internally integrated system of components (sub-systems) that respects its own identity (specifics, risks) and the existence of mutual relations and their connections with other areas of human activity, in line with the aim to eliminate the influence of the risk factors of a flight as well as of the service and to provide the maximum level of security of flights as a whole.

This article uses the historical and content professional and legal analysis to explore the issue [2].

3. Investigation Results

The term *management of the security of flights* can be defined as an active, predictive and preventive means within the range of a system of crisis management of a user of the aeronautical techniques (air operator) to eliminate the risks and solve exceptional events (situations) or crisis situations and states in the field of the security of flights.

An exceptional event (EE) in the air traffic service is understood as *a dangerous flight or ground situation* being a state in which life or health of the squad (passengers, other persons and property on the ground and in the air) or environment is threatened or in which the aeroplane loses the capability to fly or the security of the air traffic service is threatened or there is a risk that it might be. It occurs in case of a technical fault of an aeroplane, failure activity of the squad, ground personnel or device or by means of the influence of external conditions during the air traffic service.

An exceptional situation is understood as a situation with a threatening or real exceptional event. The exceptional event might turn into a crisis or catastrophic situation.

Depending on:

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- the conditions of the occurrence, process and consequences of a dangerous flight or ground situation,
- capabilities of flight and ground personnel or
- organs responsible for the security of the air traffic service to control these processes and perform non-standard processes, the following can occur:

a) an unflavored situation – a state that requires or shall require an increased duty of the flight or ground personnel to perform the flight and provide the operation,

b) a boundary situation – a state accompanied with a high psychical endurance of the flight and ground personnel or with a damage to the aeroplane (property, environment) or with the limitation of the air traffic service,

c) an emergency (crisis) situation – a state with such a level of threat of health of the squad (passengers, personnel, ...) that the squad is not able to solve it in any other way than by an attempt to save their life by means of a crash-landing in a terrain or by means of an emergency abandonment of the aeroplane, whereby it is not possible to prevent the destruction or damage to the aeroplane (property, local damage to the environment) or in case the security of the air traffic service is threatened,

d) catastrophic situation – a state in which it is highly probable that the lifesaving of the squad (passengers, personnel, ...) is not possible and it is not possible to prevent the destruction of the aeroplane (property, regional damage to the environment) or in case the security of the flights within the range of the air traffic service is threatened.

A successful solution to a dangerous flight situation is dependent on an individual level of the flight preparedness of the aeroplane squad, on the amount of time available to solve the situation, on the perplexity of the situation but mainly on the right evaluation of the situation, on an early decision making and performing effective measures and processes. As a result of a dangerous flight situation, a flight incident or a plane crash may occur.

The solution to a dangerous ground situation is dependent on the state that occurred in the time except for the time defined as a flight of an aeroplane, in relation to the preparation of the aeroplane for a flight, its operation, attendance, maintenance, repairs or waiting, on the control of persons (cargo) before the flight/after the flight the result of which is damage to health, death of a person or damage or destruction of the aeroplane (property, environment) or a threat as well as a violation of the security of the air traffic service by means of an influence of the ground factors.

Security management in the air transport is understood as an integral part of the activity and the decision-making process of the managers of the air operator and the security service, assigned to manage the security risks in the following dominant areas:

- The security of the air traffic service and;
- The security of airports.

In line with the model of the situational management of selected processes (in the area of the security of flights), we accept the following types of *management* (risk management):

- *The management of tactical risks* resulting from the usage of flight technique or security and defence measures in concrete crisis situations (terrorist attacks etc.) and
- *The management of operational* (organizational, regime, technical ...) *risks* that can influence the level of preparedness and the effectiveness of the applicability of the personnel.

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This implies that it is desirable that the goals and tasks of the security management for the protection of persons and property in a specified environment of the air transport are realised within the range of the mentioned risk management although it is not the only frame way.

The main goal of the security management in the air transport is the operation of the flight activity, provision, protection and defence of the air traffic service with an acceptable flight security level based on an elimination, reduction or management of potential risks.

The main tasks of the security management in the air transport are determined by the general goal mentioned and characterised depending on the particular level of management within the range of a complex system of the flight security management in the following way:

- to provide an effective prevention, primarily focusing on the reduction of plane crashed and incidents or a security (protection and defence) threat of the air traffic service by the fault of the human factor;
- to execute a consistent investigation of plane crashes, incidents and crisis situations in order to provide an acceptable flight operation security as the most valuable resource of prevention and a successful fulfilment of the assigned tasks;
- to perform the education and training of personnel in the field of the flight security, the priority being to prepare top managers, medium level managers and first-level managers (focusing on the commanders of plane squads and instructors of the flight training in the field of the flight operation and shift supervisors – guard commanders in the field of protection and defence of airports, security employees, ...);
- to organise and fulfil the tasks of the common training of the assigned components of the armed forces and particular components of the integrated rescue system;
- to perform the selection and management of human resources, to create legislative and material conditions for the

fulfilment of tasks in the field of the flight security;

- to take measures and use appropriate tools to achieve the assigned partial goals in the field of the flight security;
- in case of crisis situations in the field of the flight security, to manage and coordinate the rescue or liquidation works within the range of the fulfilment of tasks of a crisis management system of a particular component;
- to fulfil the tasks of protection of persons and property in the air transport on the ground and aboard.

Within the range of *the process management of the security of flight operations and airports*, the organs of flight security management (security services) execute:

a) planned activities

- by means of a continuous identification and analysis of potential risks of the planned air traffic service (flight and ground), the importance being attached to the area of human resources, material-technical provision, security and operation conditions of the air traffic service;
- by means of making preventive decisions and by means of realisation of preventive measures in terms of planning, organisation, execution, provision and protection of the air traffic service in the days of the flight activity, in line with the approved planning documents (schedules of the air traffic service, flight plans);
- by means of making preventive decisions and realisation of flight security regulations in case of an individual fulfilment of flight tasks within the range of a selected effort of the aeronautics in behalf of other branches or in case of the air transport provision;
- by means of protection and ensuring the airport security based on a combination of three basic types of protection:
  - physical protection,
  - by means of using mechanical barrier means and technical guard means (the importance being attached to the radar and monitoring technique, the usage of pilotless means etc.)
  - by means of regime protection;
  - by means of a continuous control activity and by means of an evaluation of the whole operation process, by means of securing and protecting the air traffic service, in the field of the flight security;

b) operative activity

- by means of making decisions and realisation of regulations to provide the flight security, in case of the fulfilment of flight tasks;
- by means of making decisions and realisation of preventive measures based on performed security risk analyses, by means of control activities or violation of the assigned principles and regime in case of securing or protecting the air traffic service.

Within the range of *solving a crisis situation*, the flight security (security service) management organs usually execute:

a) planned activities

- within the range of management and control of an assigned group of persons to solve the crisis situations;
- within the range of coordination and collaboration with other crisis management system organs;
- within the range of a permanent physical and technical control of the inputs, outputs and the movement of persons (own and strange personnel, passengers, ...), mobile and static means in the area of the airport and near the airport, material control (cargo, post, ...);
- the importance being attached to a continuous identification and analysis of the security situation and risks of the air traffic service in the air and on the ground;
- the importance being attached to the evaluation of available radar information about the air situation (primarily from own review and landing radars of the airport);
- in line with the regulations for the air searching and ground searching rescue service;
- in line with the plan of the assigned forces and means of the air operator and the security service for crisis situations;

b) operative activity

- by means of making decisions regarding the supplementing of forces and means for the crisis situations according to the security situation state from the airport environment and a particular finishing controlled area of the air space (the airport space);
- the importance being attached to the analysis of the information from technical means of protection, from air guardians, strong points of the protection and defence of an airport, from available radar means of air units and pilotless devices to monitor the air and ground situation in the threatened interest areas;
- within the range of a co-operation with other parts of the crisis management system, mainly other parts of the integrated rescue system of the Slovak Republic.

The security management for the protection of persons and property in the air transport respects the specific environment and conditions of the air traffic service as well as of the airport security. In a significant way, it participates in the increase of the professional preparedness of the flight and ground personnel for the handling of difficult security and crisis situations during the flight, at the airport and outside the airport.

The task of the research in the field of the flight security is predominantly the scientific analysis of preventive-security information (from the field of the flight security, flight preparation, investigation, preventive activities, provision and protection of the air traffic service, aeronautic technique operation), investigation of the security risks and threats as well as searching for optimal solutions in order to prevent exceptional events and crisis situations, today, primarily within the range of the fight against terrorism.

We are convinced that the security management in transport is primarily a realisation knowledge and situational

realisation expressed by means of acquired and trained competences of employees (or, more precisely, of the operators, squad) of a means of transport, aeroplane, flight operation commander, maintenance worker, security manager etc., in a challenging process of their professional education and training for the performance of expert functions.

The management of the development of competences of transport experts is distinguished by the limitedness of their competences in the security problem solving process, by means of narrowing and modifying the known ideas considering situational gaps in which the mistakes may be generated predominantly by the operators of the means of transport during the transport, by the flight operation commander, boatman, engine-driver or maintenance technician.

The security management in the sectors of national critical infrastructure is the important part of the protection of state interests [3].

Conclusions

The security disciplines based on general bases of the scientific work methodology and the application of the methodology of practical disciplines in a specific environment of the protection and defence of lives and health of citizens, protection of their properties and protected interests of a society or a communion of countries can also contribute to the fight against antisocial phenomena by means of the application in the field of a complex security dimensions research. We see the position of the antisocial phenomena investigation within the range of the security disciplines primarily within the context of the investigation of the protection of human rights and minorities – the protection of persons and properties, or, more precisely, civil protection, fight against intolerance, discrimination and extremism and within the range of the investigation of criminality prevention and the work with the youth.

Acknowledgements

This work was conducted within the framework of the Establish a national risk assessment and management of the security risks strategy. The authors are thankful for the cooperation provided by the Ministry of Foreign Affairs of the Slovak Republic.

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ARDL models of Military Spending and its Security and Economic Determinants

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Abstract

This contribution deals with modelling of military expenditure and its potential security and economic determinants by an Autoregressive Distributed Lag (ARDL) model. This approach is applied to several NATO member countries over the period 2001–2016, namely to Visegrad group countries and Baltic states. Time series of military expenditure (database SIPRI), the risk of inflation, GDP growth, terrorism, foreign pressure, cross-border conflict and ethnic tension (database of Political Risk Service Group) are used in analysis.

KEY WORDS: *military expenditure, security determinants, economic determinants, ARDL model*

1. Introduction

The NATO countries represent political and military Alliance covers 29 members. From the long-term point of view, only a small group of the 29 countries fulfills the recommended values of allocating 2% of GDP at a minimum in favor of defense. The issue of military spending and its link to economic variables, political stability or other country characteristics is still intensively discussed in defense economic literature, see for example [1], [2], [3] or [4]. This paper has provided an empirical analysis of the determinants of military spending in the selected NATO countries for the period from 2001 to 2016. Empirical studies [5], [6] aimed at identifying military expenditure determinants classify those determinants into groups of economic factors, political factors and strategic factors. The first group of variables, marked as economic factors contains variables like the amount of GDP per inhabitant, GDP growth and fiscal variables. The political factors include variables like the quality of democracy, voting system, form of government, ideology and finally, strategic factors cover variables describing security environment by civilian war risks, terrorism risk and by previous participation of countries in armed conflicts and participation of the country in a certain type of Alliance. We focus on modeling military expenditure in following 7 countries: Visegrad group countries (Czech Republic, Slovak Republic, Hungary and Poland) and Baltic states (Estonia, Latvia and Lithuania). Data from database SIPRI (Stockholm International Peace Research Institute) and PRS (Political Risk Service Group) are used. The aim of the contribution is to describe the development of military expenditure (a percentage of GDP) by selected economic and security determinants, such as a risk for inflation, a risk for GDP per capita, a risk for foreign debt, a risk for terrorism and a risk for foreign pressures.

2. The Mathematical Background

We analyze data from 2001 to 2016. Time series under scope are too short for applying a vector autoregressive model, or a vector error correction model [7]. We employ autoregressive distributed lag model ARDL(p,q1,q2,…,qk), where p is the number of lags of the dependent variable Y_t, $q_1, q_2, \ldots, q_k$ are numbers of lags of explanatory variables X_{it}, $i = 1,2,\ldots,k$. The model can be written as

$$Y_t = \alpha + \sum_{i=1}^{p} \gamma_i Y_{t-i} + \sum_{j=1}^{k} \sum_{i=0}^{q_j} \beta_{j,i} X_{j,t-i} + \varepsilon_t, \qquad (1)$$

where ε_t is a one-dimensional zero mean error term. It is possible to transform the model into a long-run representation showing the long run response of the dependent variable to a change in the explanatory variables. The long run estimates are given by [7], [8].

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$$\hat{\theta}_j = \frac{\sum_{i=1}^{q_j} \hat{\beta}_{j,i}}{1 - \sum_{i=1}^{p} \hat{\gamma}_i}. \qquad (2)$$

The ARDL approach offers except for the dynamic description also testing of cointegration. The cointegrated system of time series can by estimated as ARDL model (Pesaran and Shin, 1999) with the advantage that variables in cointegrating relationship can be either $I(0)$ or $I(1)$ without needing to specify which are $I(0)$ or $I(1)$. For the purpose of cointegration analysis the form of (1) in differences is used

$$\Delta Y_t = \sum_{i=1}^{p-1} \gamma_i^* \Delta Y_{t-i} + \sum_{j=1}^{k} \sum_{i=0}^{q_j-1} \beta_{j,i}^* \Delta X_{j,t-i} - \hat{\phi} EC_{t-1} + \varepsilon_t, \qquad (3)$$

where $EC_t = Y_t - (\hat{\alpha} + \sum_{j=1}^{k} \hat{\theta}_j X_{j,t})$, and $\hat{\phi} = 1 - \sum_{i=1}^{p} \hat{\gamma}_i$. Pesaran, Shin and Smith [8] proposed a methodology for testing existence of long-run relationship between independent variable and regressors. For so called bounds testing they use the following representation of (3)

$$\Delta Y_t = \sum_{i=1}^{p-1} \gamma_i^* \Delta Y_{t-i} + \sum_{j=1}^{k} \sum_{i=0}^{q_j-1} \beta_{j,i}^* \Delta X_{j,t-i} - \rho Y_{t-1} - \alpha - \sum_{j=1}^{k} \delta_j X_{j,t-1} + \varepsilon_t. \qquad (4)$$

The test for existence of long-run relationship is a test of $\rho = 0$ and $\delta_1 = \delta_2 = \ldots = \delta_k = 0$. The distribution of the test statistic based on (4) depends on the fact whether the regressors are $I(0)$ or $I(1)$. Pesaran, Shin and Smith [8] provide critical values for the cases where all regressors are $I(0)$ and the cases where all regressors are $I(1)$. These critical values are used as bound for the more typical cases where the regressors are a mixture of $I(0)$ and $I(1)$.

3. Empirical Results

Military expenditure (as a percentage of GDP) of the Czech Republic, Slovakia, Poland, Hungary, Estonia, Latvia and Lithuania is shown in Fig. 1. One can see significant decrease of military expenditure in the Czech Republic, Slovakia and Hungary. In Poland and Estonia, a level of military spending is around the recommended level 2%. Military expenditure has been increasing in recent years in Baltic States.

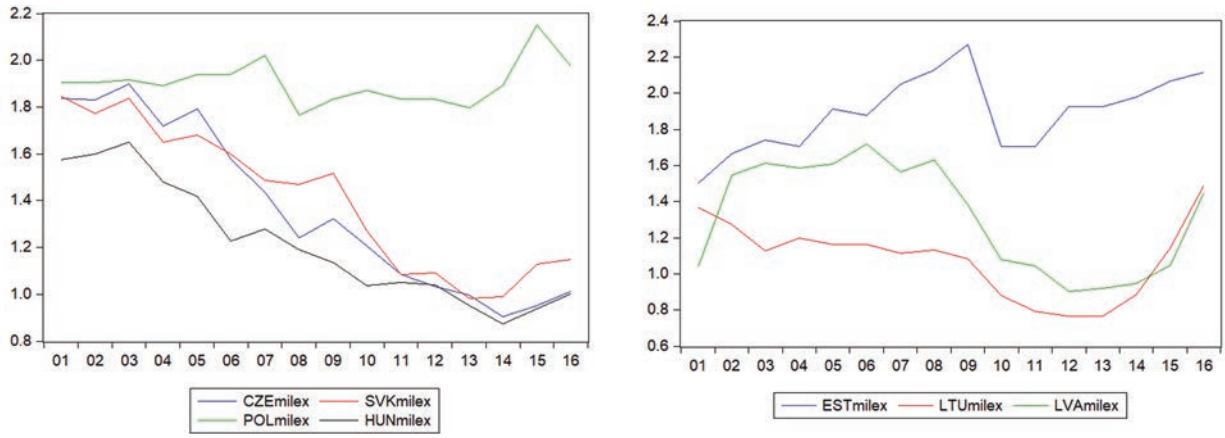

Fig. 1. Military expenditures (as a percentage of GDP) of V4 and Baltic states

In Figure 1 illustrating the development of military expenditure of analyzed V4 and Baltic states after 2001, a significant decrease in military expenditure caused especially by the effect of economic crisis can be observed (with exception of Poland). Poland is an example both as a country with a responsible policy of allocating 1.95 percent of last year's GDP to defense and compared to many other European countries not being hurt by the economic crisis. The result of government policy is an allocation of military expenditure between 1.7 and 2 percent of GDP in the analyzed period.

In spite of the reduction of Czech, Slovak and Hungarian military expenditure after 2002 we can observe increasing trend after 2014 as a result of NATO Summit in Wales. In the case of Latvia, we can observe decreasing of military expenditure in the period 2008 and 2012 as a result of economic policy aimed for having stable public finances as a part of the euro convergence criteria. Similar factor affecting military expenditure we can identify in Lithuania, where joining the Eurozone was a key priority of the government. Rapid increasing of Lithuanian and Latvian military expenditure we can see after 2014. Estonian military expenditure was reduced in 2010, it has increased since 2011 again and now Estonia met this 2 percent target. Generally, determinants of military expenditure of V4 and Baltic states as a new NATO member states were influenced both by a number of political and economic factors in the early nineties leading to transformation of society and national economies and by military factors (e.g. transfer to the professional army systems, modernization of armies, participation of V4 and Baltic states in foreign operations).

To quantify the determinants of military expenditure, the authors selected data from the database of Political Risk Service Group (PRS) defining economic, security and political risks of the respective countries. In order to analyze economic environment as a determinant of military expenditure, the following variables were monitored: foreign debt as a percentage of GDP, risk of inflation, economic condition measured by the GDP. For security risk analysis, the following variables were used: risk of terrorism, and risk of foreign pressures. Actual variables contained in the database are further observed for analytical purposes on the scale shown below in Table 1. Therefore, lower values of these variables are interpreted as higher economic, security or political risks.

Table 1

Description of variables

Variables	Description	Measurement
Foreign Debt as a Percentage of GDP	The estimated gross foreign debt in a given year, is expressed as a percentage of the GDP.	e.g. 0 to 4.9, 10 points, 5 to 9.9, 9.5 points and 200 plus, 0 points
GDP per Capita	The estimated GDP is expressed as a percentage of the average of the estimated total GDP of all the countries.	e. g. 250 plus (% of average), 5 points, 200 to 249.99, 4.5 points and e.g. up to 9.9, 0 points
Inflation	The estimated annual inflation rate (the unweighted average of the Consumer Price Index) is calculated as a percentage change.	e.g. 130 % change plus, 10 points, 2.0 below, 0 points
Foreign Pressures	A score of 4 points equates to Very Low Risk and a score of 0 points to Very High Risk.	Maximum score of four points and a minimum score of 0 points.
Terrorism	A score of 4 points equates to Very Low Risk and a score of 0 points to Very High Risk.	Maximum score of four points and a minimum score of 0 points.

Firstly, we estimate parameter of ARDL model (1) for all 7 countries. Considering the length of analyzed time series, we apply only lag 1 in the models. Table 2 contains statistically significant parameters of estimated models (at the significance level 0.05). For example, the model for the Czech Republic is of the form

$$\widehat{\text{Milex}}_t = 0.492\ \text{Milex}_{t-1} + 0.026\ \text{Inflation}_t - 0.158\ \text{Inflation}_{t-1} + 0.550\ \text{Foreign pressures}_t.$$

Table 2

ARDL model parameter estimates – V4 and Baltic states

Variable	CZE	SVK	POL	HUN	EST	LVA	LTU
Milext-1	0.492	2.871	–0.349	0.730	0.512	0.273	0.415
Inflationt	0.026	0.796	0.102	–0.054	–0.189	0.191	
Inflationt-1	–0.158	–0.244	0.175	0.077			
GDPt		–1.360					–0.248
GDPt-1		0.402					–0.326
Debtt		–1.155	0.066		0.207	0.169	0.183
Debtt-1		0.482				0.234	–0.341
Terrorismt		–0.685	0.404	–0.015		–1.796	–0.813
Terrorismt-1		1.676	–0.120	–0.349		1.041	0.090
Foreign pressurest	0.550	0.464			–2.416	–4.252	
Foreign pressurest-1		0.473			–0.699	0.690	
Const.	0.130	–8.501	–1.263	1.504	10.107	11.973	5.673
R^2	0.970	0.997	0.867	0.958	0.809	0.986	0.983

Estimated parameters of the error correction form (2) of ARDL model are summarizes in Table 3, the coefficients of long run relationship are in Table 4. For example, the long run relationship for the Czech Republic is estimated as

$$\hat{E}C_t = \text{Milex}_t - (-0.260\ \text{Inflation}_t + 1.081\ \text{Foreign pressures}_t + 0.257)$$

The existence of long-run level relationship can be verified by so calle F-bound test in the model (4). The results are shown in Table 5. At the significance level 0.05, we can reject the null hypothesis that there is no level relationship in all anlyzed countries except for Hungary. The test statistic value is close to the critical value for *I*(1) processes. The null hypothesis can be rejected at the significance level 0.10. In the Czech Republic, increase in variable Inflation (the increase means lower risk) is linked to the decrease of military expenditure. On the other hand, the increase in variable Foreign pressures is connected to the increase of military expenditure.

The outcome of the ARDL model (long run) described in Table 3 identifies 5 statistically significant variables (Inflation, GDP, Debt, Terrorism, and Foreign Pressures). In the case of the Inflation, it is possible to observe the negative link between the risk and the amount of military expenditure identifying the decline in military expenditure in the event of a decrease in Inflation in the case of the Czech Republic, Slovakia and Estonia. A positive link can be seen in the case of Poland, Hungary and Latvia. The result of the GDP per Capita Risk analysis is the positive link between GDP per Capita Risk and military spending in the case of Slovakia (indicates that military expenditure is increasing due to a favorable economic situation) and the negative link in the case of Lithuania. For most of the V4 and Baltic states (for the Czech Republic and Hungary the coefficients are not significant), there is a significant positive effect of Risk for Foreign debt on military expenditure suggesting that decreases in risk lead to increases in military expenditures. The only countries where foreign debt has a negative link to military expenditure is Lithuania. In the case of the Risk of terrorism, it is possible to observe the negative link between the risk and the amount of military expenditure identifying the decline in military expenditure in the event of a decrease in Risk of terrorism in the case of Slovakia, Hungary, Latvia, Lithuania and positive link in the case of Poland. Finally, the link between Risk of Foreign Pressures and military expenditure is really important in the case of Estonia and Latvia (–6,385 and –4.900) and indicates that increasing of value (lower risk) probably leading to lower military expenditure. The similar negative link we can observe in the case of Slovakia, the positive link in the case of the Czech Republic.

Table 3

ARDL model parameter estimates (short run) – V4 and Baltic states

Variable	CZE	SVK	POL	HUN	EST	LVA	LTU
Δ Inflationt	0.026	0.796	0.102	–0.054			
Δ GDPt		–1.360					–0.248
Δ Debtt		–1.155				0.169	0.183
Δ Terrorismt		–0.685	0.404	–0.015		–1.796	–0.812
Δ Foreign pressurest		0.464			–2.416	–4.252	
ECt-1	–0.508	1.871	–1.349	–0.270	0.488	–0.727	–0.585

Table 4

ARDL model parameter estimates (long run) – V4 and Baltic states

Variable	CZE	SVK	POL	HUN	EST	LVA	LTU
Inflationt	–0.260	–0.295	0.206	0.088	–0.387	0.262	
GDPt		0.512					–0.981
Debtt		0.360	0.049		0.425	0.555	–0.270
Terrorismt		–0.529	0.210	–1.346		–1.039	–1.235
Foreign pressurest	1.083	–0.501			–6.385	–4.900	
Const.	0.257	4.544	–0.936	5.567	20.717	16.470	9.695

Table 5

F-bound test – V4 and Baltic states (at significance level 0.05)

	CZE	SVK	POL	HUN	EST	LVA	LTU
Test statistic	5.63	15.24	13.74	3.81	7.72	24.46	20.56
Degrees of freedom	2	5	3	2	3	4	3
Critical value I(0)	3.10	2.39	2.79	3.1	2.79	2.56	2.79
Critical value I(1)	3.35	3.38	3.67	3.87	3.67	3.49	3.67

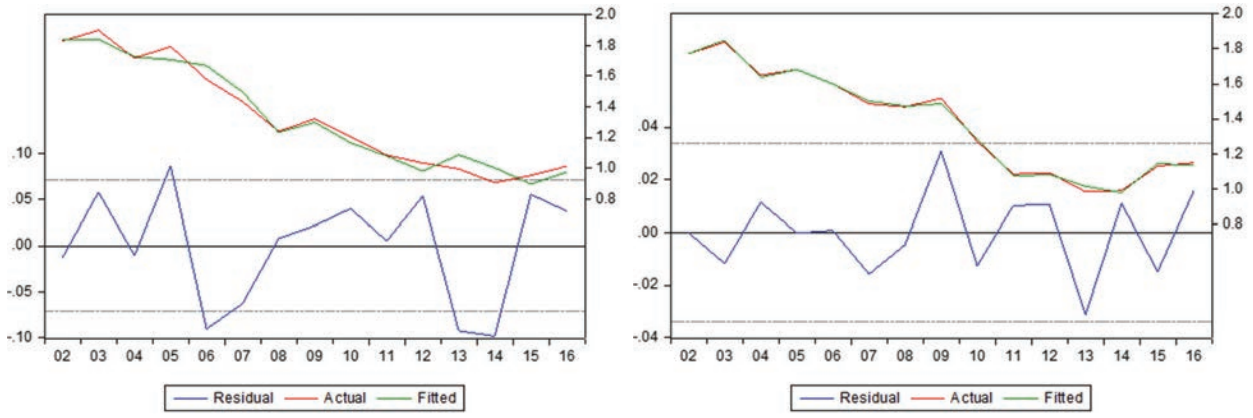

Fig. 2. ADRL models of military expenditure (as a percentage of GDP) – Czech Republic (left), Slovakia (right)

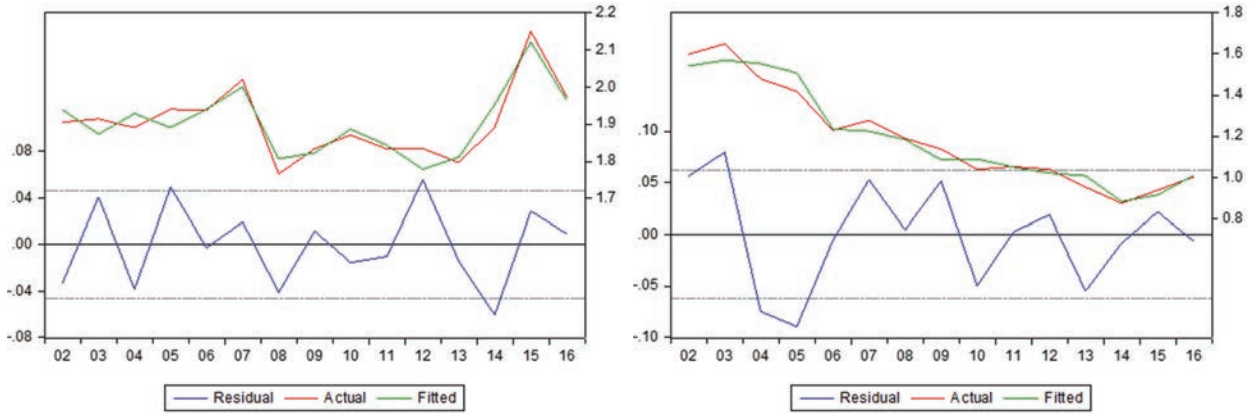

Fig. 3. ADRL models of military expenditure (as a percentage of GDP) – Poland (left), Hungary (right)

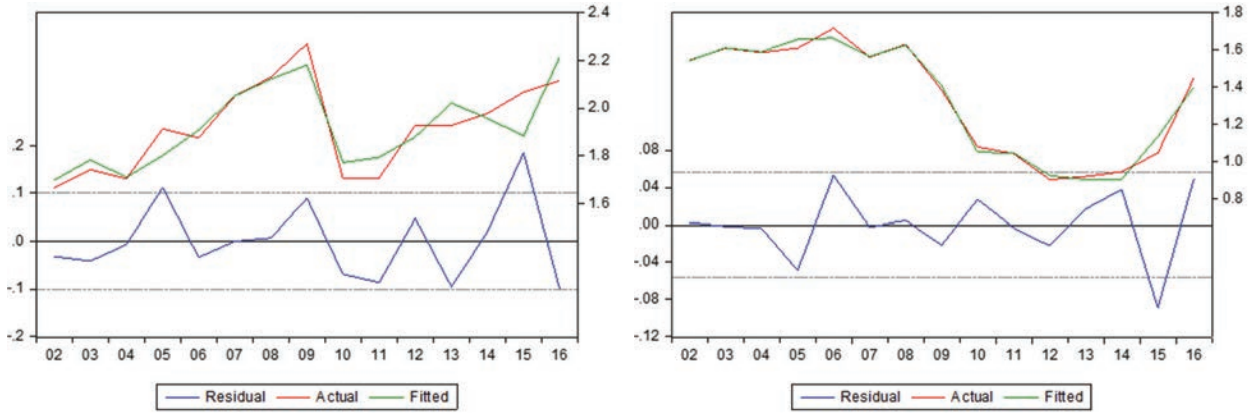

Fig. 4. ADRL models of military expenditure (as a percentage of GDP) – Estonia (left), Latvia (right)

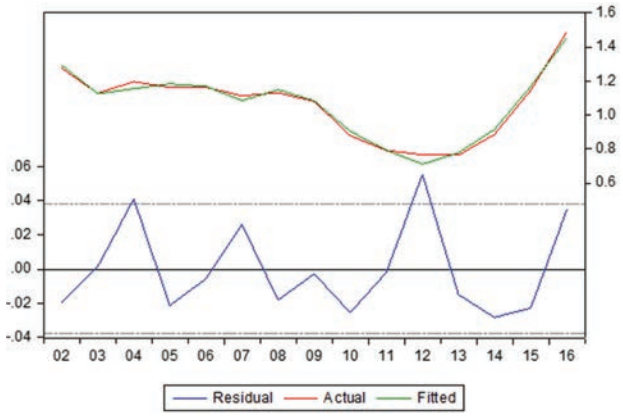

Fig. 5. ADRL models of military expenditure (as a percentage of GDP) – Lithuania

Conclusions

The contribution presents application of the autoregressive distributed lag model to identify possible determinant of military expenditure in the Visegrad group countries and the Baltic States. The aim of the autoregressive distributed lag model is to describe analyzed time series of military expenditures and describe the relationship with other regressors, such as a risk for inflation, a risk for GDP per capita, a risk for foreign debt, a risk for terrorism and a risk for foreign pressures. The outcomes of the analysis show that military expenditures are strongly correlated with their previous values and also indicate that there is very little uniformity in the factors that determine military expenditure in the Visegrad group countries and the Baltic States. Finally, the results revealed strong correlation between the risk for foreign pressures and military expenditures in the case of Estonia and Latvia as a result of current security situation and defense policy in the Baltic States.

Acknowledgements

This contribution was supported by FML Development Project AERO.

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Meteorological Application of UAV as a New Way of Vertical Profile of Lower Atmosphere Measurement

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Abstract

The knowledge of basic meteorological parameters is crucial in terms of understanding the atmospheric behavior for a given period and consequently also for creating the weather forecast. There are several ways of obtaining such data. A broadening of measurement techniques through the unmanned aerial vehicles (UAV) is one of the newest trends of today. Depending on the character of use of the unmanned platform, it could gather data from a significant part of low troposphere. Our experiences and problems with meteorological application of UAV is described in this paper.

KEY WORDS: *unmanned aerial vehicles (UAV), aerological sounding, troposphere, meteorological parameters, accuracy of measurement*

1. Introduction

The knowledge of basic meteorological parameters such as vertical profile of pressure, temperature, humidity and airflow speed and orientation, that describe the state of atmosphere in lower levels, is crucial in terms of understanding the atmospheric behavior for a given period and consequently also for creating the weather forecast [1]. There are several ways of obtaining such data. A majority of them, however, is in principle more complex and therefore more costly than measurements carried out on the ground within the terrestrial network of meteorological stations. In the past few years, the use of unmanned aerial vehicles (UAV) started to occur for other than camera related purposes such as identification of vegetation structure using LIDAR technology [2]. A broadening of measurement techniques through the aforementioned UAV is one of the newest trends of today [3]. This way of data acquisition could be classified as a local measuring technique and direct method. Depending on the character of use of the unmanned platform, it could gather data from a significant part of low troposphere [4], [5]. Our unmanned vehicle falls into category of controllable vehicles heavier than air with rotary wings with electrical engine weighting less than 7 kg.

To be able to collect the meteorological information, the UAV should possess adequate integrable sensors. Those must be sufficiently sensitive and precise, but due to a limited loading capacity not too heavy. Despite having already given space to the comparison of different measurements [6],[7], the evaluation of drone measurement precision is much more complex, as the drone itself influences its environment, meteorological elements included (mixing of air, heat production). The sensors could be calibrated or tested [8], but making tests in the course of UAV´s flight is quite difficult. Our evaluation of measurement usability focused on the comparison with other available data, whose quality however is not 100% known and thus may vary from the declared precision.

2. Method of Investigation

Drone measurements done at standstill were compared with data from meteorological station while measurements at flight faced comparison to baloon sounding and measuring using sensors attached to 250 meters high mast. Due to its structure, the UAV Robodrone SuperHornet (in Fig. 1) pertains to multi-engine vehicles (quadcopters) [9]. Besides the usual components, it also incorporates a telemetric module, suspension camera and meteorological data acquisition unit. Thanks to used engines and accumulators, the stamina of our vehicle amounts to 20-25 minutes, 10 minutes of which would be a safety reserve. For practical application, it is therefore counted with a flight of around 15 minutes. The concept of the vehicle allows flying under conditions such as high air humidity (rain) or a wind no greater than 20 m/s. Its vertical speed had been limited to 5 m/s, taking into account the capacity and discharge rates of accumulator. Bearing that capacity in mind, the flights could be, theoretically, conducted up until around 8200 ft (2500 m) above ground level (AGL). In respect of legislative limitations we can fly the vehicle in experimental mode in several designated areas up to 5000 ft (1500 m) above mean sea level (AMSL) provided a reserved air space of 3 km radius.

The aim of the experiments is to approximate to the measuring conditions of meteorological balloon probe. The flights consist of a simple constant-speed ascent to the maximum height and back, while holding the same geographical coordinates. Even at the designing phase, it was clear, that the air turbulence around propellers would cause diversions in

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measured values, especially in the case of temperature. In order to stave off this negative effect a cheap meteorological data acquisition unit had to be installed. It serves to determine the impact on each given sensor and to find an appropriate location so that the impact in the course of flight is minimal. The key point in the development stage turned to be the choice of sensors with a very small time constant, as only the proximity of ground before the take-off can heat up or cool down the sensors by several degrees.

Fig. 1. UAV Robodrone SuperHornet

At present, the drone is fitted with pressure and humidity sensor BME280 by Bosch, which communicates via I2C interface. It measures humidity from 0 % to 100 % and pressure from 300 hPa to 1100 hPa with definition 0,008 % for humidity and 0,18Pa for pressure. The precision in the case of humidity is ± 3% and ± 1Pa for the pressure. Additionally, it comprises a platinum temperature sensor 701-101BAA-B00 by Honeywell with measuring range of -70 °C to 500 °C and definition that thanks to the used processing chain amounts to 0,001 °C. At this point, the air direction and airspeed data are not usually available, but we try to obtain those experimentally through calculation from measured position angles. The preliminary results are quite promising.

3. Results

The initial verification of drone abilities took place in military barracks Černá Pole in Brno, when the UAV was at standstill. It was put inside a Stevenson screen and the values obtained were compared to those from automatic sensors of the meteorological station METEOS6. The first measurement showed that the operating drone battery (power for measuring as well as flying) even in a still position produces heat that overvalues the temperature. Better results came out when the battery was removed from the Stevenson screen and replaced only by cables. Nevertheless the data sometimes varied substantially (by several degrees). The main reason was probably radiation. The Stevenson screen was situated about 5m from automatic sensors and in its proximity were objects (buildings, tress…) that casted odd shadows whether on sensors or box. The radiation had moreover better access to drone sensor that is not covered, where the bottom part of the Stevenson screen is constituted by a thick foundation that practically does not impede the penetration of reflected sun radiation. The sensors in automatic station are much better protected. Another possible cause for difference is different ventilation of both places. In order to eliminate those factors we aimed to execute the measurements at cloudy and windy weather conditions. The drone was in the end placed on a stand close to automatic sensors. Next we tested how the situation would change with the drone left at the same place, but this time hanging. The evaluation proved some variation, but that could be explained by spatial and time variability, that is predictable in an urban environment with building structures and inhomogeneous surface. Consequently we started parallel testing in flight and gradually terminated testing in stillness.

The comparison of temperature and relative humidity during flight was performed on three locations - airport Brno Medlánky, military training area Libavá and sounding station Prostějov. The testing focused on the different placement of sensors. When the measured data could not be compared to the real data and the tests were only limited to repetitiveness of value retrieval during different flight conditions, the tests pursued the accord between measurements taken during vertical ascent and descent with varying vertical speeds. Since there is usually no significant change of meteorological conditions in the course of minutes, the values obtained at the same position should correspond.

The first measurement was realized in training military area Libavá in April 2017. Different courses of flight were tested (see Fig. 2) and a height of approximately 850 m AGL was reached. The results could be summarized as follows:

1. The UAV Robodrone SuperHorned operated without problem and reached desired levels.
2. A great inertia of temperature sensor which caused difference between up and down measurement about 5 K (in low levels).
3. Big errors in relative humidity occurred, mainly caused by bad calibration constants.
4. Software and communication problems (in data downloading) resulted in a significant waste of time.
5. Outliers in pressure were detected.

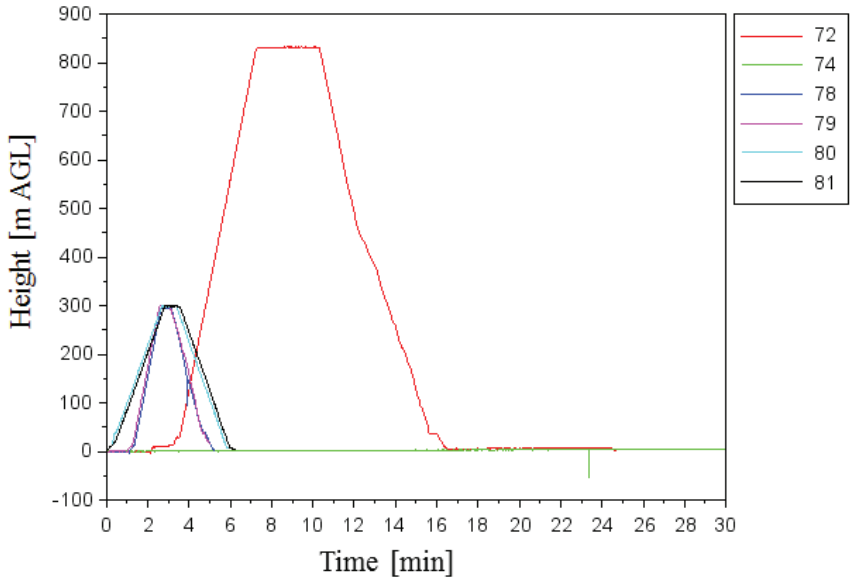

Fig. 2. Different course of flight tested in military training area Libavá

The above mentioned problems was figured out in cooperation with Robodrone Company (exchange and calibration of sensors, software improvement). For a more precise comparison, however, it is necessary to perform the comparison with real data. This took place in Prostějov, where the drone and meteorological probe with sensors by company Vaisala placed on a balloon were made to take off simultaneously (see Fig. 3). Another advantage of this measurement was the fact, that an identical probe to the one placed on the balloon could have been placed on the drone too. A complication to such comparison though is constituted in the raw-data processing from Vaisala in software on a processing device. A limitation of the comparison with upper-air sounding is the interval: only twice a day (every 12 hours), while utilization of supplementary probes is financially very demanding.

The described comparison method was applied in two days. The radio probe was placed on different parts of the drone (upper part, bottom part, bottom hanging part), so that the influence of drone itself on the temperature and humidity could be tested. The aforementioned fact, that raw data from probe are further computed and we do not know the computing algorithm, presented a limitation. It is questionable which characteristics apply to it and which conditions must be fulfilled in order to be able to use it and whether we actually even comply with them. Moreover, when pressure elevated, the software interprets it as probe falling and no calculation is done. The comparison of raw data and outgoing computed data usually returned temperature differences of less than 0.3K.

In the course of tests several modifications were made: adjustment of software for drone data processing (e.g. filter setup), clearing of discrepancies between pressure and temperature. For second round of testing another temperature sensor was added, so that there are two sensors available now – one up, second down. Another problem occurred with time synchronization that is necessary to carry out ahead of every start.

An illustration of temperature measurement comparison is on Fig. 4. V and Vsond present the same type of data from same equipment, yet several hundreds of meters above ground the difference amounts to 0,5K. Data from ascending part of flight of Vdron approximate the values of V and Vsond. Surprising is also the relatively notable difference in raw data from hanging probe at ascent and descent in upper part of ascent and a rather good concord in bottom part (computed data from descent are not available).

The testing of temperature measurement returned altogether good and optimistic results. One of the things the testing showed is variable offset, which would require calibration before every flight. Sensor inertia might still cause some problems and it is necessary to make more tests bearing this in mind. The thermal stratification on testing days was almost indifferent and it would be good to make similar tests also under more complex thermal stratification.

The issue of relative humidity measurement is more complicated. Values between ascent and descent differ significantly and even after a relatively long (several minutes) rest at standstill after flight the values do not get back to those before flight. On the other hand the humidity during flight does not vary much and the difference is usually less than 5%. The comparison indicates that it is not realistic to expect determination of humidity with precision of less than 2%. It is also opportune to test which values would be collected at flight through clouds and how would the humidifying manifest.

Fig. 3. Comparison of measurement with meteorological probe in Prostejov

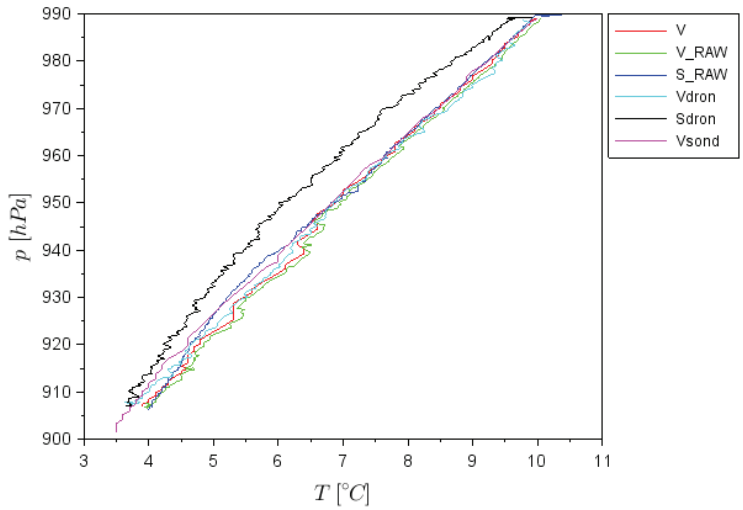

Fig. 4. Comparison of temperature measurement in Prostejov (27 October 2017 11:32 UTC). V – meteorological probe on 3 m the rope, V_RAW – raw data from this probe in ascending part, S_RAW – raw data from this probe in descending part, Vdron – dron (ascent), Sdron – dron (descent), Vsond – reguar meteorological probe (ballon)

Another possibility for comparison would be to use a 250 m high meteorological pole in Křešín (Pacov area), on which the sensors are positioned by every circa 50 meters. This distance is very rough, but the pole gives an advantage, that during one day several comparison measurements may be carried out. This possibility is though still in negotiation.

Unlike the meteorological measurement, obtaining the speed and direction of the wind is much more complicated. It is a process that requires to not only measure necessary input values but also quite a significant amount of aero-dynamical and mathematical apparatus. There are several possibilities to measure the parameters of the wind but all of them except one require to add more equipment which means that the drone must carry more weight and the precious flight time decreases. To fly to the 1500m AGL that we decided to be our goal, and back already takes approximately 10 minutes assuming that the vertical speed is kept at 5 m/s. We therefore opted for a method that uses instrument that are already present on board of the drone.

Let assume that the drone is stationary in flight and wind is pushing the drone from this position. On board GPS system tries to correct this drift by tilting the drone slightly against the wind. The tilt is proportional to the wind speed and has an opposite orientation. The direction of the tilt can be calculated using the trigonometry and the wind direction can be determined. Adding the actual angle of the yaw and subtracting 180° for the opposite orientation gives us the wind direction, see Fig. 5.Similarly, the speed of wind can be calculated but the mathematical decomposition is completely different. The speed can be derived from the forces acting on the drone while flying. In case the drone is stationary, the gravitational force is compensated by the thrust created by the four motors. Since we already calculated the tilt caused by the wind it is easy to determine the horizontal component of the thrust, which is closely connected with the wind speed, assuming the thrust and aerodynamic coefficients (drag) are known.

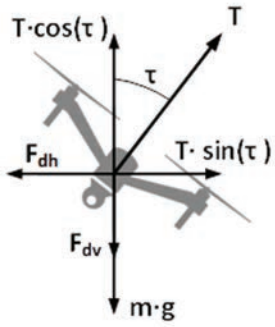

Fig. 5. Forces acting on the drone

Unfortunately, it is impossible for us at this moment to design an experiment in the aerodynamic tunnel to quantify the reference area and the drag coefficient. We therefore designed an experiment consisting of comparing known speed obtained from meteorological wind speed measurement device while hovering in close proximity. This experiment gave us a close approximation of the product of reference area and the drag coefficient. With this approximation second experiment has been done.

This time the experiment consisted of parallel flight of the drone and the meteorological balloon. This way we can compare data from both systems, see Fig. 6.

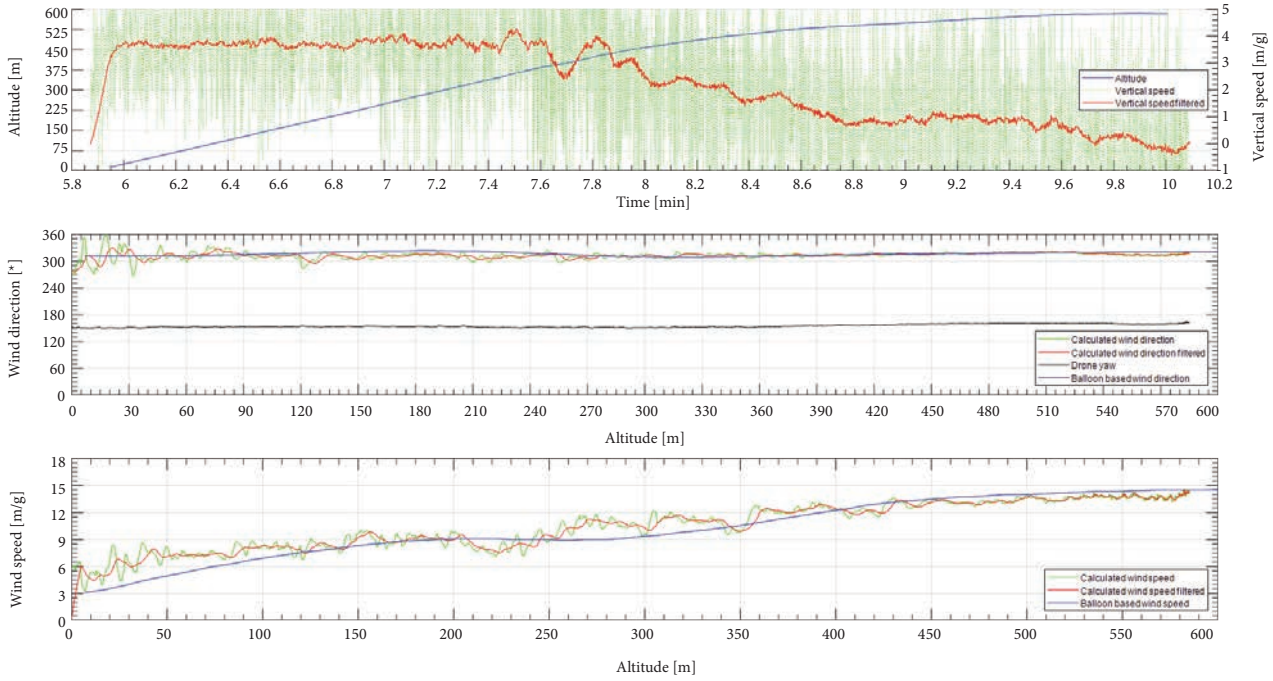

Fig. 6. Comparison between wind speed obtained from the balloon and estimated on drone

Those results show that there is a correlation between the wind speed measured by the balloon and estimated on the drone. They also show that the dynamic behavior of the drone influences the estimated speed and direction quite significantly. Balloon gives the measurements with a frequency of 0.5 Hz whilst the drone with a frequency of 10 Hz. Another thing that must be mentioned is the fact that the balloon climbs at a rate of approximately 7-8 m/s and the drone with only 4-5 m depending on the wind strength and stability and that the balloon drifts away from the place where drone climbs. It means that the wind situation may be different. Finally, without the proper measurement from the wind tunnel, it is almost impossible to calculate the vertical component of force caused by the climbing movement and it was for this experiment consciously ignored.

Conclusions

The development and comparison brought about the following results. The selected temperature sensors have a considerably lower inertia than the ones originally tested. Instead of one, there are two sensors installed on the drone (one up, the other down), so that the varying influence of the drone on the temperature measurement during ascent and descent is eliminated. The development phase also exposed some software problems, which contributed to an incorrect

determination of flight height. It appears (not only in comparison with Vaisala probe), that in order to get the real data with requested precision the collected data will have to undergo a post-processing. Another problem encountered during temperature measurement is a variable offset. Similarly, to the case of Vaisala probes, a calibration / temperature levelling will be necessary to do before the flight so that the corresponding values may be collected.

The testing to fix the most crucial problems. In order to verify and potentially correct the measured data it is necessary to carry out further comparative measurements at different meteorological conditions.

The direction and speed of wind can be calculated from UAV tilt because wind is pushing the hovering UAV from its position and GPS onboard system corrects this drift by tilting the UAV to redirect its thrust horizontal (lateral) component against the wind. Experimental results of the drone hovering and climbing in moderate and fresh breeze are presented including issues of determining the multicopter reference area and the drag coefficient as well as a difficulty to execute a valuable comparative measurement using a meteorological balloon.

Acknowledgements

The work presented in this paper was supported within the institutional support for "Development of the methods of evaluation of environment in relation to defense and protection of the Czech Republic territory" (NATURENVIR) by the Ministry of Defense of the Czech Republic.

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National Security, Values and Postmodern Society

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Abstract

Postmodernity as a concept of contemporary society together with technological progress and globalization caused changes in orientation of values as well as the transformation of individual and collective identity. Thus, increased vulnerability, both of individuals and society, caused the character of threats to national security. The aim of the article is to analyze the contemporary threats to national security as a phenomenon of a postmodern society, emphasizing the crisis of values as well as of the identity. Postmodern threats forced to revise traditional point of view on the concept of national security and demands to be based on comprehensive approach on the issues of security and defense. This article is an attempt to make an analysis on the topic of national security in an interdisciplinary context. After analyzing the actual threats to the security of the Republic of Lithuania, it was determined that the interaction of many of these threats with the crisis of values is evident. This allows to confirm the importance of further discussions and scientific research on the issues of values and identity in context of national security in postmodern society.

KEY WORDS: *postmodernism, utilitarianism, consumerism, national security, threats to national security, orientation of values, postmodern identity*

1. Introduction

Postmodernity as the phenomenon usually explores economical or cultural condition of contemporary society. Postmodernity is a typical term of art, music and literature rather than national security as well as national security is a topic of political, defense or security sciences rather than humanities. The end of 20th and the beginning of 21st century drastically changed traditional understanding of national security, which was oriented toward foreign affairs of the country. The political changes after the Cold War and global transformation in social, economic and political life under rapid development of information technologies brought a great challenge to the governments of countries. Usually enemy is using weakness point of the state for the attack - its defense system, political disagreements, social instability, the lack of energy recourses, etc. According to contemporary security situation every state faces a lot of diverse threats which are fast changing, unpredictable and uncountable. But the last decades has already shown that hybrid character of contemporary threats to national security and unconventional methods of warfare, such as terrorism and information attacks, are targeting the societies and individuals, in particular using their weaknesses in mind, emotions and morality. It became evident that the matters of security and defense, as primary interest of the country, made the shift from international affairs into the sphere of human affairs. This shift is caused on the specific features of postmodernity as cultural characteristic of the society in the 21st century.

The process of globalization and rapid development of technologies raised a lot of transformations of the society. Some of them, maybe the most important and the most controversial are these: the process of society fragmentation based on the idea of individualization and localization, changes of collective and individual identity, replacement of the priorities in the system of values, etc. All these brought about many problems and difficulties for all governmental institutions and for the state security and defense system included because it is allowed to use the societies and individuals against the state. All efforts to solve these problems of the state without understanding the nature of postmodernity as the essence of postmodern society and postmodern individual are hopeless. Contemporary threats to national security demands comprehensive approach and complex analysis of various sciences - political, social and humanities - looking for mutually agreed solutions to the security and defense issues of the state.

The aim of the article is to analyze the contemporary threats to national security as a phenomenon of a postmodern society, emphasizing the crisis of collective and individual identity, the decline of values as manifestation of society and individual.

This research was made by interdisciplinary approach - i.e. on the basis of philosophical, political and sociological theories of postmodernity, concept of national security, identity and values. Methodology of this scientific research is based on the concept of postmodernism, utilitarianism as ethical theory and consumerism as a main idea of postmodern society.

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2. Postmodernity and National Security: the Issues of Values and Identity

Postmodernism can be explained by the viewpoint of various sciences, emphasizing different aspects of its wisdom. The main problem of Postmodernism is its conception in the context of the development of society: whether this is a new phase in the development of society or it is just a new stage in the era of Modernism. Many authors have stated that the intellectual, technological, societal, political, economic and cultural developments that have occurred at the end of 20th century reflect new way of thinking and justify new era of the development of the society - Postmodernism [1]. Some of scholars suggest that Postmodernism is not so differentiated in the concept of Modernism (its ideas, values' orientation) so it is only a continuation of modern society [2]. By this point of view, postmodernism can be characterized as the reaction of society to Modernism with some disillusion of it, some discontent and debate with it and with the attempt to modify it [3]. According Fredric Jameson, Postmodernism is a culturally dominant concept of late capitalism. It means that "postmodernism is what you have when the modernization process is complete and nature is gone for good" and "it is a more fully human world than the older one, but one in which "culture" has become a veritable "second nature"[4].

Despite diversities and differences in explanation and understanding, the impact of Postmodernism on the development of the society should be undeniable. It has permeated ideas, discourses, displays which are reflected in music, architecture, literature as well as in economics and management, in politics and social life. Postmodernism could be described as the society's disappointment with Modernism, its reaction to the ideals, which were blown up. Postmodernism identifies the existence of many realities and refuses to recognize the existence of universal laws and grand theories [5]. Postmodernism denies consistency of any ideas and life events caused a certain chaos in the mind of the individual.

The influence of Postmodernism on the system on values is evident as well. Principles of Postmodernism have brought a diversity of values into the minds of individuals. The disappointment in the optimism of Modernity raised the unbelief in universal morality. Postmodern understanding of ethics denies objectivity of morality laying on personal morality and private codes of ethics: person is free to create moral principles according his subjective opinion and without the need to follow traditional values and rules. This conceptual statement left individuals free to choose value orientation. Postmodern principle about validation of all religions increased number of personal choices in beliefs as well as transnational communication opened the doors for various and alternative systems of values. Under the impact of globalization and enhanced process of internationalization the diversity of choices in value orientations has increased what was reflected in the society's way of thinking, way of behavior and style of life.

Postmodernity doesn't change the system of values: without any doubt traditional, universal values, reflected in traditional religions, traditional ethical concepts, still exist and became maybe actual and more universal. Postmodernism changed the way of formation personal system of values facing individuals alone in difficult choice of priorities.

The values are being formed by individuals basically on the system of values of a society (based on traditions, religion, education system, governmental institutions, public organizations, mass-media, etc.). Postmodernism has brought about big changes in the tendencies of social and cultural development of the societies together with technological progress and economic growth. These changes were reflected in value orientation of society and allowed the scientists (economists and sociologists) to assert that new generations have different value priorities from older generations, because they have been brought up under much more secure living conditions. "While the generations that had experienced World War II, the Great Depression, and World War I would give top priority to economic and physical security, a growing share of the younger generation would give top priority to self-expression and the quality of life" [6]. The philosophers are not so optimistic about the changes in value orientation of the society.

Postmodernity is rooted on Modernism as a concept of contemporary society. Modern idea of individualization has arisen ideas of freedom, possibility of free choice and self-expression what have become main social and cultural factors of postmodern society development. Modern idea of technical progress and industrialization caused ideas of production and consumption as main economic and cultural factor of postmodernity. The concept of neoliberal society as postmodern form of democracy is grounded on philosophical ideas of Modernity. So, utilitarianism, as the main ethical theory of Modern society and liberal democracy has been reflected on postmodernity as well.

Utilitarianism, as ethical concept, possesses to evaluate any human act by its final result: whether it is good or evil for other people and states that the essential indicator of human performance and indicator as well is the principle of utility. Utility means the happiness as the sum of pleasure for human beings. Postmodernity transferred the meaning of happiness because it came together with consumerism as the main economic idea and consumer culture of postmodern society. Consumer culture began with a wide penetration of consumer goods into the everyday lives of people across social strata, that consumption was ignited through a new sense of fashion and taste, and finally that the culture was cemented through the development of infrastructures, organizations, and practices that took advantage of the new markets, namely, the rise of shopping, advertising, and marketing [7]. Consumer culture is trying to unify individuals and societies, and it is destroying personal uniqueness and national specific features at the same.

On the other hand, the concept of consumerism encourages the acquisition of goods and services in ever-increasing amounts, treats the utility as economic benefit / profit which is expressed in cash equivalents (dollars, euros, yuan, etc.) and possessed to count the profit. Simplified principle of utility became the basic index of any human action and a standard of economic, political, social and cultural activities of state institutions, private enterprises, education institutions and other organizations. This approach denies the essential idea of utilitarianism as well as it transforms the basic ethical category - the concept of goodness. The money becomes goodness and a fundamental value that measures the entire human activity. When the money became the core value and the same main goodness, other values such as morality, humanity, state, family and other universal or civic values have started to take less and less important part in human's life.

Then it is easy to approve any amoral decisions or disgrace actions by the needs to get more profit/money.

So, individuals are free for a lot of choices in their value orientations but in reality of consumer society they faced to only value counting in cash equivalent. This choice is reasoned by conceptual idea of postmodern society and in many cases individual has no other choices at all. Postmodern situation in value orientations of individuals and society is dangerous for both individuals and society as well as it threats for the state interests and national security.

The decline of values is means a collapse of the personality: the individuals become without morality and without identity as the consequence of it. When the individuals are loyal only for money and to money they can easy change the place of living, the job, the country, etc. The flexibility of contemporary human beings is explained by the process of globalization or technological progress. In other way, it can be also the consequence of a consumerism as the worldview of Postmodernity. Anyway, at the beginning of 21st century some destructive factors to the consciousness and the identity of the society became evident.

The issues of collective and individual identity became more discussible in Postmodernity than in Modern period of Western civilization. The process of fragmentation and decentralization of the society, its transformation based on constantly changing ideas and fast going reforms in all spheres of life left individuals alone in this very complex situation. On the other hand, information technologies modified the ways of information transfer as well as the way of communication and the style of life as the consequence. It caused new forms of communities in social networks and new forms of collective identity.

The end of 20th century and the beginning of 21st century is abundance of the identities which gave birth to the ambiguous interaction of state institutions, social movements and different identity forms [8]. The phenomenon of identity cannot be perceived as something uniform, stable and constant because personalities construct their individual identities throughout their lives, and this process is affected by different factors - national, social, religious, cultural, regional, professional, etc. [9]. But individual identity and its features undergo a major change because both the person and things lose their definiteness and continuity in Postmodern world [10].

The governmental institutions, as most powerful force in shaping collective identity of Modern society, are losing their dominant position in Postmodernity. It is caused by many reasons. One of the most important reasons is the conceptual nature of postmodernity denying any stability and domination of any institution. The diversity of social actors, involved and making influence on the creation of different forms of the identity, decreased the role of national governments as well. And the third, maybe, most important reason of the weakness of state actors in the process of formation of collective identity of the society is the decline of values. It is evident that orientation of values is playing the most important role in collective and individual identity. Neoliberalism, as the concept of postmodern democracy, faced Western governments to the crisis of values: the consumers' society is oriented toward money as core value. The authorities are forced to abide by the rules of the game, which are dictated by the consumerism and, in the same way, they follow the same principles and values which are a key element in the development of the society as well as it becomes the biggest risk for its security. Consumerism as a basis of value orientation cannot be the factor consolidating postmodern society.

Postmodernity has changed the character of the threats for national security: they are becoming more complex, faster changing and have more hybrid character. As a rule, they are targeting the consciousness of individuals and of the societies because of their moral weakness and value emptiness. The human factor is the main risk and main threat for the national security rezoned by moral decline of consumer society as well as it is the biggest challenge for national states and their governments because of complexity and diversity of postmodern world.

3. National Security and the Threats to National Security in Postmodernity

Most of famous scientific researchers (Walter Lippmann, Arnold Wolfers, David A. Baldwin, Barry Buzan, etc.) stressed the role play of values in the concept of national security. Anyway, the discussions on this topic are still continued because there is no unanimous opinion about the relation between national security as a value and other values of society. According to A. Wolfers, national security is at "the apex of the value pyramid and assumes it to constitute an absolute good to which all other values are subordinated" [11]. After 40 years, this statement was expanded by David A. Baldwin's idea that "security is valued by individuals, families, states, and other actors" so "security, however, is not the only thing they value; and the pursuit of security necessitates the sacrifice of other values" [12]. These opinions are laying on the Tom Hobbes' concept about security as the common interest of the citizens to protect their most important values - life, property, freedom and peace [13]. After the Cold War much of public policy debate was focused on whether and how to reallocate resources from security to other policy objectives and it was more important to have a concept of security that facilitates comparisons of the value of security with that of other goals [14]. Then it became very important to identify what kind of value is national security - prime, core or martial, what is the value of national security and can national security threaten to other values of the society? [15].

The discussions about the concept of national security are still continuing as well as a dispute about national security as the value of the society. However, according to the scientific point of view, the priorities of national security are determined by people or their groups according to the system of their values or taking into consideration the nature of threats to certain values. The beginning of 21st century has brought about more questions and one of them, maybe the most important is whether the values of the society pose a threat to national security.

In 2014, the researchers of the department of Humanities (General Jonas Žemaitis Military Academy of Lithuania) made the test aiming to set up the militaries' opinions about the issues of Lithuanian national security. The questionnaire

survey was conducted between officers, professional soldiers and cadets. The questions about external and internal threats to national security were included. While at that moment the public discussions in Lithuania were oriented toward the issues of national budgeting for security and defense, the results of the testing have shown that professional militaries assessed the decline in values as more danger threat to the security of the country than insufficient financing of its defense system (Fig. 1). The difference between the opinion of professional militaries (36%) and the cadets (18%), which have distinguished the crisis of values as the threat, could be explained by their life experience and professional knowledge. On the other hand, the both groups (47% and 48% of the respondents) mentioned the passivity of citizens as the threat to the state's security and defense system. According to the test results, the human factor is a very important factor in the system of national security as well as orientation of values of the society and individuals as essential guides for all human activities.

Thus, values can be important element of consolidation and mobilization of the society against threats as well as deconstructive factor for security and defense system of the country. The authorities in their strategic documents highlight the importance of values in ensuring national security. The National security strategy of the USA (2017) emphasizes the importance of such values (democracy, freedom as free press, free speech, and free thought) in consolidating society and increasing its resilience to contemporary threats [16]. The National security strategy of the Republic of Lithuania (2017) identifies 15 dangers, threats and risks and the last one of these was mentioned as a "crisis of values". This threat is explained as "disrespect for inherent human rights, downgrading of Christian values, family institution, liberal democracy and pluralistic society, spreading of anti-humanistic theories, religious doctrines and ideologies diminishing or denying the value of human life, inciting racial, national or religious discord, promoting or justifying violence, coercion and genocide" [17]. So the values as the factor of national security is emphasized in a different aspect: the US government expresses value as a consolidating factor in ensuring national security, the Government of the Republic of Lithuania treats values as a threat to national security of the country.

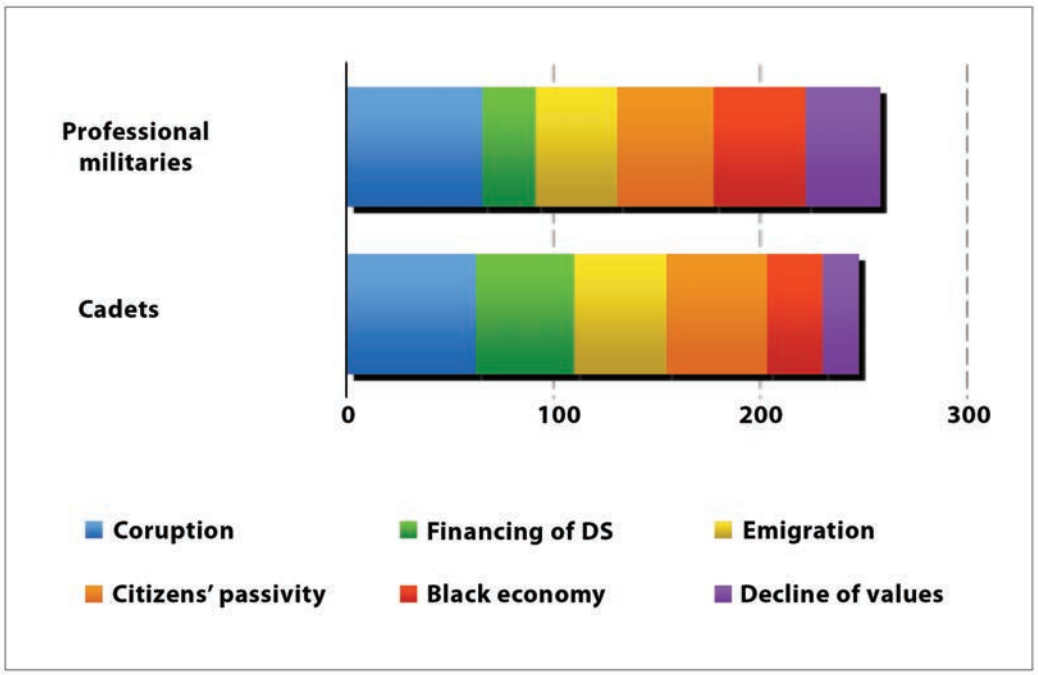

Fig. 1. The most important internal threats to national security (Test results, 2014)

Why does the government of Lithuania distinguish the values (or crisis of them) as a threat to the security of the country? Is it really serious threat to national security or just some warning about possible danger? How could it happened that the values of the society became the threat to its most important value - security and defense? These questions can cause serious scientific discussion and we need to come back to the issue of postmodernity as the concept of contemporary society looking for the answers.

Postmodernity has brought a diversity of life denying universal laws, values and world views as well as it caused the diversity of form and methods of self expression. This diversity is expressed in different ways - constructive and deconstructive as well. The last one has brought a lot of troubles for governmental institutions and society because it caused new forms of threats, hazards and risk for the state security. Traditional threats (military, social, economic) are still actual in postmodernity. However, such unconventional threats as terrorism or information attacks became more acute as well as corruption and organized crime began to play role of increasing danger to national security. All these

unconventional (or non traditional treats) to national security are caused by the changes in the value orientation of the society. The main determinants of these changes are consumerism as the main economical idea and neoliberalism as a political concept of postmodern society. All unconventional threats are targeting weak points of postmodern society - moral vacuum in the consciousness of an individual who is being attempted to fill the consumer's values of society. So such treats as corruption, crime, terrorism, information attacks (propaganda) and masked military and intelligence tools can be named as postmodern threats to national security because of their specific determinants became actual in Postmodernity.

Corruption as the threat to national security is based on this weakness of the society. According to the scientific point of view, the most of the issues of corruption are laying on the values, attitudes and behavior of individuals as cultural context of society [18]. Consumers' society is based on the idea of seeking profit as expression of only goodness of life. So, the attitudes, behavior and consciousness of individuals are oriented toward this aim. Of course, the causes of corruption vary due to national social features (traditions, religions, etc.). However, in the era of globalization, these peculiarities become equal to one consumer's idea. According to National security strategy of the Republic of Lithuania (2017), corruption can "undermine the legitimate interests of individuals and the state, compromise the rule of law, reduce citizens' faith in democratic values, democratic institutions and reduce the attractiveness of the state to foreign investors" [19]. So, the corruption as the phenomenon of the society which caused its moral weakness, becomes a threat to national security, because it even more weakens society. Similar situation can be admitted with another postmodern threats: terrorism, information attacks (propaganda) and intelligence tools.

Terrorism is caused by different determinants: economical, political, social, cultural [20]. It uses radical ideas of religious, ethnic and political extremism and so tries to fill the values vacuum in the consciousness of individuals which are not satisfied in economic, social and/or political situation and which are not able individually to find true moral guidelines for their life activities. The methods of terrorists warfare against political opponents are justified by the principle of utility what has been found to be very appealing to the schematics of simplified and primitive utilitarianism.

The methods of intelligence service, directed against the state, also use people's moral weaknesses - greed, jealousy, fear, the feelings of dissatisfaction, mistrust, losing of ideals and believes, etc. All these human weaknesses are used by foreign countries to negatively influence the political system, military capabilities, law enforcement, social and economic stability of the country.

Unreasonable and misleading propaganda promotes mistrust and dissatisfaction with the state and its institutions aiming to weaken national and civic identity, citizen's resilience against the threats and to reduce the willingness to defend their state. By the way, in the information age, more favorable conditions for the use of information as a weapon against the state and its security have emerged than before. Information technologies gave opportunities to get a lot of information in different ways, but the access to information without education does not fulfill the purpose of developing an informed citizenry, ready to engage in meaningful debate and make decisions. People need to develop the competencies necessary to understand and evaluate the information—and misinformation— with which they are confronted on a daily basis [21]. Obviously, these competences of the individuals can be formed on the basis of fundamental sciences. But the governmental and commercial educational institutions are aiming to achieve more quantitative than qualitative results: more students in shorter period. Simplified principle utility of consumers does not let to waste time and money for "useless" knowledge and impractical competences such as mathematics, physics, philosophy, literature, art, etc. The idea of consumerism is making negative influence on both, the individuals universal competences that decrease their possibility for critical thinking and value orientation based on universal human values. In postmodernity, information can be used in propaganda cases as a weapon against an individual and society, destroying a personality and making society more fragmented and unsafe.

It is obvious that, the situation in orientation of values of the postmodern society makes the society more and more vulnerable. Postmodern threats to national security are oriented towards a crisis of values and identity, using the slogans which are very important for the society such as, for example, "the struggle for justice, equality, freedom" or "fight against corruption, human greed, money, consumerism, etc.". On the other hand, the nature of the post-modern threats shows that, after ignoring the stereotypes about money as the only and fundamental value, people still want to follow the principles of goodness, justice and other values in postmodern society.

The analysis of the threats to national security of Lithuania allows to assert that there is a deep interaction between the majoring of threats and the value orientation of society. Actually, the system of values and/or postmodern identity are determinants for some of postmodern treats, such as terrorism, radicalization and extremism, information threats, corruption and organized crime as well as other threats are also directly related to value orientations and postmodern identity of contemporary society (Table 1.). Threats such as the demographic crisis, social exclusion, economic and energy dependence, are reasoned with the issues of the consumer society as well as they are making influence on the values and identity of the society and increasing their vulnerability to other threats (conventional military threats, instability in the region and world, etc.). The analysis of the threats to National security of Lithuania allows to assert that crisis of values is the most important threat in Postmodern period of the development of the society, and it influences other threats that are reasoned by the concept of Postmodernity.

Table 1

The interaction between the crisis of value and other threats to National Security of Lithuania.

Threats to National security of Lithuania (according to National Security Strategy of the Republic of Lithuania, 2017)	Interaction with the crisis of values as the threat to National security
Conventional Military Threats	Using the weakness of society in the willingness for resilience and defense.
Military and intelligence tools	Using moral failures and/or moral aspersions of individuals: lost of values, consumer's consciousness, dissatisfaction, misunderstanding, feeling of injustice, moral failures or sins.
Threats to the unity of the Euro-Atlantic community	Based on the clash of religious, cultures, systems of values, fragmentation of collective identity.
Instability in the region and in the world	Based on the clash of religious, cultures, systems of values, fragmentation of collective identity.
Terrorism, extremism, radicalization	Using the ideas of radicalism and extremism, based on religious, ethnic and political clash; dissatisfaction in economic, social and/or political situation. Seeking "true values": moral and/or political, social justice, freedom, equality, etc.
Information threats	Targeting value orientations and collective identity of society. Based on ideas of historical, social, political and moral justice
Cyber threats	
Economic and energy dependence, economic vulnerability	Influence by the ideas of consumerism
The development of unsafe nuclear energy near the borders of the Republic of Lithuania,	
Social and regional exclusion	Influenced by consumers consciousness and moral vacuum
Demographic crisis	Influenced by consumers consciousness and moral vacuum
Corruption	Based on consumers consciousness and moral vacuum
Organized crime	Based on consumers consciousness and moral vacuum
State and international levels of extreme situations	

Conclusions

The last few decades of human history has transformed the character of society - its identity and values orientations. Mostly it is reasoned by the development of technologies and the process of globalization. These new social and economic processes transformed the concept of society into Postmodernity.

Postmodernity as an idea of denial of Modernity can be characterized by fragmentation and decentralization of the society, constantly changing ideas and fast going reforms. Consumerism as a key economic concept of society has transformed moral idea of utilitarianism from goodness to benefit. Together with technological progress and globalization it caused new way of thinking and communication, new forms of communities and the transformations of individual and collective identity.

The transformations in value orientation and identity increased vulnerability of individuals and society and caused the character of threats to national security. Contemporary threats have got more hybrid character mostly targeting the weakness of human society - its values and identity. So, contemporary threats to national security and defense can be named as postmodern.

The concept of Postmodernity does not deny the importance of universal human values as essential guides for human-being and societies. The crisis of values as moral vacuum in the consciousness of individuals and society became one of most important threats to National security and defense which is a vital value of postmodern society.

Postmodern threats forced to revise a traditional point of view on the concept of National security and demands to be based on a comprehensive approach on the issues of security and defense. This approach is based on the multiple concept of postmodernism, which focuses on research on the topic of national security in a variety of fields - humanitarian, political and social sciences.

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Internal Aspects of National Security: Lithuanian Case

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Abstract

The problem of national security is relevant to all countries of the world as it is an important condition for the country's economic growth. This is confirmed by the World Economic Forum (WEF) distinguished risks of economic development, their interactions, threats and dangers on the global level. The aim of the article is to characterize the internal factors of Lithuanian national security which are related to the possibilities of economic threats and dangers. The method of basic indicator comparison is used; where as the first year (e.g., year 2007) of the analyzed period is selected as the base year. Both absolute and relative quantities of analyzed indices are compared.

KEY WORDS: *national defence; state budget; emigration; shadow economy, wage level; unemployment level; regions of Lithuania*

1. Introduction

Threats and dangers to economic development impact negatively on the results of the development of the country or region. Therefore they need to be analyzed and measures should be taken in order to regulate them. Hazards are counterproductive to security, and only reducing economic losses can ensure greater economic security in the country and achieve more robust economic growth. In general as challenges to National defence the current geopolitical risks of the concrete region and the centers of global power are analyzed. Mostly scientific studies of National defence focus on two interrelated aspects: political (cybercrime, civil wars, terrorism, religious extremism) and economic, using comparative research of countries relations [1, 2]. Another aspects of studies are: the main driving factors of secure and sustainable development and economic growth, such as foreign direct investment, education [3], energy security, including renewable and the integration energy systems [4, 5], identifying economic sectors which have an important effect to the national security (e. g., production and supply of electric energy, natural gas, telecommunications, communications, rail and road transport, water supply, banking sector, etc. activities) [6, 7]. However, for all challenges to national security sufficient state budget revenues are especially important which are needed to finance solving different problems and unexpected dangerous situations. The state budget revenue is negatively affected mostly by unemployment and emigration.

The aim of this study is to analyze and to evaluate the factors that reduce the revenue of the state budget, i.e. the problems of high unemployment level and emigration, as the biggest threat to national security.

The investigation of these factors is compared with the average results in the European Union Member States (EU-27) in the period of the year 2007-2016. Both absolute and relative amounts of analyzed indicators are compared. The method of base indicators comparison is used, whereas the first year (e.g., year 2007) of the analyzed period is chosen as the base year. The results of the theoretical research part are characterized with statistical indicators and the theoretical predictions made are checked with practical research.

Method of investigation. The estimation of the main factors that reduce the revenue of the state budget in Lithuania is used, giving the theoretical and practical research. The study was carried out using qualitative methods: scientific literature analysis, statistical data classification, systematization, synthesis, comparison, generalization and illustration, e.g., table and graphical analysis. For the evaluation of the challenges to national defence in the period of year 2007-2016 year 2007 was chosen as the base.

2. Internal Factors of National Security

In research regular emphasis is placed on economic growth, its indicators and factors [8; 9; 10; 11; 12]. It is important to note that scientific literature is still not sufficiently focused on the risks, threats and dangers of economic growth and national security [13; 14]. In most cases, macroeconomic indicators that address macroeconomic problems: the inflation [11; 12; 15], the unemployment rate (16; 17), the inequality of income inequities [18; 19; 20; 21], the shadow economy

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[22, 23], etc. are analyzed in scientific literature. At the present time, the World Economic Forum (WEF) presented the evaluation of global threats and revealed areas that can shape global threats for the upcoming in the nearest ten years. The five biggest risks are most widely discussed [24]:

1. Current weak growth in the period after the global financial crisis (more than eight years after the global financial crisis, growth remains weak and discontent high);

2. The current quick technological changes, the 4th Industrial revolution, driven by the development and increased efficiency of digital technologies in manufacturing and services. Increasing operational efficiency increases tension in the labor market, especially in the low-skilled segment of the workforce;

3. Income inequality and "increasing polarization" of population incomes (was ranked by the WEF as the third most important trend for the next 10 years and was cited by almost a third of respondents);

4. Geopolitical threats, such as uncertainties between Russia and NATO; the threat of terrorism; Russia, South Africa, Burundi and the Gambia withdraw from the International Criminal Court, accusing it of unilateralism and ineffectiveness. Geopolitical threats reduce national confidence in the international arena and commitment to international cooperation;

5. Climate change. A great deal of attention is paid to environmental risks, as they are likely to cause potential threats and cause economic losses, and that it is likely that the negative consequences may be higher than before.

Research from WEF [26] suggests that economic development processes are often exposed not only to individual risks, but also to several immediate risks or so-called "risk" interactions. These risk interactions in individual sectors or domains tend to be a long-term, constantly changing process, five of which are presented in Table 1.

Table 1 shows two important risks: 1) large-scale involuntary migration and 2) state collapse or crisis causes a long-term tendency, which is defined as a trend of rising income and wealth in the country, region or globally. This tendency has a negative impact on the country's labor market, population's standard of living, society as a whole and economy. It negatively affects other indicators of public welfare in the country, such as education level, health status, etc. These negative changes mostly affect the population with the lowest income and living below the poverty line. Another important trend - the changing climate - is the consequence of: 1) failure to adapt to climate change and 2) water crises. Changes in climate conditions often lead to undesirable shocks in agricultural products and raw materials, adversely affecting the economy of both a country and the rest of the world. The third trend - the increasing polarization of societies is caused by: 1) interstate conflict with regional consequences and 2) large-scale involuntary migration. The polarization of societies additionally depends on changes in gross domestic product (GDP), household characteristics (place of residence, number of children in the family, education, state of health, etc.).

Table 1

The main trends of economic development and interconnections of most important risks [25; 26]

Number	Trends of country, region or globally	Risks
1.	Rising income and wealth disparity	Large-scale involuntary migration; State collapse or crisis.
2.	Changing climate	Failure of climate-change mitigation and adaption; Water crises.
3.	Increasing polarization of societies	Interstate conflict with regional consequences; Large-scale involuntary migration.
4.	Profound social instability	Failure of national governance; Profound social instability.
5.	Ageing population	Unemployment; Profound social instability.

Economic threats are a potential opportunity to suffer losses to the subject of a relevant economic activity (at the microeconomic, mesoeconomic or macroeconomic level) due to specific internal or external factors. The impact of threats is of a potential nature and always depends on the interaction of various factors (internal, external). Dangers are understood as a specific probability of a threat.

Scientific research [13] emphasizes that the concept of security is anonymity of insecurity. Insecurity caused by any factor is a threat to an entity analyzed at any level (microeconomic, mesoeconomic or macroeconomic).

Internal threats to national security can be classified according to various criteria:

1) according to the source criterion, they may be: military, economic, political, social, legal, ecological, energy related, informational, moral, management, etc.;

2) according to the field/area of influence, they can also be assigned to: military, economic, political, social, legal, ecological, energy, informational, moral, management, etc .;

3) according to nature they may be: nature or natural (e. g. earthquake, tsunami, drought, rainstorms, epidemics of various diseases, etc.) and of social origin (for example, a major chemical plant, nuclear power plant accident and disruption of operation, harmful to health and / etc.);

4) according to the duration or time factor they may be: temporary and permanent (depending on the type of operation of the acting agent).

Practical experience of a wide range of problems suggests that various threats must be addressed without waiting until they are even more acute and affect society in multiple ways [25]. The key measures are to increasee employment and

reduce unemployment, the level of discomfort, number of people at risk of poverty and social exclusion in the country and the incidence of poverty. The use of economic, social, cultural and value tools to solve various problems promotes the emergence of various synergistic effects

3. Results

The paper summarized the scientific literature on the topic of challenges to national defence and analyzed the internal security threats in Lithuania. The main internal economic factors affecting country development are: unemployment and emigration. Seeking to reduce shadow economy and to increase the wage level gives an impetus to be in the line with the EU-28 government budget indicators and to create preconditions for more reliable national security in Lithuania and its regions. The comparison of the situation in Lithuania and the EU-27 allows to determine the direction and the rate of changes of economic indicators and to compare with expectations of population.

The main characteristics of Lithuanian economic development in the year 2007-2016 are given and compared with the average data of the EU-27 in Table 2. It is important that inflation measured as GDP deflator, in Lithuania increased in the period of 2007-2008, after which it was reduced to an acceptable level in 2016, as shown in Table 2. In Lithuania inflation achieved 1.0 % level in 2016; in the EU-27 in the same year it was considerably smaller – 0.8 %. The discomfort index, as a sum of inflation and unemployment level, has increased after the financial crisis in Lithuania after year 2007. This growth was mainly caused due to the growth of unemployment. The discomfort index in Lithuania was higher than in the EU-27 in the year 2007-2014. After 2008 financial crisis and 2012 recession, the risk of poverty and exclusion was constantly increasing until 2012 in Lithuania. The changes of poverty are described by the indicator risk of poverty of social exclusion, in percent. The risk of poverty coefficient, as it shown in Table 2, has dramatically increased in Lithuania since 2008 and in 2010 was accordingly 34.0 % when in the EU-27 it was 23.7 %.

Table 2

The changes of social development indicators in the period 2007-2016[27]

Indicator/Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Growth rate 2007-2016, %
1.Inflation (according GDP deflator), %											
-Lithuania	8.6	9.7	-3.3	2.4	5.2	2.7	1.3	1.1	0.3	1.0	-88.4
-EU-27	2.9	3.2	1.6	0.9	1.7	1.7	1.3	1.0	1.1	0.8	-72.4
2.Unemployment rate, %											
-Lithuania	4.2	5.8	13.7	17.8	15.4	13.2	11.8	10.7	9.1	7.9	85.7
-EU-27	7.1	6.9	8.9	9.6	9.6	10.5	9.5	10.2	9.4	8.6	21.1
3. Discomfort index, %											
-Lithuania	12.8	15.5	10.4	20.2	21.6	15.9	13.1	11.8	9.4	8.9	-30.5
-EU-27	10.0	10.1	10.4	10.5	11.3	12.2	10.8	11.2	10.5	9.4	-6.0
4.People at risk of poverty of social exclusion, in % and 1000 persons											
-Lithuania	28.7	27.6	29.6	34.0	33.1	32.5	30.8	27.3	29.3	30.1	4.9
-EU-27	24.4	23.7	23.7	23.7	24.3	24.8	24.6	24.4	23.8	23.5	3.7
5.Inequality of income distribution											
-Lithuania	5.9	5.9	6.4	7.3	5.8	5.3	6.1	6.1	7.5	7.1	20.3
-EU-27	5.0	5.0	5.0	5.0	5.1	5.1	5.0	5.2	5.2	5.2	4.0

Not a very significant increase of risk of poverty occurred in EU-27 in the period of 2011-2012. The level of population inequality of income distribution shows that the ongoing economic and social policy is not efficient. The change of risk of poverty coefficient in Lithuania is compared with this index in the EU-27. The comparison shows, that the inequality of income distribution in the EU-27 is significantly lower than in Lithuania. In Lithuania the income differentiation after the economic crisis has dramatically increased from 5.9 in year 2008 to 7.3 in year 2010 and from 5.3 in year 2012 to 7.5 in year 2015. At the same time, the inequality of income distribution in the EU-27 shows positive economic and social policy changes during the post crisis period.

Table 3

The changes of social development indicators in the period 2007-2016 [28]

Indicator/Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Growth rate 2007-2016, %
Unemploy-ment rate, %	4.2	5.8	13.7	17.8	15.4	13.2	11.8	10.7	9.1	7.9	85.7
Long term un-employment from total un-employment,%	...	21.6	23.7	41.7	52.1	49.2	42.9	44.7	42.9	38.3	77.3
Long term un-employment, %	...	1.3	3.3	7.4	8.0	6.6	5.1	4.8	3.9	3.0	130.8
Youth (16-25 year) unemp-loyment rate, %	8.4	13.6	18.4	34.6	32.6	26.7	21.9	19.3	16.2	14.5	72.6

An important issue is the employment of the individual demographic groups and the unemployment rate, especially long-term unemployment, in the labor market of the country. Unemployment rate during the period of 2007-2016 in Lithuania increased from 4.8% to 7.9%, i.e. increased by 85.7%. It is important to note that long-term unemployment in Lithuania is significant, and in 2011, it amounted up to 52.1% of the total unemployment rate of the country. Long-term unemployment in 2016 accounted for 38.3% of the total unemployment rate. Long-term unemployment in the year 2008-2016 increased to 130.8%. The data show that youth unemployment rate is higher than the total unemployment rate throughout the analyzed period and in 2016 it amounted to 14.5%. Scientific literature identifies various factors for the growth of unemployment, including youth, such as lack of professional qualifications and work experience, and the absence of a part of the youth "dropout" from the education system [17].

Scientific literature indicates that the decrease in unemployment rate is partly related to emigration of the population. After Lithuania's accession to the EU, changes in the emigration of the population are shown in Figure 1. The scientific literature analyzes the most common reasons for emigration [29]:

- free movement of workers;
- economic reasons;
- unemployment and wage differences;
- quality of life differences;
- social and cultural factors;
- studies abroad.

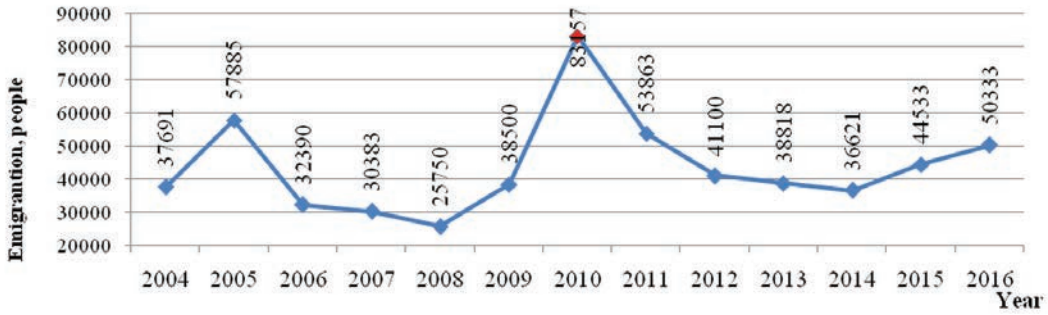

Fig.1. Emigration from Lithuania in the year 2004-2016, people [28]

Emigration flows in the period of 2007-2008 after Lithuania became a member of the EU in 2004, were the smallest. During the global financial crisis, emigration flows increased again and in 2010 were the largest - 83,157 inhabitants emigrate. During the period 2011-2014 the flow of emigration decreased, but during the period of 2015-2016 began to grow up again. Emigration level in 2016 compared to 2007 increased by 65.7%. This process is most strongly encouraged by low incomes of the population, unemployment and limited social and economic policy of the country directed at solving social problems of the population due to the limited possibilities of the state budget. The minimum wage in Lithuania in 2016 in comparison with other EU countries is presented in Figure 2. In 2016 in Lithuania it was 380 EUR and was higher only than the minimum wage in Bulgaria. The minimum wage in the EU-27 was EUR 836, thus the minimum wage in Lithuania was 45.4% of the EU-27 minimum wage level.

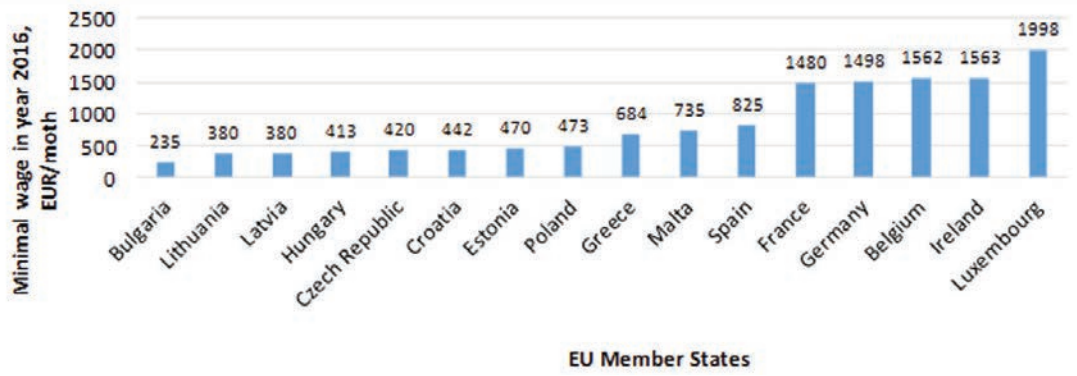

Fig.2. Minimum wage in Lithuania and others EU member states in the year 2016, EUR/month [28]

The changes of the average monthly earnings in Lithuania and the EU-27 in the period of 2010-2016 are given in the Fig.3.

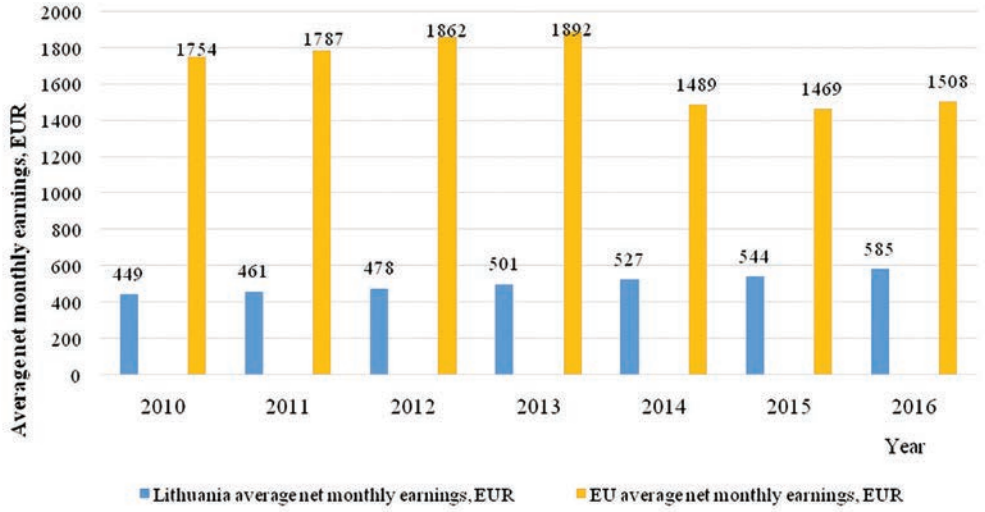

Fig.3. Average net monthly earnings in Lithuania and EU-27 in the year 2010-2016, EUR [28]

The data show that in the period of 2010-2016 monthly net wages in Lithuania increased by 30.28%. However, compared to the EU average in 2016, wages in Lithuania make only 38.8%. Compared to the EU-27, the low average incomes of the population in Lithuania have an impact on poverty indicators and the need for social support.

Conclusions

The following results of our investigation were obtained:

- Threats, dangers to economic development adversely affect the outcome of the development of the country or region, and therefore need to be analyzed and measures taken to regulate them. Hazards are counterproductive to security and only a reduction in economic losses can ensure greater economic security in the country and achieve more robust economic growth. We argue that there is a need for comprehensive analysis of internal security threats in Lithuania. The main internal economic factors affecting country development are: unemployment and emigration,
- Economic development processes are often exposed not only to individual risks, but also to several closely related risks or so-called risk interactions that multiply negative outcomes. The main labor market indicators (unemployment, emigration and its structure), the transparency level of the country market (low level of employees in comparison with the EU average level, shadow economy share) reduce both budget revenues and both preconditions for national security in Lithuania;
- The research shows that internal indicators of economic development in Lithuania (unemployment level, emigration, low level of average net monthly earnings, minimal wage level) are important inside threats and dangers for the national security in Lithuania.

The observations above allow us to foresee that the determination of different aspects of challengers to national defense helps to discover new aspects, to enlarge the security of the country and to increase its competitiveness.

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Understanding People and Technology. Professional Military Education and Challenges of Future Commanders Development

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Abstract

Significant changes to security environment make military operations more complex and demanding. Preparing military commanders to face future challenges has been vital for military success and national security. While the system of the Professional Military Education seems good, there are opportunities to make it more responsive and efficient. The article summarizes the ongoing discussion on the Professional Military Education, and identifies challenges related to preparation of future commanders. Based on recent developments some ideas on improving Professional Military Education are offered.

KEY WORDS: *Professional Military Education (PME), social dimension, new technologies, military operations, commanders*

1. Introduction

The security environment evolves rapidly and employment of military power becomes more and more complex. Military commanders face compressed battle space and levels of warfare and act in complex social, cultural and economic environment. Despite the level of command and control, all future military commander require comprehensive knowledge stretching out of typical military toolbox to be effective in achieving objectives of a broad scope of military operations. Technology becomes one of the most rapidly changing aspects of security environment. It is especially true for emerging and readily available technologies with military relevance that may be available even to non-state actors. All that requires diligent efforts to prepare future commanders for making decisions and acting in intertwined social and technological scenarios. Understanding people and technology seems a prerequisite for success, while not understanding even one of those aspects may be disastrous. Lessons learned from military operations just in recent decades prove the value of comprehension of both social and technological dimensions of security environment.

Depending on the level of command and control as well as a type of military operations future commanders will need different mix of social and technological expertise. Professional Military Education offers unique opportunities for future commanders to grow intellectually, reflect and anticipate changes in security environments. Case studies serve as a way to improve future commanders' skills to act in complex environments. Along with introduction to theoretical approaches to decision making under certainties and simulation and modelling, case studies proved to be effective in preparing commanders for operations in complex environments.

2. Ongoing Discussion on the Professional Military Education

The Report of the Panel on Military Education appointed by the Armed Forces Committee of the House of Representatives of the US Congress is for many reasons an extremely valuable analytical study on the Professional Military Education. Since it was published on April 3, 1989, it has been setting the stage for further discussions on developing future commanders and provides clear benchmark to proposals related to Professional Military Education nowadays. The so called Skelton Report offered broad scope of analyzes and assessments of officers' command and staff education and recommended changes in the education and training of officers, which translated into practical solutions in US military education and influenced similar solutions in other Western countries. In 2010, the U.S. Congress published a follow-on report that attempted to assess the extent of changes that took place as a result of the 1989 recommendations. For those interested in the professional development of officers it may be interesting that there were numerous problems that could not have been solved and some of the recommendations of the Skelton Report proved to be more difficult to

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implement than it seemed back in the eighties. A significant part of the observations contained in the Skelton Report is universal and remains valid after almost thirty years inspiring stormy discussions and fierce disputes over the education and training of officers in American political, military and academic environments. They influence also professional discussions related to Professional Military Education in other countries.

Work on the Skelton Report began in November 1987. The panel for military education was to check whether the existing command and staff education and training system allows harmonized training of officers for the needs of particular types of armed forces and joint forces. The panel was also supposed to assess the ability of the Defense Department's military education system to develop professional military strategists, joint warfighters and tacticians. An additional area of work, was the quality of military education and training of officers, which was considered to be crucial for the effectiveness of teaching the problems of strategies and operations of joint forces. Although in the general assessment of the panel, the defense education system of the Defense Department was considered good and the schools were fully comparable with the most prestigious military universities in Europe, it was recognized that a significant improvement in the existing situation could and should be made. The panel proposed specific recommendations regarding various aspects of officers' command and staff education and training. From the perspective of more than a quarter of century, it is not so much a literal familiarization with particular recommendations as the analysis and understanding of the arguments used by the panel when proposing individual conclusions and postulates. The Skelton Report advocated precise delimitation of the content of education programs at particular teaching levels and to standardization of the essential elements of education programs in schools of all services of armed forces in such a way that it would be possible for officers to study in the other services' schools. Skelton's panel proposed that the education and training of command and staff officers for the needs of the joint forces should be divided into two stages. In the first stage, in schools for middle-level officers of different types of armed forces (service intermediate college), all students were to learn about operational capabilities and limitations of particular types of armed forces, command of particular types of armed forces, doctrines and organizational concepts, as well as the planning process in connected forces. In the second stage, the officers envisaged to take positions in headquarters, staffs and joint institutions, were to educate themselves in the scope of the doctrine of joint forces and to conduct analyzes of possible operational scenarios. An important element of the second stage was to strive for a better one concerning the issue of training officers.

In addition to the activities allowing for greater freedom to recruit and reward civil teachers, it was postulated that only the best officers would be lecturers at the command and staff schools, with a clear prospect of further promotion, knowledgeable in a specific specialty, and academic education. Interestingly, the need to graduate stationary command and staff studies at the level at which they will teach would be emphasized. The quality of education was to be improved also thanks to the tightening of didactic rigors for students. The report recommended introduction of the systematic requirement for students to prepare written assignments, exams, essays and other studies. Writing was to increase the students' skills in the field of developing various types of documents, formulating conclusions and assessments, and arguing. Teaching staff had to study the students writings thoroughly, criticize their content and assess it [1]. The Skelton Report had a significant influence on the command and staff training of the officers of the American armed forces. The recommendations of the Congress led to clear changes in the education philosophy of commanders and staff officers, unification of approaches in particular types of armed forces to the content of teaching and the introduction of didactic rigors. Clearly, from the perspective of more than two decades, the quality of command and staff training has increased.

In April 2010 the Committee of the Armed Forces of the House of Representatives of the US Congress published "The Another Crossroads report? Professional Military Education Two Decades After the Goldwater-Nichols Act and the Skelton Panel", in which it assessed the implementation of its recommendations and the PME in the U.S. Armed Forces. The scope of analyzes and evaluations made for the needs of the report was significantly smaller than the work related to the Skelton Report. However; the authors formulated a number of conclusions referring directly to the improvement of Professional Military Education [2]. For people involved in the professional education and training of officers, there may be some interesting themes in the 2010 report. The first one, concerning these aspects of education, which were improved as a result of the Skelton panel's work. The second one, which describes the difficulties and failures in improving the PME of the American armed forces. The 2010 report conclusions considered that the officers' PME system was basically good, but some of its elements needed improvement. The introduction of solutions and didactic rigors ensuring the quality of education was recognized as an unambiguous success. The flexibility and adaptability of officers' PME were positively assessed. The general philosophy of officers' command and staff education and training has evolved along with dynamic changes in the security environment and changing operational needs. The scope of the training content of junior officers has been extended, which are currently being prepared for activities in the framework of combined forces and senior officers, who are more familiar with the problems of national security strategy to a greater extent than before. Despite the reactive nature of changes in education, both its content and form were adequate to the operational needs of the US armed forces.

Some of the problems in the implementation of the recommendations of the Skelton Report resulted from the intensity of the use of armed forces in military operations after the end of the Cold War, especially after the terrorist attacks of September 11, 2001. The simultaneous operations in Iraq and Afghanistan caused such a heavy burden that a significant number of officers had difficulties with participation in resident command and staff study programs. Increased staffing needs in both operations meant that some officers were assigned positions in commands and staffs without the required training and without some key skills necessary for proper performing duties on the positions held6. It should also be noted that at the same time many officers assessed that during the command and staff education and training, they were not properly prepared to take up staff positions. The 2010 report critically assessed the efforts of the Department of Defense and services of armed forces to prepare officers to able to function at strategic levels. It

was assumed that the PME did not play essential role in shaping the professional development of officers envisaged to occupy key positions at the strategic levels in the future. The Committee of the Armed Forces of the House of Representatives of the US Congress assessed that the efforts of services and combatant commands in identifying and selecting officers predisposed to occupy positions at strategic levels and support their professional development were incoherent and not fully effective.

The 2010 report revealed that activities aimed at increasing the quality of the staff engaged in the PME turned out to be a half-successful ones. The problems related to the provision of high-quality teaching and managerial staff as well as students endured. Teaching in command and staff schools turned out to be not always attractive to officers with the greatest potential for professional development. All-too-long stay at the university reduced the officer's chances for promotion, while a rapid promotion and return to the line before the end of the three-year term as a lecturer did not allow full use of the officer's experience in didactics. The report also suggested to adopt more precisely defined criteria for appointing officers to managerial positions in the PME institutions and to extend them he term of assignment so that they could better understand the complexity of the command and staff education and, consequently, ensured stability in the PME institutions management. One of the aspects of the PME organization, which was highlighted in the 2010 report, was the selection of students. There was a differentiated approach of services in the field of personnel policy related to directing officers to full-time studies, which diversified the level of substantive competence between students in different universities.

The title of the report on the command and staff training from 2010 begins with the question "(if) "Another Crossroads?". After learning about its contents, one can risk answering "yes". Although the authors of the 2010 report did not recommend such radical changes as the Skelton panel did in 1989, they emphasized the need for constant care for the PME and decisions affecting the future of officers' education. The Skelton Report and the 2010 report were the only documents of the U.S. Congress devoted directly to the education and training of officers, despite the fact that the issue was important enough to merit more systematic and more frequent parliamentary oversight [2].

The language, conclusions and recommendations of both reports on the PME can be considered balanced and often even too restrained. The language of the public debate devoted to this problem is different, which may be seen on the pages of professional military and civilian periodicals in the USA. One of the most prominent voices in the American debate on the PME was the article of retired general Robert H. Scales "Too Busy to Learn" published in "Proceedings Magazine" in February 2010. A former commander of the Army War College, a recognized expert in the use of ground forces and a doctor of history, Scales risked the thesis that American forces do not pay sufficient attention to the intellectual development of officers, which may have negative consequences for future security [3]. Scales noted that, similarly to the experience of the British army in the second half of the nineteenth century, the involvement of the U.S. Armed Forces in small and easy wars led to negative changes in organizational culture. In his opinion, excessive preference for operational experience in personnel policy led in the land forces to the situation in which officers avoided taking part in command and staff studies, fewer and fewer officers were lecturers in such studies, and the duration of studies was significantly shortened. Scales accused the armed forces that they prefer acting at the expense of the intellect (action versus intellect) and do not pay sufficient attention to the PME. Importantly, Scales did not treat changes in military education as a "pedagogical" problem, but as "human". He believed that only when the personnel system would "reward" the intellectual development of officers, would the long-term development of armed forces be possible [3]. Recalling the changes initiated by the Skelton panel, Scales recommended investing in the intellectual development of officers in the early stages of their military career. He also pointed at the importance of humanistic education of officers, which will allow them to function better in diverse cultural environments. Scales explicitly advocated teaching by officers (and curbing teaching by "contractors"), college entrance examinations, and extorting knowledge of a foreign language as a condition for officers promotion. In his opinion, the individual PME assessments describing the intellectual achievements of the officers should be as important as the other official opinions and should have a measurable impact on their professional development.

Charles D. Allen, in the article "Redress of Professional Military Education", attempted to explain some of the problems raised by Scales. Allen, a retired colonel, a professor at Army War College, described the phenomenon of "new, normal". Intensive participation in operations accelerated obtaining higher military positions by the Army officers. It was also typical for the superiors to delay the direction of the best officers to resident command and staff studies, or even to justify non-participation in such studies due to operational needs [4]. Due to the needs of operations in Iraq and Afghanistan, officers and infantry officers in Army War College almost did not participate in command and staff studies. Allen suggested that the consequences of such an approach to command and staff education and training of officers would be felt in the future and manifest in inadequate preparation of officers occupying key positions in the armed forces and advising representatives of the government. Like General Scales, Allen sees problems related to the PME through the prism of organizational culture. Allen resembles the principle of the same approach to lifelong learning and professional development by the institution, commanders and individual officers enshrined in the development strategy of the leaders for the Army of the 21st century. Everyone should equally care for the education of successors and their intellectual development. Allen also points to the staff aspect of the effectiveness of command and staff education and training of officers. Commanders should pay due attention to providing their subordinates with adequate education in a time allowing for its full use in their professional development. Allen concludes that if the path to the promotion (success) will run through the PME, and not bypass it, the system itself will be repaired [4].

The need to give more intellectual development to officers was indicated in the statements for the Committee of Armed Forces of the House of Representatives, by civilian and military specialists. One of its kind respondent was prof.

Williamson Murray, who provided information to the Skelton panel members in 1987-1989, and then supported the work on the 2010 report. Prof. Murray observed that, unfortunately, most of his fears dating from a quarter of a century ago remained valid. The professor said that a thorough education is necessary for the preparation of senior officers to understand the nature of the war and its diverse contexts, and consequently for efficient functioning in a security environment. According to Murray, education of officers is a long-term investment in the future of the country, which is why services of armed forces should be willing to devote some of their short-term priorities to long-term activities aimed at intellectual development of officers. Professor Murray had no doubt that the success of the PME was entirely dependent on the fundamental reform of the staffing system and the promotion rules that would ensure the promotion of competent officers. Like General Scales, Murray proposed introducing entrance examinations to the command and staff schools, to radically change the anti-intellectual culture that characterizes many of the junior officers in the US Air Force. In the words of his speech, Murray appealed to Congress to give officers enough time to study, so that they would not be punished in their further career for spending time at school. In his recommendations he also stressed the need for "much more rather than in the past "selecting persons for managerial positions in military academies, suggesting that such positions should be assigned to persons with significant experience gained in operations and with serious academic references [5].

Retired general David W. Barno, in his statement to the Congress in 2009, pointed at the promotion of "muddy boots" bias. In his opinion, the unintended effect of preferring in the recent years the promotion of "action people" and not "people of reflection" will result in the next few years in a generation of generals fluent in tactics at positions requiring thinking in strategic terms. Barno also proposed increasing the PME of generals who in the last ten or fifteen years of service are engaged in solving more and more complex problems, but they do not have time to study and reflect [6]. In the recommendations for Congress, General Barno appealed to create an atmosphere of respect for military intellectualism, thinking soldiers (warriors) and thinking warriors (soldier warriors and soldier-scholars).

In the American discussion about the PME, the arguments about military anti-intellectualism, anachronism of the content taught, and post-commander-staff studies for too late a period in the officers' career were often made. Depending on the inclinations of political authors, it was postulated to train officers in the "free market" or only in military schools and only by the best officers. Regardless of the fundamental differences in views, participants in the public discussion underlined the importance of thorough and comprehensive education and training of officers as a guarantee of state security. Officers with wider intellectual horizons are considered in American political, military and academic environments as people who are able to make decisions and effectively operate in complex environmental conditions safety. Excessive favoritism, partly at the expense of Professional Military Education, of operational experience in the professional development of officers was considered potentially dangerous in a longer time horizon, when proficiency in tactics may prove insufficient to solve strategic problems.

3. Challenges to Professional Military Education

The challenges to the Professional Military Education and preparation of future commanders result from changes to security environment, to include new threats and requirements for employment of military forces in a growing spectrum of operations. Post-cold war military operations provide a lot of examples how complex security environment may be and how difficult it is to apply traditional tenets of war to new operational scenarios. The NATO involvement in peace support operations in the Western Balkans back in the nineties resulted in creating a separate part of allied joint doctrine focused solely on non-article V crisis response operations. New principles of such operations were named, among others, consent, perseverance, mutual respect and transparency. Most of them quite different from well known ones of surprise, economy of force or unity of effort. It must be understood that it takes time for organisations to learn. The bigger they are, the more hierarchic, the more difficult it is for them to adapt. The change in the nature of military threats immediately after the end of the Cold War resulted in wider use of armed forces in crisis response operations, which were then called military operations other than war. The operations of the UN and NATO in the Balkans, carried out in the nineties of the last century, and the actions of the UN and the U.S. forces in Somalia, made politicians and military officials understand how complicated it was to combine combat, stabilization and humanitarian activities in a single operation. Thus a term "the three block war" proposed by the USMC General Charles Krulak entered the military dictionary. Activities in Iraq and Afghanistan only confirmed the experience accumulated in the nineties of the last century. While the changing nature of military threats and operations resulted in adaptive changes in the doctrine, the development of information technologies has provoked a number of radical concepts and raised expectations that are difficult to meet. The belief in an almost unlimited access to information was reflected in the concepts of the network-centric warfare and effect based operations based. Those two examples offer good examples about possible challenge to the Professional Military Education as both revealed the complexity of understanding human and technological dimensions of military operations.

The origins of the network centric warfare dates back to 1998, when the article by Arthur K. Cebrowski and John J. Garstka "Network Centric Warfare: Its Origins and Future" was published. The network-centric warfare was supposed to be the response of the armed forces to the development of information technologies and the beginning of the information age in the civilian environment. Networking troops was hoped to increase combat capabilities of smaller, faster-acting, self-synchronizing, distributed military units, sensors and measures of kinetic and non-kinetic influence. Operations of networked forces was expected to result in fast concentration of effects, without the need for concentration of troops. As a consequence, the execution of combat tasks might require smaller forces, less logistic support, reducing the overall costs of military operations. The network centric warfare concept developed to include idea of knowledgeable force, which assumed

that the networked military units would be able to better understand the implications of the changes in operational and tactical situation, the intentions of the commander in the same way and to conduct autonomous operations more easily [7]. The U.S. approach to the network-centric struggle made networking the central element of the concept of warfare affecting the fundamental changes in its nature. Such a radical approach has not been adopted in other countries or in the NATO as a whole. Although networking has been recognized as important for warfare, it is now considered one of the many capabilities affecting the way the armed forces operate. Examples include the British approach to network-enabled capability, the Australian concept of network-enabled warfare or the NATO Network Enabled Capabilities - NNEC. It is interesting to observe that the Professional Military Education was initially impressed by the ideas of the network centric warfare and it took some time for more critical views to reach future commanders' teaching environment. Over a decade of using network-centric solutions in military operations revealed a number of prosaic problems that can be caused by the implementation of network solutions. The network of sensors necessary for having an information advantage now provides so much data that it is almost impossible to analyze them in time. Sensor lifetime can be problematic in high-intensity conflict conditions. The availability of reconnaissance data has increased the military's expectations for the availability of image data in almost real time, which translated into the size of data transfer and the load on the command, control and communication network. It seems that no matter how much the data transmission capacity increases, the expectations of network users will increase even more, making it difficult to meet the call for network-centric access to high-quality information services. For that reason, the network centric warfare concept provides a good example on how to remain careful in putting new concepts in the Professional Military Education.

Another concept that influenced directly the preparation of future commanders was that of effect based operations (EBO). This concept had its origins in the network-centric struggle, and the first official publication describing it was published in 2001 by the US Combined Forces Command (USJFCOM). In essence, such operations were to be aimed at influencing the cognitive domain of the opponent and its individual components. Proponents of the concept argued that precise kinetic and non -kinetic actions were not so much to destroy the opponent's military forces, but to convince adversary political and military decision makers about the futility of further battle. The concept of effect based operations led to changes in planning. While traditionally the objectives of the operations were the basis in military planning, the results were to be found in the EBO. These results were divided into direct and indirect ones. Among the direct results, physical, functional and collateral effects were distinguished, among others. However, the typology of indirect results was slightly more complicated and included results: functional, side, psychological, systemic, cascade and cumulative. Additionally, in the planning of operations based on the expected results, it was assumed that the indirect results could be predicted and evaluated not only for first-order effects, but also the second, third and subsequent orders (which can be the consequences of the opponent's reaction to our forces, and then what further consequences of these consequences may be, etc.). Planning activities in accordance with the EBO methodology was to help find the answer to the question, what actions should be taken to achieve the desired changes in the behavior of the opponent in the tactical, operational and strategic dimension. If one takes into account that system-of-system analysis (SoSA) necessary to make operational decision making should include nodes and systemic ties in political, military, economic, social, infrastructure and information systems (PMESII), it is easy to understand the scale of challenges related to the implementation of the concept of effect based operations in the U.S. armed forces. About five years after the publication of the EBO concept, its implementation in the U.S. armed forces was at least controversial and sensitive. The concept was still not fully defined, its application in various combined headquarters differed significantly, and planning based on the expected results long-term engaged a significant number of specialists. In 2006, professor Milan N. Vego from Naval War College published the article "Effects-Based Operations: A Critique" in which he pointed at an excessively deterministic, even mathematically zero-one, approach of EBO supporters to war [8]. Australian officers, J. Kelly and D. Kilcullen, also argued that the use of mathematical methods to measure non-measurable effects of the second or third order (eg in the social system) is at least problematic and it is difficult to expect that the EBO will reduce the basic the uncertainty associated with conducting military operations [9].

Disappointment in the US armed forces with the concept of effect based operations led to the publication in 2008 the memorandum of the U.S. JFCOM, General J. N. Mattis assessing such operations. Mattis expressed his conviction that the diverse interpretations of the EBO concept have created confusion both in the US armed forces and among the U.S. allies. In his opinion, the concept of EBO began to be misapplied and created more harm than help to operations. Mattis called for a return to historically proven principles and terminology, which could be understood by all involved: the commander's intention, unambiguous tasks and achievable ends. It should be noted however that Mattis did not condemn the whole concept and pointed to the usefulness of some analytical concepts related to EBO to some elements of planning activities with regard to the so-called closed systems [10]. So what's the linkage between the Professional Military Education and the preparation of future commanders and the effect based operations concept? First and the most important is to keep new concepts in touch with real world observations. The real life has as much to say as new concepts do. If new concepts do not translate into better operations, it's probably better rethink those concepts. Another point is the complexity of teaching. It is unrealistic to assume that all future commanders will be men of reflection with broad knowledge stretching out of military expertise. So the Professional Military Education should find a way to teach complex issues in a way that allow understanding them by a wider audiences, not only small elites.

The armed forces for which the concept of EBO turned out to be the most harmful, were the Israeli self-defense forces. Assuming that the actions of a potential enemy may be paralyzed as a result of precise air and missile strikes on its key military objects, less attention was paid to the development of tactics for land operations. Israeli methodology of systemic operational planning (Systemic Operational Design - SOD) was to encourage commanders to critical, systematic and methodological thinking about warfare and give them tools to conceptualize both the opponent and own forces by

designing appropriate campaigns. The creator of the SOD, General Naveh, believed that his innovative methodology would allow commanders using creativity, experience, intuition and assessment skills to develop detailed operational plans. Israel's war with Hezbollah in 2006 showed, however; something quite different. There were a number of reasons for the failure in implementing the Naveh's methodology. The terminology used in the SOD came from postmodern French philosophy, literary theory, architecture and psychology. The new terminology and methodology of conduct and the complexity of the approach, which Naveh described as "not intended for ordinary mortals", meant that a significant proportion of the Israeli officers did not understand why simple and understandable command and control procedures was replaced by a methodology that only a few of them could understand. Adopted in April 2006 for use in the armed forces of Israel, the new doctrine was largely based on Naveh's methodology, and the boundaries between EBO and SOD were not precisely defined. Israeli military theorist, retired officer, Ron Tira, noted that of the 170 pages of the new doctrine many experienced officers did not understand more than half, and the terms used in it were so imprecise and ambiguous that it was difficult to plan and conduct combat operations on their basis [11]. Thus, one may see the risks associated with the attempts of turning not fully proven concepts into standard operating procedures. While those concepts would beneficial in classroom environment in many PME programs, they turned out not to be suitable for tactical level decision making.

Nowadays, the situation seems even more challenging than just a decade ago. Technology becomes one of the most rapidly changing aspects of security environment. If one thinks about information operations the cyber attacks are no longer the most dangerous threat as we are better and better prepared to deal with them. Smartphones and social media have become much more powerful tools of influencing society and military opinions. No bullet is as fast as a tweet, no weapon reaches more "victims" that Facebook. Future military commanders need to be aware of that and stay one step ahead of possible adversaries. But; is it realistic? One may point to another phenomenon of emerging and readily available technologies with military relevance. Unmanned remotely controlled vehicles used to be for a long time available to advanced militaries. Right now they are readily available to non-state actors and even individuals. What's more non-state actors are more open to experimentations with new technologies and not bound by rigid planning and financing mechanisms typical for armed forces. Such situation challenges long-term assumption held by military. Non-state actors no longer are those weaker ones, with lack of advanced weapons, doomed for defeat. Cheap weapons available to non-state actors may be technologically advanced enough to fight regular military forces in efficient way. Israel fighting Hezbollah in 2006 experienced that and recent operations in Syria show employment of unmanned aerial vehicles as a hallmark of non state actors activities. At some point it may be difficult to predict what of civilian technology may be used as a weapon and with what effect. To paraphrase Donald Rumsfeld, with nanotechnology at the corner, we are approaching a security environment not only of "known and unknown knowns", but with a wide spectrum of unknown unknowns. Human dimension of future security environment requires as much attention as emerging technologies. As Western militaries engage in a number of crisis response operations worldwide we need to put more attention to human side of conflict. It is necessary to understand what makes people fight and what is necessary to make long lasting peace. The difference in cultural values is obvious not only for far away societies, but it is present here and now inside the NATO and the European Union. Most uneasy to observe is the lack of common values between the Russian Federation and the Western community. For the future commanders it is absolute must to understand both adversaries and allies and that's why Professional Military Education matters.

4. Possible Improvements to the Professional Military Education

Professional Military Education along with specialized military training and professional, including combat, experience will remain crucial for developing future commanders to meet challenges of evolving security environment. Although the current set up of Professional Military Education in Western militaries seem sound and generally effective; nevertheless there are some areas that require more attention and there are opportunities for improvement of existing solutions. One of the most basic questions related to development of future commanders is what to teach, when to teach and whom to teach. As the development path for future commanders starts typically with majority of specialized training and focuses on tactical level, the comprehension of operational and strategic aspects of warfare comes later – usually for field grade officers and then senior officers. The change in the nature of threats and growing spectrum of military operations make such an approach not fully compatible with requirements of developing future commanders. While Professional Military Education for officer candidates and junior officers should remain focused on tactical level it need to include also at least introductory modules stretching into operational and strategic dimensions of employment of military power. Taking into account that tactical actions and decisions by junior officers may result in operational and even strategic consequences, it is worth investing some period of Professional Military Education to make them familiar with some of facets of security environment they will operate in. To put it simple, it makes sense to show junior officers – future commanders how intertwined, contested and dynamic is the security environment, how little dot on that picture are their actions, and finally how important they are to the overall success of the operations. Similarly to findings of Skelton and 2010 reports, there is a growing need to prepare officers earlier in their careers to operate in international, culturally diverse, environments, to make them aware of operational and strategic consequences of their actions or inactions, and finally not to scare them with growing responsibility of command.

Understanding people and technology at the same time by future commanders should be instilled at every level of Professional Military Education. There are different approaches to developing social and technological competences of future commanders. For those who will remain "operators" and not "technicians" it is important to know what can technology provide and what limitations it has in military applications. With the use of simulation and modelling during Professional Military Education; it is possible to raise awareness of future commanders about technological aspects of

future security environment. Typically, modelling and simulations should be "eye – opener" by giving future commanders non-negotiable reference figures and calculations about operational performance, logistic support requirements or force-time-space calculations. As important as above would be to reveal consequences of miscalculations of technological aspects of military operations. For the younger generation of officers it is quite common to adopt simplified assessment of technology. One smart bomb seems enough for every target, Power Point presentation fidelity seems precise enough, etc. More complex assessments related to combat and combat service support requirements offered thanks to modelling and simulation may be beneficial to future commanders. Because of that a carefully tailored package of modelling and simulation should be a part of Professional Military Education at every step of future commanders professional development. Use of "technology watch" should not be hesitated to keep future commanders aware of technology development that may impact security environment.

Developing social skills of future commanders requires more focus on human aspects of security environment. A careful selection and use of case studies will be helpful in preparation of future commanders to understand people better. Possible improvements in using case studies should be sought in selection of such cases, and then in using them to reinforce another elements of Professional Military Education. The ongoing operations or those conducted by the NATO in recent decades should be studied in details. It would be beneficial to future commanders to be exposed to the complexity of factors that influenced international community involvement in the Western Balkans, Afghanistan and Libya. Comprehension of competing objectives, national perspectives on specific courses of action, complexity of logistic support or local community attitude toward allied troops, may improve the quality of future commanders' preparation through the Professional Military Education. Studying military history remains vital element of preparing future commanders. The point is to study more this part of recent military history that may be useful in ongoing operations and to capitalize on lessons learned not hundred years ago, but during recent decade, in similar operating conditions.

Finally, political and military decision makers should resist the temptation to limit the Professional Military Education as a part of future commanders development. While favouring operational experience may accelerate individual officer's professional development, in long term it may decrease strategic thinking skills at the military top levels. One should avoid treating military education and training interchangeably. The Professional Military Education constitutes a critical component of developing future commanders because it prepares them for uncertainty that will remain a characteristic feature of future security environment [12]. It is education that gives future commanders a broad base of knowledge and develops their critical thinking skills. All necessary to make proper decisions and act wisely in not fully predictable situations. Military specialized training will not hone such skills of future commanders; although it will prepare them for known tasks.

Conclusions

The dynamic changes to security environment observed in recent decades influenced significantly employment of military power. Military commanders make decisions and act in compressed battle space not bound by traditional levels of warfare. Military operations are conducted in complex social, cultural and economic environment. Future commanders will require comprehensive knowledge to be effective in a broad spectrum of military operations. Two dimensions of future security environment seem to be the most important ones to preparation of future commanders: technology and human dimension of armed conflict. Technology changes security environment and redefines what's possible in military operations. But there are more and more emerging and readily available technologies with military relevance that are available to non-state actors. All that requires future commanders to be prepared to make decisions and act taking into account intertwined social and technological factors. Understanding people and technology seems a prerequisite for success of future commanders. Use of modelling and simulation along with applying case studies during the Professional Military Education programs are just examples of tools to improve technological and social skills of future commanders. Changes to security environment should result in the evolution of the Professional Military Education and some of the anticipated changes should even shape curricula and teaching content. To assure the quality of future commanders development proper support to the Professional Military Education is needed. It should be treated as an investment in future commanders that will pay back in increased national security.

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Research Trends in Knowledge Management in Military

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Abstract

The objective of this study is to review current research on knowledge management in military and to identify the main streams where research is performed. Knowledge in the military is perceived as a tool and means for effectiveness and has been analyzed from diverse standpoints. Accordingly, the studies in this field take different paradigms and represent the perspective of management, social networking, organizational psychology, information technology and other fields towards the phenomena of knowledge in the military and its management practices. Although previous studies on knowledge management in military have presented some literature overviews, this study is the first to provide a systematic analysis using content mapping.
Systematic literature review using in-depth text mining and bibliometric networks are used as methods for this study. The data consist of theoretical, analytical and research papers retrieved from Web of Science Clarivate Analytics (VoS) (N=406) and Scopus databases (N=317). According to findings, knowledge management research in the military is performed in three streams. The larges stream represents management science paradigm. The second largest stream represents interdisciplinary perspective and the smallest stream is predominated by technical solutions in the military knowledge management. The results of in-depth text mining identify the recent trends in knowledge management research in the military. They are associated with knowledge integration and strategy.

KEY WORDS: *knowledge management, military, bibliometric networks, in-depth text mining, knowledge integration, strategy*

1. Introduction

Knowledge management in the military has long been an activity related to training and many efforts are related to knowledge sharing among and between the teams and levels of command. In this context, knowledge in the military is perceived as a tool and means for effectiveness and has been analyzed from diverse standpoints. Accordingly, the studies in this field take different paradigms and represent the perspective of management, social networking, organizational psychology, information technology and other fields towards the phenomena of knowledge in the military and its management practices.

The objective of this study is to review current research on knowledge management in military and to identify the main streams where research is performed. Although previous studies on knowledge management in military have presented some literature overviews, this study is the first to provide a systematic analysis using in-depth text mining and networking.

2. Theoretical Framework for Knowledge Management

International conflicts, the war on terrorism, the refugee crisis and other *global* threats on modern countries have accelerated the need for more flexible, rapid strategies and innovative security systems. According to Schulte and Sample (2006), it will continue to constitute a major challenge for democratic governments for many years to come. It is believed that knowledge integration is an important element of the long-term solution to many global threats (Schulte, Sample, 2006; Jyoti, Rani, 2017). In this context, it is growing the importance of knowledge management theory and practice in public sector, including military, organizations.

Ives et al. (1997) analyzing historical aspects of knowledge management, declare that knowledge „has always been central to human performance and it has been defined as the capacity to act", by the way **"**knowledge is a high value form of information that is ready to apply to decisions and actions" (p. 269). They also say that the actions of managing knowledge have a long history, starting the earliest pre-writing oral civilizations and finishing the digital age. Therefore, managing knowledge is not a new concept. It is just newly framed and enabled by new technologies, media, devices and techniques (Ives et al., 1997).

Knowledge management in scientific literature (Ives et al., 1997; McCampbell et al., 1999; Schulte, Sample, 2006; Moffett, McAdam, 2009; Jyoti, Rani, 2017; Gao et al., 2018) is named as one of many components of good management in the 21 century. Knowledge management "embodies organizational processes that seek synergistic combination of data

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and information processing capacity of information technologies, and the creative and innovative capacity of human beings" (McCampbell et al., 1999. p. 172). Knowledge management includes the creating, finding, collecting internal knowledge and best practices, then sharing and understanding those practices so they can be used, as well as adapting and applying those practices to new situations (McCampbell et al., 1999; Gao et al., 2018). There are several dimensions of knowledge management in all organizations including organizational structure, organizational performance (financial, employee, operational), learning culture, leadership, content management and technology (Schulte and Sample, 2006; Jyoti, Rani, 2017; Gao et al., 2018).

Analyzing contemporary scientific literature (Gao et al., 2018), reveals such areas of knowledge management as the diversity of the concept of knowledge management, different perspectives of process and stages of knowledge management, knowledge representation, organization and sharing, as well as performance measure for knowledge management.

It is highlighted that effective knowledge transfer often depends on such elements as teams, relations and networks, therefore currently grows up the importance of collaborative knowledge transfer researches (McCampbell et al., 1999; Schulte, Sample, 2006; Jyoti, Rani, 2017). Organizational culture and climate, the factors of information and people (employees) are underlined in the researches, as well (Moffett, McAdam, 2009). There are analyzed such knowledge management dimensions, as knowledge environment, teams, openness, transparency, welfare, support, experimentation, creativity, customer knowledge, risk taking, information capture, information flow and access, external and internal sources, employees' focus on knowledge management, flexibility and ect.). Besides that, it is highlighted the importance of technical climate (Moffett, McAdam, 2009; Jyoti, Rani, 2017). According to Schulte and Sample (2006), technology is not the most important dimension of knowledge management, at the same time most agree that technology enables knowledge sharing, integration and collaboration (Schulte, Sample, 2006).

The significance of knowledge management in military context is also undoubted. Innovation implementation, problem solving and decision-making are more complex and more essential in military situations than ever before. Similarly, practical experience, competence and interaction are also important factors in a military organization's ability to attain knowledge superiority. According to McIntyre et al. (2003), "command and control is taking on new dimensions, and the role of military personnel is evolving into that of 'knowledge worker'" (p. 35). Knowledge management, which facilitates the creation and use of knowledge for increased innovation and value, could have a profound influence on the challenges to be solved by modern military institutions (McIntyre et al., 2003). The review of scientific literature below could help to find out the application of knowledge management principles and techniques in the military context and to determine how knowledge management might be applied to the military environment.

3. Method

Systematic literature review is used as a method for this study. The data consist of theoretical, analytical and research papers retrieved from Web of Science Clarivate Analytics (VoS) (N=406) and Scopus databases (N=317) up to 2018. The only articles covering knowledge management issues in military are selected for the analysis. All together 723 articles were analyzed. The data are analyzed using the VOSviewer software for constructing bibliometric networks using keywords as well as content analysis. These networks are visualized and interpreted using general trends in knowledge management development.

The first step of the analysis is performed creating co-occurrences among keywords from the title and abstract text of the articles. The concepts "knowledge management" and "military" are used to detect a network of interrelated keywords. The keywords were filtered using pre-defined thesaurus words and clustered according to distances among them. Previous example using this method can be found by Holman, Lynch, Reeves (2017). Bibliometric networks are created using co-citation analysis. The network is based on Belli's (2009) assumption that co-citation trace the map of relationships among key concepts, that share some kind of intellectual similarity. In our research these similarities are reflected in bibliometric networks using VOSviewer software.

The second step of the analysis uses in-depth text mining. Term maps are created using a corpus of articles using the same using VOSviewer software. The composition of terms in the maps identifies the distance between two terms and represents the relatedness of the terms. Since we were interested in the trends of knowledge management research in military, the analysis was performed using year of publication as a metric. VoS and Scopus data were analysed separately and two maps were produced out of in-depth text mining.

4. Results

Three clusters (conceptual categories) are identified in the analysis. The first and the biggest cluster of research embodies management sciences and is represented by papers in leadership, strategic management as well as another field of military management. The papers analyze how knowledge management is used in planning and executing military operations. This cluster provides new approaches developed by investigating the emerging trends for knowledge exchange in military decision superiority (Bannister, Byrne, 2013), as well as classical military theories are re-examined using knowledge management perspective (see Boe, 2014). The second cluster consists of papers from highly diverse fields where an emphasis is made to integrate different approaches and develop a new attitude in military knowledge management. The researchers take the most challenging issues in military and provide new solutions. As sense making, decision making and learning are identified as a major activities where knowledge creation take place in the military (Mattila, 2016), an integration of these activities are a primal focus of the research. The third cluster represents studies performed in the paradigm of system management. The

stream reflects a range of technical solutions and best practices in knowledge management system development. Multiagent system to combat terrorism (Galka et al., 2009), fuzzy cognitive maps as a mediator in decision making (Perusich, Mcneese, 2006) and other solutions are presented in the papers of this cluster.

The visualization of all three cluster is presented in Fig. 1. An interrelationship of articles in VoS and their keywords co-occurrences is presented using VOSviewer software. As discussed, three big conceptual categories occur in the analysis. The first (blue) presents management and interrelated topics as leadership and strategy. This category is related to smaller stream that represents organizational learning. The second biggest (red) category is related to knowledge organization, coordination, decision making and other issues related to knowledge management. The third category (green) consist of systems and information maintenance. Identified categories serve as a framework for further analysis using text mining.

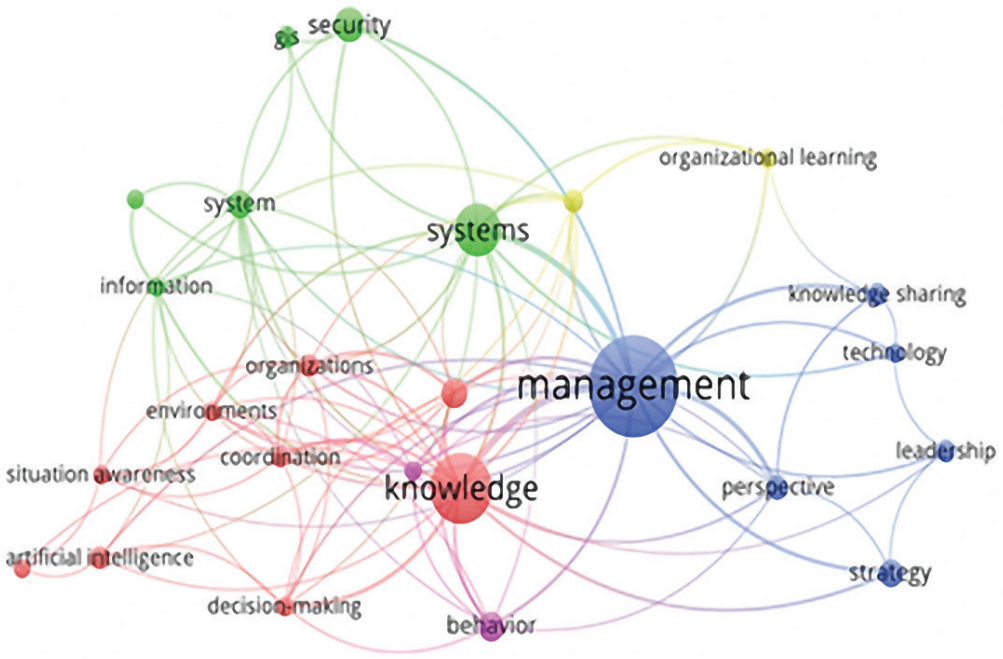

Fig.1. Main streams in knowledge management research in military: inter-relationship of articles

To identify main streams in the research on knowledge management in the military an in-depth text mining was performed. First, we analysed VoS articles. The analysis shows (Fig.2) the main research focus on information and clears research trends over time.

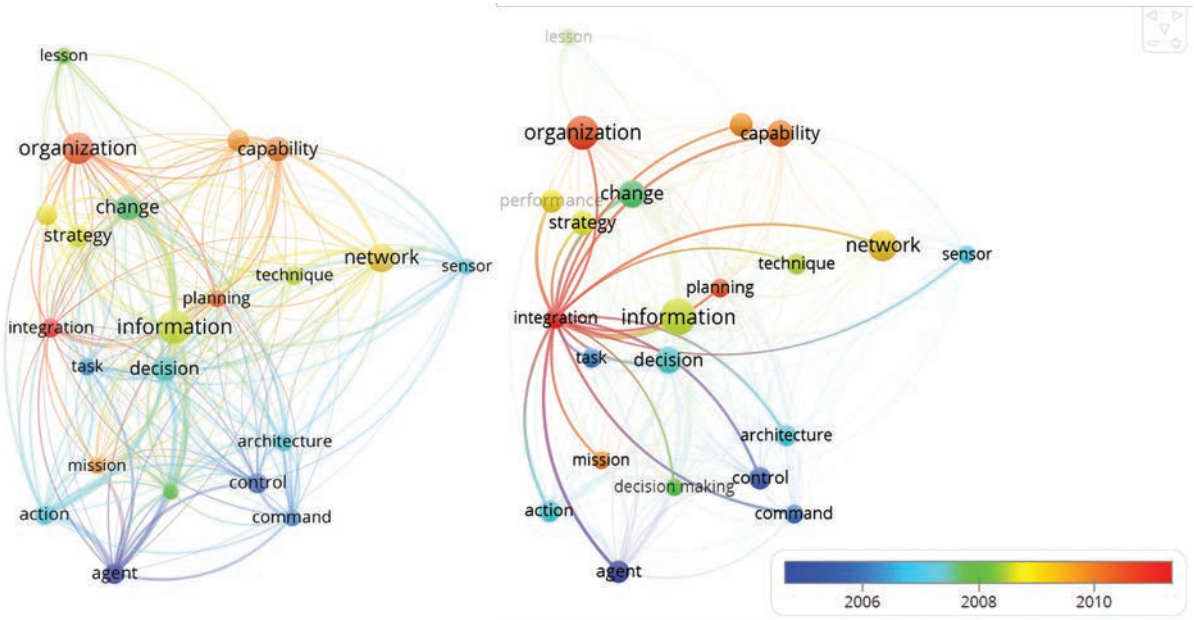

Fig. 2. Clustered results of text mining over time: VoS articles. a) clusters of different time periods; b) topic of integration and its interlinkages

The articles published before 2006 focus mainly on decision support systems and provide solutions for knowledge management architecture, change agents, present results form web generated sensor data and other technical insights. A short period of 2006-2008 provide research focused on command and control and continues a development of technical solutions as intelligent agents for knowledge management. The period up to 2010 is diverse in sense of research topics. We can find there information and techniques for knowledge identification and maintain as well as focus on knowledge management from the strategic perspective. However, the most recent trends in knowledge management in the military is related to knowledge integration issues. The articles analyse how to manage the unstructured data and integrate it into knowledge lifecycle applicable to military logistics planning (Fitzpatrick et al., 2013), how to integrate the domain knowledge for high-level reasoning (Pai et al., 2017) and collective understanding of the extreme circumstances (Godé, Lebraty, 2015). It is important to add that the topic of knowledge integration follows from previous topics as decision making, information management, change management and others (Fig. 2 b). Therefore the articles analyse not only the standards, methods and tools of knowledge integration (Varga, Bauer, 2017), but also the impact on assurance of efficient and effective solutions in military organizations (Tolk, Aaron, 2010), the significance to the quality of information management and evidence-based practise (Alexander et al., 2017), the interrelations with innovative solutions and other various types of changes in military (Barbulescu at al., 2003).

An analysis of Scopus database presents slightly different results as the dominant topic is related to a system instead of information (Fig.3). The most intensive period of knowledge management in military research starts in 2007. There similarly to VoS database analysis, the research focus is on technical issues as knowledge architecture, as well as on managerial questions related to command and control or lessons learned. The period of 2009-2010 is marked by a conceptual shift from system and information to strategy and decision making.

The most recent stream in Scopus database is related to strategy (Fig.3 b) which is interlinked with previous research on command and control, information users and etc.

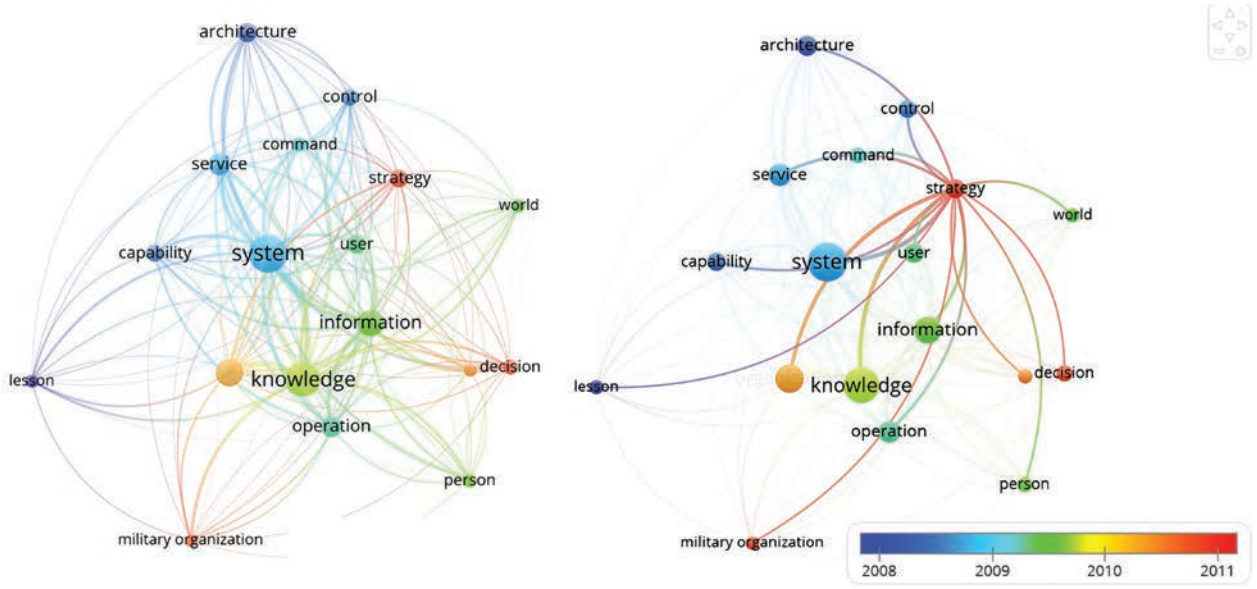

Fig. 3. Clustered results of text mining over time: Scopus articles. a) clusters of different time periods; b) topic of strategy and its interlinkages

The articles present cases of managing strategic science and technology projects in the military (Shore, Zollo, 2014), solutions for strategy development (Mattila, 2016) and decisions for military operations using knowledge management (Strakos et al., 2016). Also, the articles analyze innovative approaches of knowledge management strategies, as ignorance management in multinational organizations (Israilidis et al., 2012) or usage of video-based performance support systems for online management information system (Ruffner et al., 2011). Strategy approach towards knowledge management in military marks a new era in this research field. Knowledge management is perceived as a strategic resource for the organization. It also should be emphasized that strategy is closely interlinked with research of information management. The papers present such information management tools used in the military, as hybrid knowledge visualization (Eppler, Pfister, 2014), grid computer systems (Shrihari et al., 2015), model checking (Bernardi et al., 2015) and etc. There articles illustrates how strategy is converted into techniques and processes and flow from strategic to tactical level.

Conclusions

We conclude that knowledge management research in the military is performed in three streams where new ideas and solutions are developed. The larges stream identifies management science paradigm and represents classical approach in knowledge management. The second largest stream is created by researchers from diverse disciplines. This stream represents interdisciplinary perspective. The last and the smallest stream is predominated by technical solutions in the

military knowledge management. To identify main streams in the research on knowledge management in military an in-depth text mining was performed.

The analysis of VoS and Scopus databases showed the main research trends over time. The most recent trends in knowledge management research in the military are associated with knowledge integration (in VoS) and strategy (in Scopus). These two trends represent not only the most challenging issues but also outline the prospect breakthrough for the coming years in the field.

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EU-friendliness: a Point in the Checklist of Reforms

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Abstract

Organizational processes are often described as being "top-down" or "bottom-up". At the level of EU integration relations between EU and member-state institutions can also be conceptualized in these terms. European integration is based on decisions made by representatives of its member-states and member-states have a large degree of discretion in the implementation of EU policies. This gives off an appearance of a "bottom-up" quality to pan-European policy. But when it comes to part and parcel of public administration many national government agencies can only perceive this process "top-down". The complexity of policy design process and absence of co-ordination of how national agencies go about their business means that policy adoption is seldom straightforward across member-states. Once policies are set in motion, there are limited possibilities of review stemming from the "bottom". In some sense, this is the story of the road to Brexit. The paper claims that current challenges to European integration may in part be attributed to this institutional setup. This paper revisits the concept of European Administrative Space to see if it can be framed in terms of "bottom-up" integration, whereby essentially member states would be encouraged to test their proposed national reforms from the point of view of EU-friendliness. Proliferation of such a practice would not require any major legal change or governance process standardization. With proper monitoring the practice could augment the existing international co-operation between government agencies by opening venues for cost sharing, and streamlining the "top-down" policy decisions once political will becomes available.

KEY WORDS: *European Administrative Space, Convergence of Administrative Practice, Interoperability*

1. Introduction

2000s were a period of asserting and redefining the EU. Initiatives such as the Constitution for Europe, or the Treaty of Lisbon constructed a perspective of EU that went beyond being just a mere peace project. Rather EU was supposed to become the continents' vehicle for adaptation to globalization. EU leadership perceived United States and China as having economic dynamism to which EU had nothing to match. EUs fragmented and complex governance was and continues to be blamed for this lag. The 2010s economic problems in the Union have led many to believe that EU is a barrier, not a means for the adaptation to globalization. The most notable examples of EU decline of legitimacy are the "Brexit", and proliferation of Eurosceptic-led governments of the likes of Poland and Hungary. In many ways, EUs legitimacy now depends on finding a new mission more than in the 2000s. It is also true that EU now has less capacity to pursue that mission than a decade ago.

Until recently there has been optimism that EU has the resilience and capacity to adapt to new challenges, and many precedents do show that. Convergence in administrative practices among EU member-states (MS) has occurred as common goals and benchmarks necessitated (Cioclea, 2010). However, "Brexit" showed that no immutable law states that integration is a one-way street. In post-Eurozone crisis Europe policymaking as usual has lost the support of the public, and even the retention of status quo seems to be an achievement on its own. So much so, in fact, that integration concepts such as the European administrative space (EAS) have become seldom used in academia.

EAS literature has pondered the pursuit of common principles of public administration and the application of uniform rules in public administration (Torma, 2011). National administrations of EU MSs remain among the least-affected institutions by EU integration. And this is a problem, because the capacities to implement policy lie primarily with MS. A Europeanized administration on the other hand does not necessarily need to mean a breach of the Treaty or an infringement of sovereignty. It can mean better compatibility of administrative practices among MS, which would create possibilities for quicker and less burdensome adoption of EU regulation when such regulation is passed.

And the process of Europeanization of administration itself can be imagined in more ways than one. One venue we would like to entertain is measuring national reforms from the point of view of EU-friendliness in addition to measuring their effectiveness in achieving stated policy goals. EU-friendliness for the purposes of this analysis is best defined as the intended reforms' compatibility with similar recent reforms across Europe, stated policy agendas of the Commission, and adopted pan-European strategic documents. Application of such a test in the evaluation of reforms may yield better data on the benefits and costs of EU integration not only at the macro-economic level of analysis, but at the organizational level of public agencies. Reforms that appear to be suboptimal at one level of analysis may demonstrate a net-positive impact at the level of MS. And if proven otherwise – EU institutions might focus their policy measures to address these specific issues and thus regain its lost legitimacy and reinforce its relevance vis-à-vis globalization.

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2. What is the Endgame of Integration and EAS

EAS was gaining academic attention in 2000s, as some predicted further and deeper EU integration in the wake of its flagship policies of eastern enlargements, Schengen and the Eurozone. Despite the failure of some political documents, most notably the Constitution for Europe in mid-2000s, there was a belief that EU law is sufficiently harmonized in a sufficiently large number of policy areas for best practices in public administration to begin spreading (Hoffman, 2008). This, it was assumed, could lead to administrative isomorphism, which would allow claiming that EU will become a globally-relevant polity (Olsen, 2003). But more recent research suggests that European administrative space for all of its achievements is still a long way off to allowing EU achieve a status of an integrated polity (Trondal & Peters, 2013). One of the reasons for this maybe that some forms of isomorphism may not apply to member states due to internal institutional fragmentation. That is, if Europeanization occurs in one policy area, it may be far from certain that others will follow within that member-state. This is evidenced by some studies suggesting that public administration reforms based on the New Public Management model in the 1990s did not create convergence of administrative practices, rather – fragmentation occurred (Pollitt, 2001 & 2007). Agencification and policy inertia in the largest member states, where national governance traditions remain strong means that the "deep Europeanizers" are often the new and smaller member-states (Versluis, 2004). In other words, what the Council and the Commission hand down is not enforced in ways that are similar between MS.

However, institutionalist literature suggests that isomorphism can occur by means other than "top-down" policy of a nation state (DiMaggio and Powell, 1992). Research into institutions over the past two decades suggests that a carefully managed process may lead to the adoption of best administrative practices across policy areas and national boundaries, and through that, a commonality of governance may be built. In this case, the focus needs to be shifted away from policy issues and towards the process of public administration. National administrations very often act on behalf of EU in their jurisdiction – this is where capacity to follow through with policies lies. Therefore, effective civil services with sufficiently compatible governance processes is a key element for a successful development of EU integration. And the opposite maybe true – ineffective administration hinder Europeanization not only in the given MS, but may slow down the integration process. Essentially, national administrations impact the overall state of the EAS in multiple ways (Cardona, 2009). A positive view of Europeanized administrations may be extended to notions of capacity sharing, whereby officials from one country could help improve administration in another. Examples of this maybe found in places like the Frontex mission in the Mediterranean.

The formation of EAS was seen simultaneously as a cause and effect of convergence, creating a feedback-loop whereby previous decisions for integration necessitate future decisions. Eventually this could've led to a redistribution of capacities and competencies between national public administrations in favor of a unified European administration, with reduction of Member States' sovereignty (Torma, 2011; Cioclea 2010). Hoffman (2008) saw EAS as a process resulting in a common European governance model. EAS may also be framed as a collection of values, social expectations, certain management principles and statutory administrative standards, based on appropriate procedures and reporting mechanisms (Koprič, Musa, Lalić Novak, 2011). From this perspective EAS is the European emanation of "good governance". Descriptions of what EAS vary widely, from a structure indistinguishable from a European state, to a highly fragmented pool of shared values by government officials. A variation on theme of hard EAS versus soft EAS. The hard vision is, potentially, what makes integration politically problematic, while the soft version is hard to pin down in terms of what it may mean in practice.

3. The Criticisms: has the Animal Grown too Big?

EAS as is currently defined, it seems is unable to be a bases for further integration, as the principles of good administration can be enforced only on countries acceding to the EU. Once in the Union administrative reforms primarily follow the logic dictated by national political considerations (Kovač, Bileišis 2017). The implementation of these principles of good administration is one of the most important trends in the reform of public services in the candidate countries seeking accession to the EU. The White Paper (2001) issued by the EC states that the basic principles of the EAS are: the rule of law, openness, participation, accountability, efficiency, coherence, proportionality and subsidiarity. These principles are codified in many documents, from legally binding to less stringent policy, institutional and professional documents (Koprič, Musa, Lalić Novak, 2011). But it seems that EAS cannot advance beyond this point, because there is a realization among member states that reviewing specific institutional setups within EU is too difficult. While the example of "Brexit" demonstrates the "nuclear" option of countering unsatisfactory status quo by an MS, other less extreme examples are plentiful as well.

One objection to EAS suggests that constant harmonization of legal systems between MS does not mean that overall administrative convergence will be achieved (Skora, Mlynarkiewic 2003). At points of adopting and implementing EU legislation member states have a lot of discretion for interpretation and leniency. Therefore, some believe that EAS, if to be successful should include differentiated administrative reforms, and a reassessment of implementation model (Heidbreder 2009). Existing institutional diversity complicates inter-institutional cooperation within countries, not to speak of pan-European ideas. Overall, events of the past decade such as the Eurozone crisis, Brexit, and the coming of Eurosceptic governments means that a resurrection of EAS is only possible in a new guise, which would recognize the reality of highly fragmented and complex nature of MS administrative practices and regulations. The alternative seems to be conceding that the European animal has grown too complex for Europe's institutional ecosystem, and risk failing at the expense of all involved.

4. "Multi-speed" Failure of "top-down" Integration

EU has encountered many crises over its history, but has managed to retain its core of four freedoms. However, innovations that build of these freedoms causes serious challenges. One key challenge is that flagship initiatives such as Schengen area or Eurozone do not cover the entire Union. The notion of a multi-speed Europe occurs at specifically that point. Getting an agreement across the board on anything beyond the four freedoms proves illusive. While an institutional solution of incorporating only part of MS seems like a practical way forward, there is a risk of creating a byzantine system where an ever-smaller group of MS gets ever more integrated, until there is only one left. Therefore, a non-one-size-fits-all model must entail a certain institutional integration that would bare markers of a state. And solutions such as fiscal union risk leaving EU only with a tiny group of believer-states that would lack power to maintain other, more-widely adopted policies in the Union. It seems the current state of the Union is one of limbo. MS chose policy opt-outs creating core-peripheral regions within the Union. And this "multi-speed" reality is undesired as it sets a precedent for future fragmentation. However, not adopting it leaves pro-integration member states hostage to the ones lagging behind.

E. Macron's vision of fiscal federalization in one of retrenched "top-down" approach to integration of the Union. E. Macron wants the EU to become an economic powerhouse that will play a crucial role in a multipolar world order (Tiersky, 2018). The problem, he shows, is that the member states are too weak on their own to enjoy effective sovereignty in various fields: finance, economy, immigration, foreign policy, defense and in its current form, is unable to remedy these deficiencies (Simms, Shade, 2018). Macron's plan would create a much clearer two-speed EU than currently exists, with the 19 Eurozone countries on one track and the other EU member states on a second (Tiersky, 2018). It is one policy that could create a powerful center that could maintain the achievement of EU integration in the periphery. But the likelihood of implementing this decision seems low, and that is its weakest spot. Policies of this perspective may be effective in order to channel resources to the most socio-economically deprived areas. However, more prosperous MS will not accept such a solution without proper administration of funding. We believe that if in the long term new flagship integration policies are to be adopted a stop-gap measure is necessary in the meantime, one of "bottom-up" integration of administrative processes, and an accompanying collection of data at MS government agency levels of how EU policies can be made more responsive to national considerations. We propose to devise an EU-friendliness test for all national reforms, including the adoption of EU regulation.

Data gathered through the adoption of such tests may indicate to MS publics of the benefits and costs of not having a Europeanized administration. E.g. the Eurozone crisis has showed that decisions leading were critical for how MS faired during the crisis. And the reforms imposed on countries that found themselves being bailed out hardly focused on the Europeanization of their administrations. The crisis experience left the publics in these countries resentful of EU integrations (Vidmar Horvat, 2014). Although EU's ability to maintain peripheral areas aligned with its agenda is an important marker of the capacity and resilience of institutions, without a vision for the periphery and its development, EU risks losing the loyalty of some of the states if another similar crisis occurs (Dobrescu, Palada, 2012). A test of EU-friendliness may act as a means for all stakeholders to debate EU integration policy from an evidence-based position, and would allow EU institutions regain much of its lost standing with MS and their publics, and possibly build preconditions for new integrations policies whatever they may be.

Conclusions

Multi-speed Europe beyond Schengen and the Eurozone seems to necessitate a measure of federalization of core MS. We believe this is unfeasible at present. However, current EU institutions have lost much of their legitimacy in past decade and measures need to be taken to remedy this. Currently Europeanization is conceptualized as the process of adopting EU directives, regulations and institutional structures to the internal level and it is understood as the top-down influence of the EU on its Member States. "Multi-speed" Europe means an ever more complex governance at a time when rapid decisions are high on demand by businesses and citizens. In the context where decades of reforms have hollowed-out states, fragmented their hierarchies' addition public servant corps this can spell doom to the Union. In our analysis we suggest that the current level of debates of integration are unproductive because they only address the vision of integration and its political acceptability or otherwise. Whereas shining a light on the administrative mechanics that underpins any integration effort is necessary for any meaningful debate about what policies are feasible and what outcomes they are likely to achieve. This is a gap in both the academic and political discourse, which leads to conflicts among the multitude of EU and MS institutions. Our proposed EU-friendliness test needs to be well theorized, and grounded in the existing knowledge of EU and MS administration and policymaking, but it could serve to enhance the quality of integration politics.

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Influence of Social Media on National Security: Lithuanian Academic Youth Experience

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Abstract

The articles analyses the penetration of social media through personal use into daily life and the relation of this phenomenon to national security. A survey of Lithuanian higher-school students aged 18-29 was conducted according to quantitative research methodology. Young people actively use social networks for various purposes (personal, learning, work, recreation). Statistically, each individual, aged 18-29, has personal profiles on four social networking sites, yet most often does not adequately evaluate and link the use of social networks with possible national security threats and risk factors. Less than two-thirds of young people have heard something of possible threats and risk factors; however, the impact of social media on national security is not considered significant. Thus, it seems that young people lack information about real threats presented by social networks to both personal data storage and national security.
no more than 600 symbols with spaces (approximately 100 words).

KEY WORDS: *Social Media; National Security; Academic Youth, Generation Z*

1. Introduction

The spread and penetration of social media into everyday life are perceived as self-evident and natural phenomena. Generation Z is often identified with mobile technology, which, according to Ozkan & Solmaz [12], they use to interact with each other, maintain social relationships, etc. On the other hand, Facebook, Twitter, Instagram, etc. have become the inseparable elements of everyday social contacts for the representatives of previous generations, too. As Conti and Passarella [3] point out, today's media world is in close contact with the real model of human social behaviour. Such a close interaction between real and virtual worlds that helps solve everyday problems is often seen as a given that makes not only personal but also public life (e.g., e-government [6], business world [7], tourism [11] easier. However, despite these advantages, social media users irresponsibly use personal information, revealing it not only to friends or family members but also to other social network users [14]. Such, at first glance, innocent personal information display creates preconditions for a potential violation of privacy. As Thompson, McGill & Wang [15] point out, personal computer users are among the most vulnerable because of information security threats, as individuals often lack knowledge of technology as well as consequences of its use and have no ability to identify threats.

The problem of the research is to see how social media through personal use are related to national security. The object of the research is the impact of social media on national security. The purpose of the research is to reveal the impact of social media on national security.

2. Research Method

The research was modelled on the methodological approaches of quantitative research. The cross-sectional design model [5] was used to carry it out as it is the most commonly used one for research in a particular group. The construct of the research instrument was designed on the basis of theoretical considerations of the analysis of social networks [13]. The choice of the research model was conditioned by the peculiarities of the analysed phenomenon - as Carolan [2] notes, in the case of social network analysis, it often involves both the method and the theory, thus combining the aforementioned theoretical considerations of social network analysis and combining them with social constructivism [1] and knowledge management [9]. A questionnaire survey method was chosen for the empirical research. Indicators of measurement of the instrument used in the research were selected based on the meta-analysis data of scientific sources and the specific context of the legal environment characterizing the situation in Lithuania [10]: national security interests, contribution of conscious citizens to the development of the country's security and prosperity, information and cyber threats, etc. Young people (18-29 years old) born and / or raised in the digital age of Generation Z [4] and studying in different

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Lithuanian higher education institutions (Vilnius, Kaunas, Klaipėda)) were interviewed for the research. The subjects were selected by simple random sampling (n = 152[4]). The research involved 32.24% men and 67.76% women, 51.97% of the participants were studying at universities and 48.03% at non-university higher education institutions at the time of the research. It was conducted in March and April, 2018. Descriptive and inferential statistical research methods were used to analyse the collected data using SPSS 22 software package.

3. Research Results

Research data shows that young people (aged 18-29), who were born and / or raised in the digital age of Generation Z, enjoy a wide range of social media benefits – most often social networks are necessary for them to communicate with their friends (95.39%), to search for information (84.87%) and spend leisure time (81.58%), for studies (66.45%), to communicate with family members (66.45%) and share photos (50.66%), for work (or business) (44.08%) and discussions (35.53%), to share experience (25.00%) and videos (19.74%), to look for new friends (15.79%) and play games (10.53%). The results are presented in the Table 1.

Table 1

The purposes of using social media (%)

The purposes of using social media	Most often	Least often	Never
Searching for information	84.87	13.16	1.97
Games	10.53	62.50	26.97
Leisure	81.58	16.45	1.97
Learning (studies)	66.45	25.66	7.89
Work (business)	44.08	34.21	21.71
Communication with friends	95.39	3.95	0.66
Communication with relatives	66.45	26.97	6.58
Searching for new friends	15.79	51.32	32.89
Discussion (sharing opinions)	35.53	50.66	13.82
Sharing videos	19.74	63.16	17.11
Sharing photos	50.66	40.79	8.55
Sharing experiences	25.00	57.89	17.11

Research data shows that the prioritization of some goals is related to gender (e.g., communication with family members, $r=-0.246$, $p<0.005$) or age (e.g., communication with friends, $r=0.281$, $p<0.001$). On average, young people use four social networks (M=3.6), the most popular (see Fig. 1) of which are Facebook (98.68%), Youtube (93.42%), Instagram (73.03%), Google+ (43.42%).

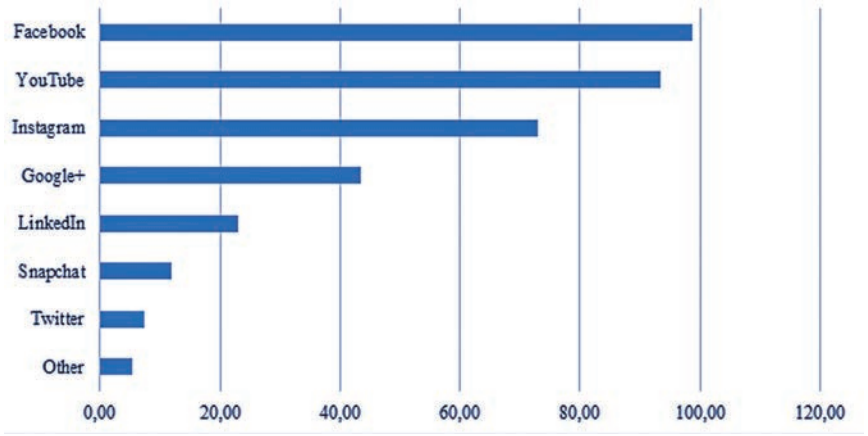

Fig. 1. The popularity of using social media (%)

Almost all young people (95.39%) who participated in the research have indicated their real name and post their personal photos (90.79%) on social networks (see Fig. 2).

4 Limitations of the research - the generalization of findings due to a relatively small sample of research is not possible; the results of the research show only a trend.

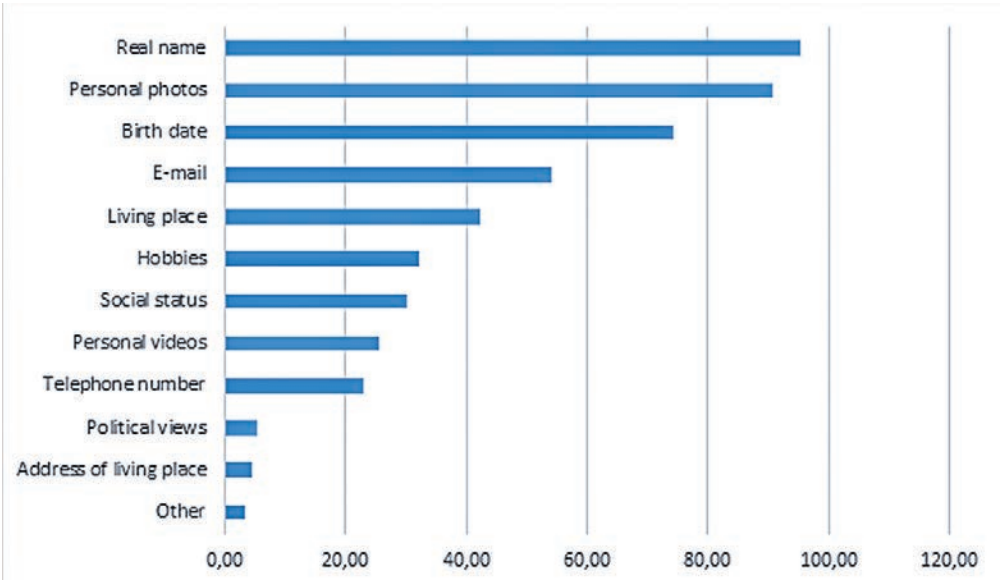

Fig. 2. Frequency of publishing personal information on social networks (%)

Also, most social network users have provided their exact birth date (74.34%) and email address (53.95%). One third has indicated their interests, a place of residence as well as a social status; a quarter has published their personal telephone number. 4.61% of the participants indicated that they have provided the exact address of their place of residence. Almost all young people connect to their social networking accounts with smartphones (99.34%) or personal computers (65.13%). A significant proportion (14.47%), however, regardless of any security requirements, uses public facilities in their education or work institutions. It turned out that only 48.03% of all the participants while connecting to social networks pay attention to the security of public and unprotected networks. Half of them refrain from joining such networks and the rest rely on their connection passwords. 94.74% use a password to protect their personal profile, the rest state that it is not necessary when using a personal device that only he/she alone uses.

Table 2

Awareness of threats, dangers and risk factors to national security (respondents' opinion, %)

Threats, dangers and risks to national security	Aware	Have heard	Unaware/ do not have an opinion
Conventional military threats	25.00	33.55	41.45
Disguised military and intelligence tools	27.63	40.13	32.24
Threats to the unity of the Euro-Atlantic community	21.71	19.08	59.21
Instability in the region and in the world	38.82	38.16	23.03
Terrorism, extremism, radicalization	59.21	27.63	13.16
Information threats	67.11	21.71	11.18
Cyber threats	63.16	25.00	11.84
Economic and energy dependence, economic vulnerability	36.18	28.29	35.53
The development of unsafe nuclear energy near the borders of the Republic of Lithuania	41.45	25.66	32.89
Social and regional exclusion, poverty	55.26	23.03	21.71
Demographic crisis	49.34	25.66	25.00
Corruption	64.47	21.71	13.82
Organized crime	52.63	33.55	13.82
National and international levels extreme situations	36.18	36.84	26.97
Crisis of values	37.50	28.29	34.21

A much more problematic situation emerges when a stranger sends a friend request - 2.63% accept all requests and 38.82% do that sometimes. The magnitude of the problem is highlighted by the fact that only more than half of all participants have heard about some of national security threats and risk factors (see Table 2; 67.11% have heard of information threats, 64.47% of corruption, 63.16% of cyber-terrorism, 59.21% of terrorism, 55.26% of social exclusion, poverty, etc.).

Table 3

Awareness of national security threats dangers and risks factors (Mann-Whitney Test by gender)

Threats	Gender	Mean Rank	Sum of Ranks	Asymp. Sig.
Conventional military threats	Male	62.21	3048.50	0.004
	Female	83.30	8579.50	
Disguised military and intelligence tools	Male	65.42	3205.50	0.025
	Female	81.77	8422.50	
Threats to the unity of the Euro-Atlantic community	Male	66.88	3277.00	0.042
	Female	81.08	8351.00	
Cyber threats	Male	63.77	3124.50	0.01
	Female	82.56	8503.50	
Economic and energy dependence, economic vulnerability	Male	64.00	3136.00	0.012
	Female	82.45	8492.00	
The development of unsafe nuclear energy near the borders of the Republic of Lithuania	Male	61.51	3014.00	0.003
	Female	83.63	8614.00	

The findings of the Mann-Whitney test show that women know about the identified national security threats and risk factors statistically better than males ($p<0.05$); in terms of educational institutions, college students know about the threats statistically better than university students ($p<0.03$). The results are presented in the Table 3. Of all the participants in the research who have heard something of possible threats to national security and risk factors only 74.34% associate the spread of information threats and 65.79% of cyber threats with the use of social networks.

Table 4

Awareness of national security threats dangers and risks factors
(Mann-Whitney Test by study institution)

Threats	Institution	Mean Rank	Sum of Ranks	Asymp. Sig.
Disguised military and intelligence tools	University	64.88	5125.50	0.000
	College	89.08	6502.50	
Threats to the unity of the Euro-Atlantic community	University	67.79	5355.50	0.005
	College	85.92	6272.50	
Instability in the region and in the world	University	66.35	5241.50	0.002
	College	87.49	6386.50	
Information threats	University	69.32	5476.50	0.027
	College	84.27	6151.50	
Cyber threats	University	68.59	5418.50	0.016
	College	85.06	6209.50	
Economic and energy dependence, economic vulnerability	University	67.47	5330.00	0.006
	College	86.27	6298.00	
The development of unsafe nuclear energy near the borders of the Republic of Lithuania	University	66.09	5221.00	0.002
	College	87.77	6407.00	
Social and regional exclusion, poverty	University	64.85	5123.50	0.000
	College	89.10	6504.50	
Demographic crisis	University	66.30	5237.50	0.002
	College	87.54	6390.50	
Corruption	University	69.64	5501.50	0.037
	College	83.92	6126.50	

More than 60% do not see any possible links between all other national security threats and risk factors and the use of social networks. In this regard, there are no differences between male and female opinions. However, regarding educational institutions (see Table 4), the findings of the Mann-Whitney test show that college students statistically see potential links more often ($p<0.01$).

Conclusions

Young people actively use social networks for various purposes (personal, learning, work, recreation). A statistical person, aged 18-29, has personal profiles on four social networks, yet most often does not adequately evaluate and link

the use of social networks with possible national security threats and risk factors: relatively often accepts friend requests from little-known people, posts a lot and various personal information, does not deter from using public computers and unsecured networks. Less than two-thirds of young people have heard something of possible threats and risk factors; however, the impact of social media on national security is not considered significant. Thus, it seems that young people lack information about real threats presented by social networks to both personal data storage and national security.

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Management Presumptions and Possibilities of Human Resources Formation

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Abstract

Scientific researches were carried out when deepening into the problems connected with the fields of human resources and their formation, possibilities and activity perspectives. The aim of these researches was to clear out management presumptions of human resources formation influencing regularity and entrepreneurship orientated towards up-to-date problems as well as to present their formation possibilities. In the article the object of the research was analysed at both general and organizational levels. Following the results of the carried out researches, management presumptions of human resources formations were grounded, the characteristic of the competences of the alternation, as one of the processes in the processes of the development and progress of system elements, was presented in the article. The systematic approach towards entrepreneurship as well as towards the groups of factors influencing it (from the management viewpoint) was emphasized in the article. The further directions of the researches of human resources formation were directed in the article.

KEY WORDS: *Human resources, Regularity, Entreprerneurship, Competence*

1. Introduction

Considering globalization processes under conditions of society transformation, managerial theoretical and practical provisions of requirements for entrepreneurship and professionalism, which form human resources are brought up-to-date. In a constantly changing environment, the necessity arises for constant researches of these problems and deepening into the level of the problem's investigation by searching for new decisions' measures and ways.

In the interface of millennia, under rapid progress of science and technologies and emergence of new possibilities and perspectives of social and economic development, today's period of our generation is characterized by expressions of radical changes and obliges to realize development strategy as essential human activity process, unity of nature's and human activity's worlds and necessity of complexity in society's development and progress (Melnikas, 2012).

Intellectual resources become the main source of business subject's stable competitive advantages formation, increase of their potential market value and satisfaction of dynamically developing users' needs. Thus, knowledge become an intellectual resource or active of any business subject or organization, which requires for highlighting of consistency of their functioning, systemic assessment of interaction with other economic factors, economic attitude, spread and efficient use. The problem of management of intellectual resources is one of the newest fields of management theory, and it is given a lot of attention worldwide and, first of all, in the western countries (Brooking, 1996; Sveiby, 1987; Strassman, 1998; Stewart, 2003; Edvinson, 2002). However, until recently, in scientific community there is no united opinion in examining the concepts, structure, most significant factors of intellectual resources, ways and measures of their management.

Insufficient level of knowledge and knowing for efficient management of organization describes the main presumption of human resource formation. Possibilities of human resource formation reveal how to develop that level and make human resource management more efficient: the use of intellectual resource management and knowledge/knowing; research and analysis in the process of individual's competence education by forming and developing the systems of training oriented towards development of competence; assessment of qualified counseling by determining the need for education, using career development modelling methodologies to tackle them. Thus, *scientific problem* of this article is insufficiently revealed human resource managerial formation presumptions and possibilities as well as their management.

Present time could be described as a society of knowledge and organizations. In economic sense, knowledge is valuable only in so far as it is realized by creating a new value and performing a certain purposeful activity. According to H.V. Perimutter (1997), any organization in becoming of global civilisation, which is professing to become competitive in global market, must orient its activity towards a global problem and to develop three main managerial abilities in paradigm of change: thinking of global civilisation, literacy of global business, competencies of conventionalism mastering.

Considering assessments of modern situation and possible perspectives, the presumption is done that human resources are formed, in perception of systemic attitude, by activity organization (entrepreneurship) and professionalism education in mankind's development and change of processes of progress evolution.

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The object of the researches analysed in the article: aspects of human resource formation professionalism and entrepreneurship, ***goal:*** to highlight managerial presumptions of human resource formation affecting professionalism and entrepreneurship oriented towards modern problems and present possibilities of their formation. *Research methods used:* scientific literature analysis, systemic, logical analysis and synthesis, summarizing, induction and deduction.

2. Essence of Human Resource Formation

Human resource formation is related to activity of various presumptions. The main presumptions are managerial, economic and social ones. Human resources are individual and collective knowledge, skills, talents, professional competencies, abilities, psychosocial state (e.g., commitment, motivation) of the people working in the organization, learning of employees, creativity, novelty, power to create additional value to a customer. And the ones influencing efficiency of organizational activity with certain competencies (creative abilities, leadership, entrepreneurial and management skills, knowledge, organizational abilities etc.) by decision making and realization. Human activity is one of the main factors of production, however, it is not the only - natural resources and capital are also important in product's production (Martinkus, Sakalas, 2003). It is important to identify weak and strong sides of human resource potential and to understand how it enables organization to act spectacularly and gain an advantage against its competitors.

The basis of intellectual resources consists of knowledge that form the biggest part of additional value created by society, and intellectualization of the used technologies guarantees a strong growth of productivity. Intellectual resources can be perceived as a good and possibility of knowledge availability and use in market's area usually depends on the fact if knowledge is a value of public or private property.

Human resources have to be perceived as organization's employees with particular competencies who influence efficiency of organizational activity by decision making and realization. Significance of human resources, that now got the name *human capital,* that reveals another aspect, constantly increases. In order to ensure efficiency of use of human resource, there should be created an organizational culture based on declared organizational values that would be acceptable to all employees. It is important to identify weak and strong sides of human resource potential and to understand how it enables organization to act spectacularly and gain an advantage against its competitors.

Human resources, i.e. people, unlike so called technological miracles, have a genetic, not a constructed - artificial, programmed - intellect, mind. They consciously, not mechanically react to managerial decisions: tasks, orders, instructions. These managerial instruments can stimulate enthusiasm for ones and have a suppressing effect on others. Manager using these resources must take into account intellect, temperament, character, instantaneous emotional state. They have a possibility for constant development, adaptation to technological, administrative and other changes taking place and implementation of the tasks determined by the latter. Naturally, that also depends on human's personal goals, strategy and policy of human education characteristic to the organization (Jančauskas, 2006).

All named elements and features of human resources in scientific researches are used in the context of knowledge society formation.

In modern world, change became a normal and constant phenomenon and transformations taking place in society can be considered an essential condition of global development and progress. The word "transformation" is associated with changes, therefore, while applying this concept to society as a social system according to B.Melnikas (2012), social transformations should be treated as quantitative and qualitative changes determining formation of society's life style substantially new, future or characterized by new qualitative level. In order to implement reforms successfully, not only a systemic approach is important. Knowing has a significant meaning - what needs to be changed and foreseen, how it should be done, to foresee change (reform) strategies.

P.Dalin (2001) considers change as adaptation and education. Perhaps, a training as organization of change could be measured most significantly by five disciplines of learning organization presented by P.Senge (1990): Creation of general vision as managerial problem; Systemic thinking as problems of scientific researches and counseling; General (made) thinking models as formation problems; Training by team/in team as methodological problems; Personal mastership as problem of responsibility.

Therefore, strategy of change during formation of human resources in entrepreneurship and professionalism aspect should be characterized by characteristics of active position, overcoming of limitations, sustainability through systemic approach and formation of this attitude. Thus, human resources can be looked twofold: first, as already existing ones that could be distinguished, studied and described - direction of cognition, second, as the ones under creation, formation - direction of action, and, in current situation, this is a necessary condition for formation of human resources in education of competencies of professionalism and entrepreneurship (Adamonienė, 2005).

3. Systemic Attitude Towards Entrepreneurship in Managerial Aspect

In the area of human's mental activity, mind, there exist two directions of research of objects, phenomena or processes - analysis and synthesis. By analysing there is a striving to understand essence, structure of the analysed object, phenomenon and to look for answers to questions - of what elements the object consists, what is its structure, what are internal relations and links, what are characteristics of the object and its constituents, how they could be changed towards desired direction, etc. Synthesis is expressed in striving to connect individual components into one totality, to analyse the object, phenomenon not in isolation, but in relation with external environment in which it exists and functions. During coordination of analysis and synthesis, systemic attitude is very significant – an ability to see and cover objects not only by highlighting their internal structure, but also by assessing it in the environmental context. During this particular time

there show up two directions and their synthesis: the first, related to social sciences (state and law theory, sociology and social psychology, history), the second is related to expansion of practical intellect (in areas of policy, administrative law, big industry mass production formation). The process of this synthesis has managed to fuse two types of activity: research (objective-ontologic) and design (organizational) which existed before, however their activity results transformed independently from each other.

With regard to development of management science, starting with period of A.Smith (according to Simon H.A., 1947) and focusing on the main studies of fundamental science on strategic management by A.D.Chandler (1962), H.I. Ansoff (1965), K.Andrews (1965), according to R.Jucevičius (1998), it can be noted that management is concurrently related to economic organizational theories or economic organization forms. By that a presumption should be done that change of activity conditions, which determines necessity of strategic management or mankind development and progress, influences entrepreneurship as reproduction of human lifestyle conditions.

In scientific literature, entrepreneurship is analysed in two main aspects. On the one hand, scientists describe entrepreneurship differently: some state that entrepreneurship is an incentive, others state that it is inborn and acquired human characteristics that allow him to think innovatively and act actively and risk. On the other hand, despite entrepreneurship is often perceived as expression of human characteristics and abilities in activity, external factors stimulating the entrepreneurship are not less important.

Summarizing, there can be distinguished two main groups of factors determining entrepreneurship: internal and external factors. Internal factors determining the entrepreneurship are related to employee's personal characteristics (activity, responsibility, persistence, determination, diligence, economy, activity, self-reliance, self-expression, factor of communication, tendency for novelties, susceptibility to information, self-motivation, cooperation, organizational abilities, ability to manage, etc.), motivation to take business (striving to be independent, desire to show own abilities, to create own work place, to implement own idea, need for self-expression, etc.), with knowledge and abilities available. External factors are related with certain environment: political, social, legal, economic, technological. These environments influence business and determine its changes. At the same time business affects environments and determines their change (Adamonienė, 2008).

Presumption is done that change of activity conditions which determines necessity of strategic management or mankind development and progress is ensured by entrepreneurship as reproduction of human lifestyle conditions, and mind development as substantial result of society's development and progress forms managerial (socio-technical) activity that enables differentiation (specialization in segments) of managerial competencies in human resource formation.

4. Entrepreneurial Segments of Human Resource Formation

Literature analysis and studies of management theories and concepts created a possibility to distinguish and to formulate for this case four entrepreneurial segments of human resource formation.

The formulation of the first entrepreneurial segment was enabled by studies of modern management science theories and concepts to which there should be ascribed „The Guru Guide: The Best Ideas of the Top Management Thinkers" (1998), which presents managerial factors, mega-skills, principles, characteristics, values and truth (studies of W.Bennis, B.Nanus, J,O`Toole, S.Covey according to Boyett J.H., 1998); names the main managerial concepts and strategies of organizational activity (studies of A.M.Brandenburger, P.Drucker, G.P.Hamel, H.Minzberg, J.F.Moore, M.E.Porter according to Boyett J.H., 1998); distinguishes the main processes influencing organizational change and prospects (studies of W.A.Pasmore, R.Jacobs, J.Kotter, D.Conner, P. Strebel, P.Barwise according to Boyett J.H., 1998). The first entrepreneurial segment presents management factors, mega-skills, principles, characteristics, values and truth; names the main managerial concepts and strategies of organizational activity; distinguishes the main processes influencing organizational change and prospects. This is an entrepreneurial segment of execution, oriented towards conceptual knowledge you must know, you must know how to use them as principle rules and requirements, and without which any action is impossible. It should be ascribed to speciality knowledge and proficiency that have to be repeated and renewed constantly.

Distinguishing of the second entrepreneurial segment such as managerial skills, abilities, knowing how to orient in changing environment and act according to situation was enabled by studies of modern management science theories and concepts orienting towards modern global situation, socio-political context, international economy and competitiveness, updating globalization and multinational corporations, international financial market, strategic management of changes in undefined future world. These are the scientific studies of A.Reis, J.Traut, P.Senge, T.W.Dunfee, J.Mahoney, S.Garelli, P.Strebel, P.Barwise, J.D.Wood, S.J.Kobrin, which, in the context of professionalism and entrepreneurship for human resource formation, are raising the necessity of managerial qualifications and competencies for execution (working skills and abilities), organization (abilities and knowing how to organize employment and occupation), counseling (knowing and ability to execute future activity), i.e. upgrade the direction of organization activity in order to ensure functionality of activity. This is ascribed to a practice of professional activity.

To the third entrepreneurial segment of human resource formation there is ascribed the activity based on innovation, formation of new attitude, future creation oriented towards strategy of change paradigm. These are fundamental scientific studies of P.Drucker (1964, 1985, 1993), J.Naisbitt (1995), R.M.Kanter (1995), S.Dombergs (1998), A.Tiwana (2002), Watermann R. H. (1988) that brings up-to-date the concept of educated human, importance of new knowledge creation, value of mentality formation. This is prescribed to "marginalization" - overcoming of traditionalism, disability, inaptitude, limitation of unknowing (Adamonienė, 2005, 2007, 2013).

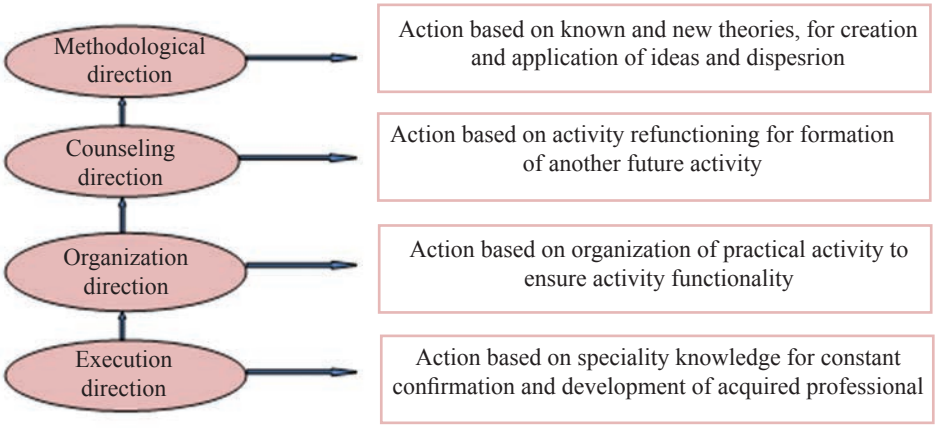

Fig. 1. Entrepreneurial segments of human resource formation

The *fourth* entrepreneurial segment is based on creation of ideas, dispersion, search for new methods, tools for creation of new knowledge. Therefore, methodological problem becomes more topical today (1 figure).

Thus, based on that, there was created a theoretical human resource formation model in managerial aspect (2 figure), which presents the processes directly taking place in change and formation of future (from direction of increase of cognition to activity efficiency).

Keeping in mind society's transformations in policy, economy, technologies, information and social fields and uncertainty of the future, human resource factors become one of the most significant. On the other hand, we become participants of modern society change - "economic human" and a phrase "we know what he wants" give the place to "mosaic human" and a phrase "nothing needs to be changed, it needs only a different thinking and the world will change".

In point of view of management strategy, purpose of organization of change, in aspect of human resource formation, is education of entrepreneurship and activeness, not only to organize or to be organized by others, but growing of knowledge, abilities and powers in order to organize occupation and realize the idea where strategic is not change itself but organization of change and its management. In other words, strategic is what is "doing" but not "what is done".

Interest in the problem of intellectual resource management is related to the sixties of the last century when post-industrial society started forming in the most developed countries of the world.

Economic activity has always been based on knowledge. Knowledge, energy resources and organization are the primal factors people used in the past and take care of them now. Production technology is nothing else than knowledge-based activity of human groups and individuals. On the other hand, the resources provided by the nature depend on knowledge. Thus, gathering, transferring and enriching of knowledge become a focus of society's progress.

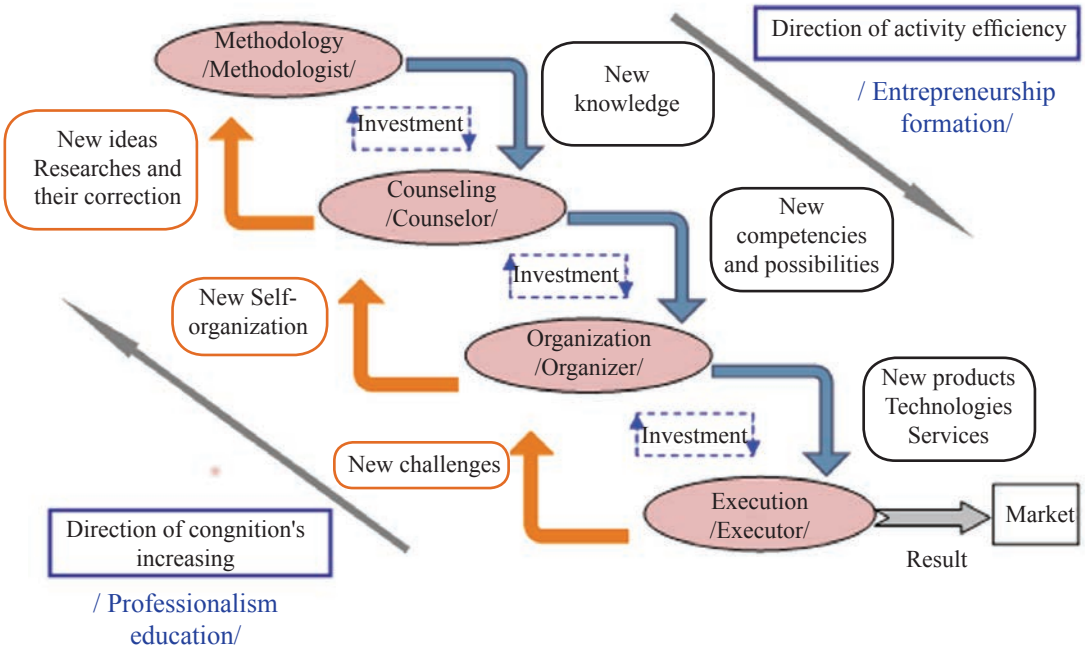

Fig. 2. Model of human resource formation in managerial aspect

Knowledge economy society is characterized by few distinguishing features. First, knowledge directed towards products and services forms a big part of additional value created by society. This can be explained by the fact that intellectualization of the used technologies guaranties strong growth of productivity. Another feature - susceptibility of goods and services to scientific knowledge grows systematically. Besides, the market is literally dominated by intellectual goods and services. Intellectual products and services are taking more and more solid positions in the international markets. Due to the mentioned phenomena, production, protection, recycling and use of intellectual resources in knowledge-based economy obtain a substantial meaning and significance. Special role in this activity field falls on education, nature and importance of which are changing most of all.

Having summarized presented facts, there is a possibility to indicate qualitative peculiarities of knowledge economy that describe it as a way of society's advanced production (Klimov, 2000; Milner, 2003). One of the peculiarities - pace and scale of scientific technical progress are so notable that modern material production base and quality of labour resources do not correspond the progress possibilities. Another peculiarity - growth of transactions costs related to information search, market research, contracting and control of contracts' execution, protection of property rights etc., which can be assessed as a result of increasing competitiveness. Another characteristic of knowledge economy is a highly increased role of intellectual resource management.

While analysing intellectual resources in the context of economic activity, we are facing two living contradictory attitudes. On the one hand, knowledge, abilities and other components of intellectual resources are similar to all known production factors. Second, it can be indicated that such resources are a special, distinguishing potential of economic activity. Besides, there is an opinion that functioning of intellectual resources directly contradicts the main principles of economics.

Considering that such opinion is correct that would mean that knowledge cannot be treated as object of economic and market relationship. Therefore, knowledge is emphasized as economic value as well.

Knowledge is not for sale directly, but goods and services are being purchased and sold, and, which is the most important, decisions taken are based on knowledge available. Usefulness of the latter to customer depends on the value of decisions. It can be stated that situation of information that is as if working intellectual resource is different. Information based decisions are taken independently by using information together with knowledge available. However, in this case as well, there also is no preliminary valuable information available. The degree of value of the latter depends on the level of decisions taken on its basis. It is obvious that knowledge value is determined by the value of decisions available. While managing business processes, decisions can be changed, however, knowledge can't be changed (Adamonienė, 2005, 2007, 2013).

Principle of limitations of goodies states that any value characterized by usefulness is involved into the system of economic relationship due to its rarity in comparison to society's demand for it. However, it is clear that this provision is not inherent to knowledge as economic resource. It is considered that principal difference between different kinds of resources and knowledge is forming because of the excess of the latter (Stewart, 2003). Thus, value of knowledge as a resource is determined according to availability by applying it to tackle the problems, and not only the intellectual, but, first of all, economic, social, technical or behavioural ones.

Researchers many times tried to justify analysed categories of information and knowledge. One of them is R.Ackof (1972), a well-known expert of systemic research field, who proposed the use of human consciousness content analysis scheme that is being adapted and, in the recent period, consists of five concepts. It is obvious that every primal concept is a stimulus, or some kind of source for further new quality concept to appear. R.Ackoff indicates that first four components are related to the past, that means, to what was and is known, and the fifth - wisdom - is directed towards the future. Later in the literature on knowledge management, the scheme proposed by R.Ackof was modified (Bellinger, 1997), by composing it of four components: *Data - Information – Knowledge – Wisdom*, and it was named *DIKW*.

Data is a fixed but not arranged symbols, single primal facts on observed real objects, processes, phenomena, particular human activity, treated independently in any context. Usually data is grouped, differently summarized, rearranged by giving a content of information to it. Data directly has no big value, however, it is convenient to be kept in one or another form. In the processes of individual decision making, data sometimes is used directly.

Information is understood as a fixed and processed data that, during the process of thinking and understanding, is given a meaning and goal, i.e. prepared for further use. In other words, any striving to interpret, make presumptions, foresee content, i.e. gives a particular context, turns data into information. It has higher value than data as it is used for assessment of real situation, decision making. However, information is defined insufficiently and could be differently understood by subjects and explained ambiguously.

Knowledge is a determining of tendencies or substantial relations between phenomena presented in information. It is kept in people's minds and is very valuable, because, based on it, there are created new ideas, events interpreted. Unlike information, knowledge itself creates the context and can be guidelines of particular management decisions and factors. Knowledge management is sophisticated because knowledge is a product of human mind nature, it is invisible and unmeasurable and its use and transfer to other individuals depend on motivation of the transferring person. Knowledge has no value if it is not used for achievement of practical and useful goals.

Understanding expresses a regularity existing in most scattered knowledge, which gives an answer to the question "Why?" Understanding in *DIKW* model has not gone anywhere and became one of the coordinate axes determining knowledge vector, the second measurement is independence from the context.

Wisdom. In this stage of knowledge vector formation, there take place a summarizing of information and knowledge and highlighting of their systemic principles and regularities in point of view of the past and the present. Moving towards

knowledge vector from data to wisdom is not a mechanical summing up of information and knowledge. Rather it is assessed understanding of regularities in point of view of the civilisations' past and present. Sometimes, wisdom forces to keep under cover till a corresponding time the knowledge that society is morally unprepared to use.

In scientific literature there are known other knowledge management models that help to determine stages of knowledge formation. One of them was proposed by T.Durand (1996), who raised experience to a much higher grade - content of competence. In this case, knowledge is created gradually by information accumulating and turning into a system of attitudes that provides consistency and structure to a gathered base of knowledge. Information is not only a simple data. This is data that has been recognized, selected for processing and adapted for a corresponding structure of knowledge. On the other hand, experience has to be interpreted as a higher grade of knowledge which covers a level of competence. Experience is not only prescribed to the level of substantially progressed competence, requires not only a coordination of knowledge and knowing, but also an ability to understand, explain, act in the field of competence. In certain points the experience exceeds the competence due to a substantial jump in the level of competence and re-combination and merging of various elements of competence. In other words, there exists such sequence of stages of knowledge change that leads from data and information to knowledge and experience.

Intellectual resources became the main source of acquiring of stable competitive advantages for business organizations of any type, increase of their potential value and satisfaction of dynamically developing needs of customers.

Under market economy conditions, value of people's work, value of products and services realized by enterprises depend on used information and knowledge. Therefore, organizations must learn to manage intellectual resources because they became the main resource of economic activity and their efficiency in point of view of use became the framework factor allowing to determine market's demands and to satisfy them in innovative way (Adamonienė, 2005, 2007, 2013).

All innovative processes are being managed by a human who is considered to be the main element in modern organization. Most changes in labour market that were analysed by management scientists Greenhaus H.J., Goldshalh M.V., Hartung J.**,** Drucker P., V.W.Cascio require human's ability to act in a changing situation by taking responsibility for the tasks delegated to him. The same responsibility comes for own career. Under market conditions, everyone has to take care of own qualification and its development and show an initiative: to select and keep or create a prospective working activity that corresponds abilities and helps to realize themselves in full and to ensure material security. Human's wishes, needs, goals, interests are reflected in his career in formation of which there participate both the organization and he himself. Career, as activity of the organization and the human, is influenced by various factors and environmental changes.

Career theory is often analysed in cultural aspect by assessing differences of individuals. Each individual is different and unique. Differences of individuals are expressed through their abilities, needs, goals and interests. Meanwhile, abilities and interests are affected by constantly changing environment and such factors as social status, gender or dependence to some ethnic group. It is considered that future working society will be older, the number of working women will increase. Drucker P. states that one of the most striking characteristics is a strong decrease of birth rates in developed countries and at the same time increase of elderly people.

There are distinguished few reasons due to which career concept remains and ideas of its progress inside organization or another activity expand. One of them, career, is dynamic in time. This enables individuals to assess their abilities. Individual can asses his working life by interpreting the past in the context of present situation. Thus, they can correct their future goals. Career concept still can be used in organization. In order the organization to be able to achieve its goals, activity advantage, it needs to strive for full use of employees' potential.

Changing work structure and content require for new skills and abilities, the need for employees of higher competence shows up, however, due to the same reason the existing works and the employees performing that work are being eliminated. Another aspect of increasing technological level - employee only services and maintains modern technological equipment; increased demand for highly qualified employees; employees' without high qualification supply - demand balance is changing.

High competitiveness and market globalization have impact on changes inside organizational structure. H.J.Greenhaus states that bureaucratic organizations characterized by stability and certainty will be changed with organizations of new structure possessing the same characteristics: a small number of the main employees (remaining contingent consists of part time employees and employees working according to the specific temporary contracts); flat hierarchy with self-government groups responsible for main organizational activities; rapid integration of new technologies to work process; intense creation of alliances with internal and external partners.

Environment of high competitiveness requires for high level of flexibility from the organizations. And that, according to H.J.Greenhaus, creates presumptions for organizations to use short time transaction contracts. Employees are expecting the flexibility in respect to new structure job and a development of new skills depending on organizational need. Organization, in turn, is not committed to the employee by long term employment, however, it creates possibilities for career, i.e. further professional growth and development. That determines changes towards employees' career attitude and formation.

Career, its management was analysed by many Lithuanian (A.Sakalas, A.Šalčius, Petkevičiūtė N., A.Valackienė, V.Stanišauskienė) and foreign authors (H.J.Greenhaus, M.V.Goldshalh, P. Drucker, M.Segalla, D.Rouzies, M.Flory et al.). A human spends a significant part of his life in organization (in the course of working activity). Relationship of employee and organization and striving for their mutual benefit is best illustrated by the statement of J.W.Newstrom: "organization needs employees to achieve enterprises goals, and employees need organization to realize their human goals, needs and interests".

Foreign literature analyses career in two approaches: career as a structural achievement of profession or organization

and career as an individual achievement. *Career as a structural achievement of profession or organization.* This attitude is illustrated by a presented career as a sequence of particular positions or "ideal" profession of a practitioner. Career can also look like a climbing „stair" in a particular organization. *Career is an individual achievement*. Everyone gathers unique part of work, position and experience, and that determines different career of each person. Thus, individuals have to understand what type of career they want to achieve and to strive for it by taking certain decisions.

Most employees do not analyse their abilities and career goals not because they don't want but because they pay no attention enough to that. It is an organization that should stimulate self-assessment and to create conditions for that. During counseling conversation, an individual can reveal his preferences and assess own possibilities. At the same time, it is purposeful to find out personal problems because they determine individual's career aspirations. While foreseeing real career goals, individual needs to know its possibilities and boundaries in the organization. For that purpose, the organization has to familiarize employees with forecasts of demand, to inform constantly on new jobs (Greenhaus, 2000).

In modern society, there efficiently work the organizations which are running such policy as rational work regime, space creation for initiative and creativity, give a priority for own employees for career or follow the principle that employee looks for job but not vice versa. In this case, every employee is an activity partner. Professional career, its real ensuring is a particularly vital, spontaneous, originating from human nature source of activation of staff members, their initiative. Career management application in organization helps to use efficiently employees' possibilities, increase confidence in own skills, ensure constant increase of number of qualified professionals, satisfy the needs for development of employees' potential and professional growth.

Global practice indicates that human is preparing for career in a pre-school age already. There exist integral structures of preparation for career, which bring together education institutions, the government, trade unions and employers. Efficient organizations are interested in professional growth of all employees, take care of their career and offer different programmes of its planning. And that gives a tangible benefit both to employees and the organization, because career planning allows to relate the plans of employees' professional growth with organizational tasks. When career of individual employees is directly related to organization, they are more interested in the problems, participate their tackling, are interested in success of the whole organization. In this case employees are caring themselves about their qualification refreshment, professional knowledge deepening and renewing, higher use of own possibilities. This is evidenced by the fact that professional career begins with the human's birth and plays a big role during human's entire conscious life.

During different changes, big emotional and economical transformations are being experienced, there are changing entire fields of human life between which there distinguishes a change of working world. New changed conditions of the present are direct challenge for an individual because they are reflecting in human's activity and behaviour. People's working life, professional career models are changing as well. Specifics of career as a research object requires to examine organization and employee together. Organization and employee affect each other in the context of working environment. Organizational development affects career changes, changes of individuals lead to organizational changes. Interaction of employee and organization is based on striving to satisfy mutual needs.

In foreign literature, the model of incentive-contribution proposed by B.Barnar and R.Simon long time ago could be found. The essence of this model - individual results of organization's incentives applied to persons and that of person's contribution to organization have to be satisfying in order relationship between person and organizations would be efficient and constant. Thus, a correspondence of personal and organizational needs shows up. Incentive-contribution model directly integrates into the model of modern career, where career formation is based on coordination of personal and organizational interests.

Summarizing possibilities of career development, in aspect of incentive - contribution, it can be stated that organizations offer incentives to employees in efforts to satisfy personal needs, and persons offer own behaviour in efforts to give some contribution to the organization. As the authors of incentive-contribution model state, organizational needs arise from interaction of its individual members. A more precise argument from a similar start position sees the organizations that have three important main activities: adapting to external environment, striving for goals and internal self-supervision. One of the most important modern career needs is a need for development. In the case organization does not respond the need for development, it is likely the work tools will be not corresponding. The need for protection will be satisfied when organization gives a third opportunity. Thus, organization has to please a person's need to keep the career, and also to allow the person to assist less experienced colleagues.

In modern career, organization takes no responsibility for employee's career. However, in some cases organization, being responsible for people's career needs, has an opportunity to benefit from the general level of commitment. Performed career researches in theoretical point of view revealed the main aspects of career concept by assessing working environment changes and their impact on organization, its employees and career formation. Lithuanian economic and social situation is specific and therefore we are interested in dominating attitude towards career, career needs and possibilities. During the research there was a striving to determine: importance of career planning; what are the needs for development and what employees expect from the organization; how organization helps new employees to adapt in the organization; what special attention is given to new organization members. Based on the research results, it was determined that leaders of organizations are giving insufficient attention to the process of career planning, employees wishes and needs are taken into account insufficiently, no special attention is given to new employees and possibilities to refresh qualification and career progress are introduced insufficiently because organization's efficiency also depends on the fact if employees satisfy their expectations, if their goals meet the goals of the organization and if execution of tasks is successful. And for employees, it is very important to know about the possibilities to realize own goals and expectations, refresh qualification, satisfy needs in the organization.

5. Further Directions of Human Resource Formation Researches

The changes taking place, available input and performed researches suppose the main directions of development of scientific researches performed and under performance.

According to the statements of modern theoreticians, known and applied theories and concepts have no necessary tools and methods for work with a becoming object. That means that while creating "new" knowledge by using "old" tools and methods, we simply are continuing the past. This is also confirmed by the statement of P.Drucker (1993) - "the being is formed from the future". That means that ontological and methodological problems are becoming more and more topical today. Therefore, there are requirements for human resource formation for new logics of thinking and activity, search for new channels of dispersion (translation), intellectual resource management and use of new knowledge/know how.

In organizations, human intellect is considered the main capital of the enterprise. Quality of provided services and successful activity of organization depend on employees' qualification and available competence. All that poses new requirements to both the employee and his work. Tackling of any new problem, ability to apply available knowledge in a particular crisis situation, execution of qualitative work requires for a corresponding competence of employee. Therefore, it is necessary to research and analyse individual's competences in the education process in order to determine existing peculiarities of teaching/learning systems, different methods of education - formal and informal - and looking for new methods, forming and developing systems of training oriented towards competence education.

Competence - human's expression in activity. By acquiring profession, human acquires only a certain qualification that includes primal skills in that professional activity. He demonstrates and develops his competence later - by executing and developing his professional activity, striving for both horizontal and vertical professional career. The goal of constant need for learning should be - *a condition of keeping of interesting job in a changing society* and *career possibility*, with regard to the aspects of human nature, because employee's attitude towards modern job he chose, work style and impact of his personal characteristics on work are very important to employer. Modern Lithuania is lacking information library that would assist human to know and develop himself, to strive for a targeted professional career according to his intellect and efforts. It is natural, that in every stage of life human faces many questions that are not receiving qualified answers. Therefore, importance of qualified counseling is huge today. Counseling goals and methods are determined by different theories that the counselor must know. Counseling and its impact are known for a long time, its methods and measures are rapidly changing and developing, however, due to its insufficient scientific assessment there still are some uncertainties. Career counseling is a special activity providing assistance for the client while tackling the problems of individual employment by assessing his inner characteristics and labour market situation. These problems are related to selection of profession, determining of profile of vocational education, employment and change of professional activity field. For most clients of employment services, the search for socialization problem tackling is topical as well. Therefore, while examining these problems, it is topical to analyse motivation of employees' career creation, assess motivation of professional activity, determine the need for learning by qualification refreshment, stages of career creation, by using methodologies of career development modelling to tackle their decisions.

Conclusions

Change, as one of the elements of evolution processes system in processes of mankind development and progress, should be initiated by formation of systemic attitude and active work method. Formation of systemic attitude, dual principle, in modern situation, is a necessary condition while forming human resources oriented towards strategy of change paradigm, novelty, formation of new attitude, concept of the educated person.

Mankind development and progress, as reproduction of human living conditions, is ensured by development of professionalism and entrepreneurship competencies. Managerial presumptions of human resource formation in the aspect of professionalism and entrepreneurship are differentiated by specialization segments: direction of execution - action based on speciality knowledge for constant confirmation and development of acquired profession; direction of organization - action based on practical organization of action in order to ensure activity's functionality; direction of organization consulting - action based on re-functioning of activity for formation of another, future activity.

Intellectual resources became the main source of acquiring of stable competitive advantages for business organizations of any type, increase of their potential value and satisfaction of dynamically developing needs of customers. Knowledge management as type of managerial activity is characterized by the fact that it is a resource and expresses itself as a management object practically at all management levels and in all management functions, because there is no activity where knowledge would be not a source of development and improvement. Besides, management of the latter is directly related to use of modern informational technologies, internet and other universal networks that allow gathering and dispersion of knowledge required. Knowledge became a value that requires systemic assessment, sustainable attitude, effective dispersion and efficient use.

Environmental changes are changing not only activity of organizations, but also an attitude towards career organization and development inside the organizations. Modern organizations are creating presumptions for transformations of career formation. They must be able to assess markets, culture, employees and new management styles, and that means that the attitude is changing not only towards a work and its assessment but also towards a career that as the main mechanism allows integration of employee's needs, personal goals and expectations into a targeted organizational activity.

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Conceptual Model for Minimization of Losses Caused by Illegal Immigrants to Road Freight Transport Operators

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Abstract

Trending processes in certain regions of Africa, Middle East and Asia forced many people to immigrate to Europe. After arriving to Europe's periphery, migrants apply for the asylum, or move to the predetermined countries. However, some circumstances encourages refugees to migrate illegally. As Europe is mainly covered by land, the illegal immigrants use land transport as a mean for movement across the Europe. 27% of illegal immigrants use road freight transport. There are some evidences that intrusions into the road freight transport units became better organized and planned. European road freight companies are taking preventive measures to reduce or avoid such incidences; however private sector is not able to control the risks of illegal immigrants through its preventive measures alone. The present paper discusses conceptual model which serve as initial background for the cooperation between private and public sector and joining their efforts towards elaboration of common actions necessary for solving problem of intrusions of illegal immigrants.

KEY WORDS: *European migrant crisis, illegal immigrants, road freight transport, international road freight transport operators, road freight transport units*

1. Introduction

According Eurostat, EU member states received over 1.39 million first-time asylum applications in 2015 and these statistics do not even include the refugees who did not try to attain the asylum-seeker status. Long waiting periods for the asylum permissions, asylum application cancellations, and people's fears to be unaccepted by the governments' decisions, force people to take illegal actions to enter other countries, and increase illegal migration. In most cases these refugees migrate by intruding road transport units to cross the border of their chosen European country. The intrusion of illegal immigrants into road freight vehicles to cross borders without being noticed has caused a great deal of problems to the international road freight carriers. Taking into consideration that road freight transport is the main mode of transport ensuring the functioning of logistics system in Europe, the economic consequences may be very serious.

This article presents results of the study aimed at assessing problems caused by illegal immigrants to European road freight transport companies.

The first chapter of this article describes the reasons behind the EU migrant crisis and current status of this phenomenon. The second chapter provides results of the study, i.e. depicts main results of the study, which was conducted in order to highlight the potential consequences (loses) of intrusions of illegal immigrants into road freight transport units. The last chapter of this article discusses possible conceptual model aiming at decreasing negative impact of illegal immigrants on the performance and economic results of road freight transport operators. The article ends with summarizing conclusions.

2. Current State and Reasons Behind the European Migrant Crisis

Reasons that stand behind people migration are discussed in many scientific papers, and works of K.J. Bade and R. Münz (2000), R. King and A. Lulle (2016), P. J. Oiarzabal and U. D. Reips (2012), C. Harzig, D. Hoerder and D. R. Gabaccia (2009) are just a few among the vast list. The European migrant crisis, or the European refugee crisis, is a term given to a period beginning in 2015 when rising numbers of people arrived in the European Union (EU). U. D. Reips and L. Buffardi (2012) distinguish voluntary and forced migration. D. Courgeau–Andevalelievre (2016) states that voluntary migration is based on an internal self-help system. When the discussion comes to the EU migrant crisis, rather than referring to economic migrants, who are looking for better lives, it discusses people, who try to save their lives (such as refugees and asylum seekers). Forced migration phenomenon is discussed in the works of R. King and A. Lulle (2016),

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D. Courgeau and E. Lelièvre (2006), G. Masood and P. Nijkamp (2017). The root reasons for forced migration, were hidden in 2007 world-wide financial crisis, civil wars in the South-East (Syria, Iraque, Iran, Afghanistan, Pakistan, etc.), and natural disasters (droughts, floods, earthquakes, hurricanes, etc.) in Africa (Lake Chad Basin, South Sudan, Somalia, etc.). All these factors brought hunger, poverty, discrimination, persecution and wars. By the UN Refugee agency 65,3 million people, or 1 person in 113 were displaced from their homes by conflict and persecution in 2015 (King & Lulle, 2016). This number of people movement is the highest level since World War II. According to the United Nations High Commission for Refugees, the main countries from which refugees comes to the EU are Syria, Afghanistan, Somalia, Sudan, South-Sudan, Congo Dem. Rep., Central African republic, Iraque, Eritrea, Pakistan and etc. European countries, which are mainly reached by refugees first, are Italy and Greece. It is due to a comfortable geographic position, between South-East Europe and Africa.

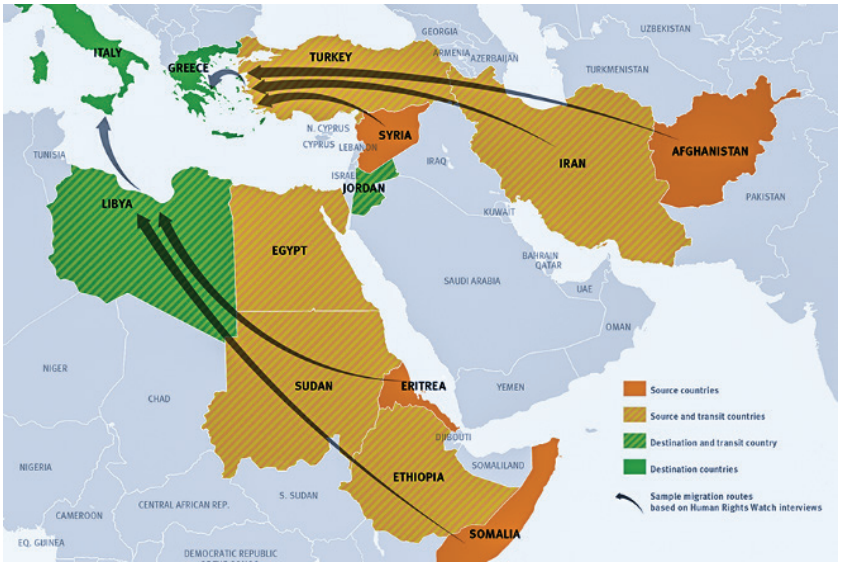

Fig. 1. Main migrants paths to the EU (UNHCR, 2017)

Even if migrants use different first paths of migration to the EU (Mediterranean sea or South Eastern), once they reach Europe, everyone travels using land transport, as it is essential and connective movement unit between EU countries. Heavy land transport, such as trucks and trains, gives a possibility for refugees to hide with a hope not to be caught at the borders, and easily move from one country to another.

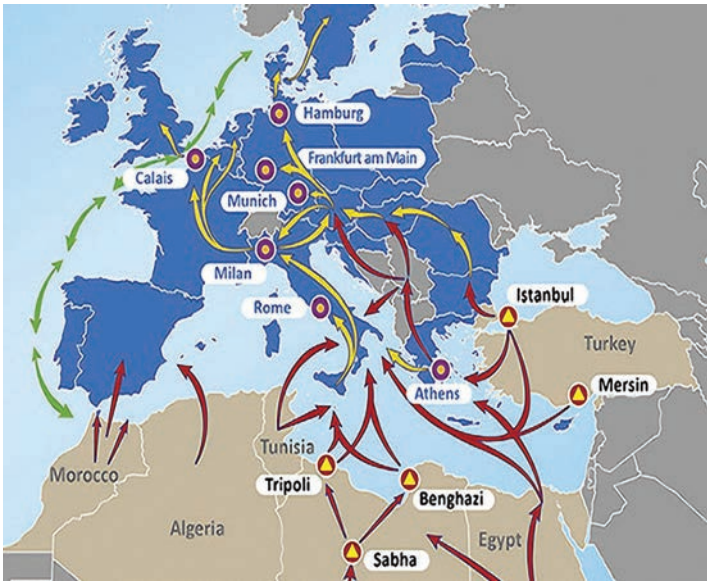

Fig. 2. Migration routes to the primary country of arrival, and subsequent refugee movements inside Europe (Katehon think tank. Geopolitics & Tradition, 2017)

In a large part of the EU - the Schengen area - people can move freely without being checked at internal borders. As countries border officers inspect only suspicious vehicles which meet specific risk criteria (each country has its own assessment of risk criteria) capable of transporting refugees, most of them successfully cross border sections and continue moving in Europe towards their targeted country. While checking all vehicles would be much more effective, there would

be an excessive waiting line at the borders, and the number of civil servants on the border would be increased, resulting in more additional costs for States.

However, if this were to be done, there would be more precision and more precise assessment of this phenomenon. In fact, refugee flows have forced some Member States to reintroduce passport checks at borders with other EU countries as illegal migration inside Europe reached a critical level. After improved border control in 2015, 1.82 million people were detained and arrested while attempting to cross the borders of the EU states illegally.

In general, illegal migrant movements inside the EU is not defined, as not all migrants are captured at borders, and not all of them have the same ultimate destination of the country, which means, that the movement roads and corridors as well are different, and risks to road freight transport operators and their transport units is still of great concern.

3. Identification of Damages and Losses caused by Intrusions of Illegal Immigrants

As it was mentioned earlier, there are some uncontested evidences that intrusions of illegal immigrants can cause damages to road freight transport operators. Potential risks that can occur in the supply chains and process of transportation particularly, are discussed in the scientific works of S. Tang and M. Nurmaya Musa (2011), P. Kouvelis, Ch. Chambers and H. Wang (2009), S. Rao and T. J. Goldsby (2009), M. Helander (2006), E. Hollnagel (2014), W. Karwowski (2006).

However, in order to reveal the exact situation of intrusions of illegal immigrants into road freight transport units, and identify extent of losses caused to international road freight transport operators, the research in the spring-summer of 2017 was conducted at the most problem point – French Calais Port.

A questionnaire-survey method was applied aimed at determination of few important issues:

- Identification of respondents experience with illegal intrusions.
- Identification of the respondents losses and damages because of intrusions.
- Identification of preventive measures taken by respondents.

The research was conducted verbally and in written. The questionnaire was sent to 41 representatives, however, due to only 17 fully completed and returned questionnaires, a verbal interview was carried-out to receive additional 19 questionnaires. Overall, 36 respondents took part in the research.

The results have shown that this problem is particularly relevant. 92% of companies noted that they had encountered with this problem, and only 8% of carriers managed to avoid incidents with intruders.

Respondents identified the most dangerous cities and regions, where intrusions had happened more frequently (Table 1). Results provided in the table confirm that the most risky regions are in France, Germany, Spain, Belgium and the Netherlands.

Table 1

Cities, regions where refugees invaded into vehicle (compiled by authors)

City or region	Country	The frequency of refugee intrusion
Calais	France	62
Coquelles eurotunnel	France	32
Dunkerque	France	41
Rotterdam	Netherlands	21
Antwerp	Belgium	12
Le Havre	France	12
Lille	France	8
Stuttgart	Germany	5
Koln	Germany	4
Bilbo	Spain	3
Mannheim	Germany	3
Vlissingen	Netherlands	2
Terneuzen	Netherlands	1
Oostende	Belgium	1
Donostia	Spain	1

53 % of the surveyed road freight companies have noted that the greatest rate of intrusions was detected in 2015. The fact that the percentage of intrusions into vehicles in 2016 was equal to 42 % and it is only 9 % less than it was in 2015, indicates that this is a particularly relevant problem.

It was also determined that 89% of international road freight transport companies experienced the losses in regards to illegal immigrant intrusions.

As for the damage caused, 32 companies out of 36 have experienced losses in regards to cargo damage or negative impact to the cargo caused by illegal immigrants. 16 companies have indicated that damage was done to a lorry or to a part of it. And even 12 companies marked that the damage was done to the driver (Fig. 3).

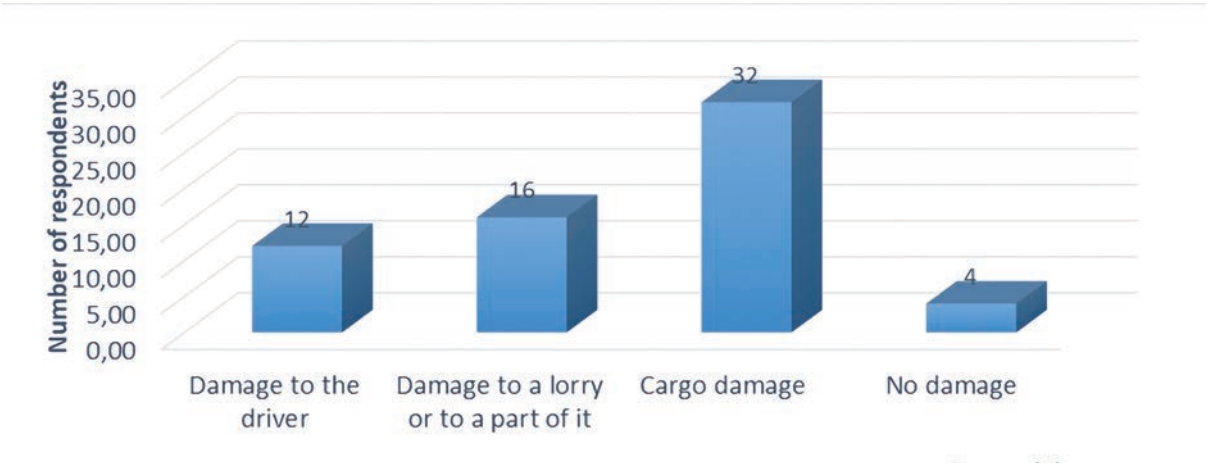

Fig. 3. Type of damage caused by illegal immigrants (compiled by authors)

It is important to assess the extent of consequences that international freight transport companies face after confronting illegal immigrants. All the 36 surveyed companies were a subject to additional insurance costs due to carriage to the United Kingdom and cargo transportation on a risky direction.

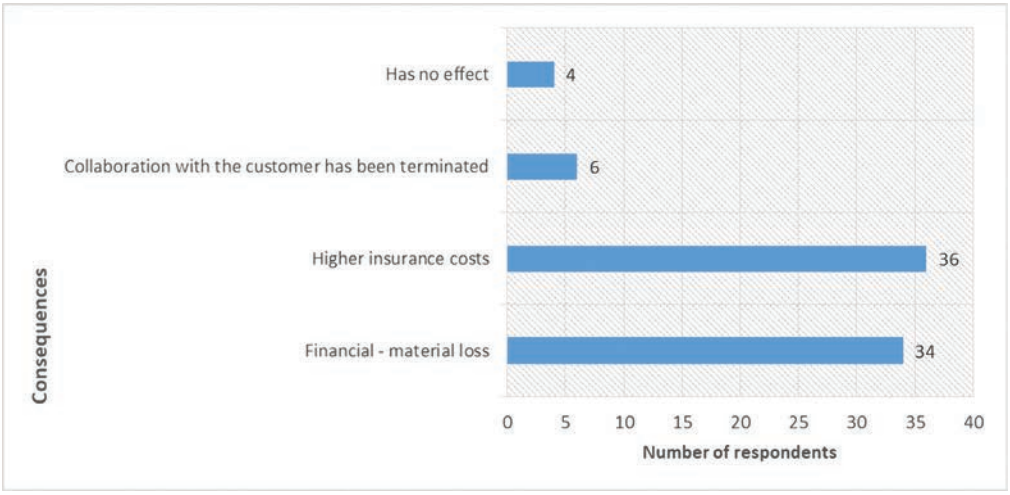

Fig. 4. Consequences of encroachment of illegal immigrants (compiled by authors)

34 companies suffered financial losses. Cooperation agreements with the clients were discontinued in 6 companies, and only 4 transport companies did not face any consequences as illegal immigrants did not intrude in their vehicles (Fig. 4). These data suggest that in the event of an encroachment of illegal immigrants into a vehicle, financial and material damage is inevitable.

4. Conceptual Model for Minimization of Threats Caused by Illegal Immigrants

Bearing in mind that transportation is a part of supply chains which assure existence of particular enterprises and even entire national economies, it should not be surprising that after some cases of smuggling into road freight transport units and following financial losses, road freight transport operators took some preventive measures to protect their property, drivers and freight. However statistics shows that percentage of intrusions in 2016 dropped down just by 9% in comparison with 2015, which leads to an assumption that preventive measures taken by the operators are not efficient enough.

That's why third part of the research was dedicated to identification of preventive measures taken by road freight transport operators in order to avoid or minimize intrusions of illegal immigrants. The two main findings from this part were as follows:

- 81% of respondents currently apply certain preventive measures against the intrusion of illegal immigrants;
- current preventive measures can be divided into two categories: a) documentation of the process (codes of conduct, instructions, and standards) and b) technical security measures (TIR cables, seals, locks, surveillance cameras).

These two findings lead to formulation of current "model" (see figure 5) of coping with threats faced by road freight transport operators. In parallel statement can be made, that all administrative and technical measures currently taken solely by operators are not sufficient and efficient enough.

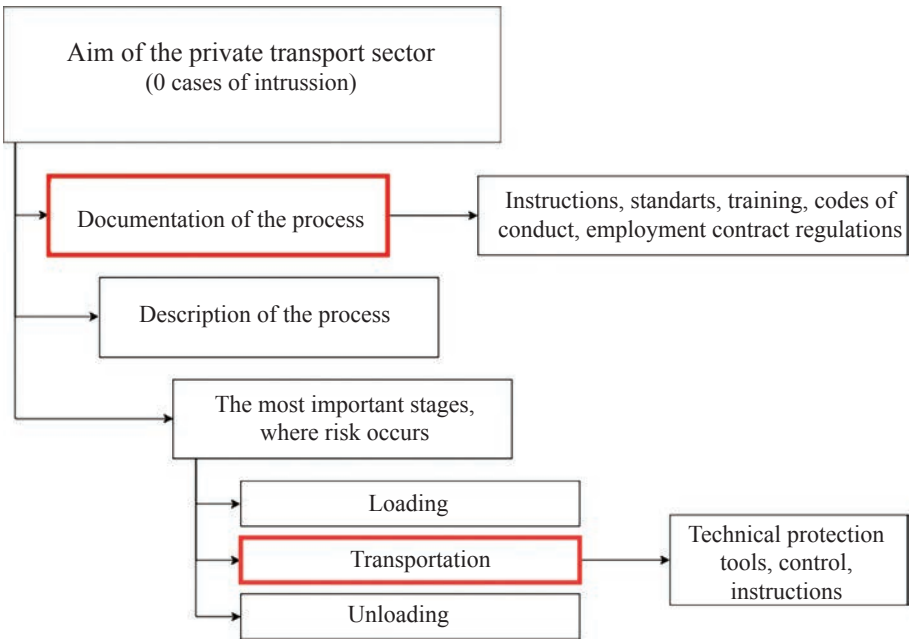

Fig. 5. Current model of coping with threats faced by road freight transport operators (compiled by authors)

Also, in the third part of research, respondents were asked to identify measures, that besides already applied by road freight transport operators would be most suitable and efficient to minimize their losses. Results are presented in the table 2, which ranks measures from very inefficient (rank 1) to highly efficient (rank 5).

Table 2

Most appropriate measures to minimize losses of road freight transport operators
(5 – highly efficient, 1 – very inefficient) (compiled by authors)

Measure identified by the respondents	Efficiency of particular measure
Training of the drivers	1
Tightening up of internal rules of road freight transport companies	2
Compulsory application of technical security measures in road freight transport units	3
Tightening up and unification of border control procedures at the EU level	4
Reduction or limitation of refugee camp resident's in particular geographical zones or relocation of such camps further from the main (transit) roads, rail lines, seaports.	5

As it is clearly seen from the table above, respondents do not give priorities to measures applied solely by the private sector. Instead of that, they are expecting more involvement of public sector, i.e., they prioritize measures that can be applied by public sector. In other words, private sector clearly states that their own efforts should be complemented with those that depend on the government of particular countries, or even entire EU. Therefore assumption can be made that successful elimination of problems caused by intrusions of illegal immigrants can be achieved only through the cooperation of public and private sectors. Based on that, conceptual model for the elimination of losses of road freight transport operators due to intrusions of illegal immigrants can be proposed (see figure 6).

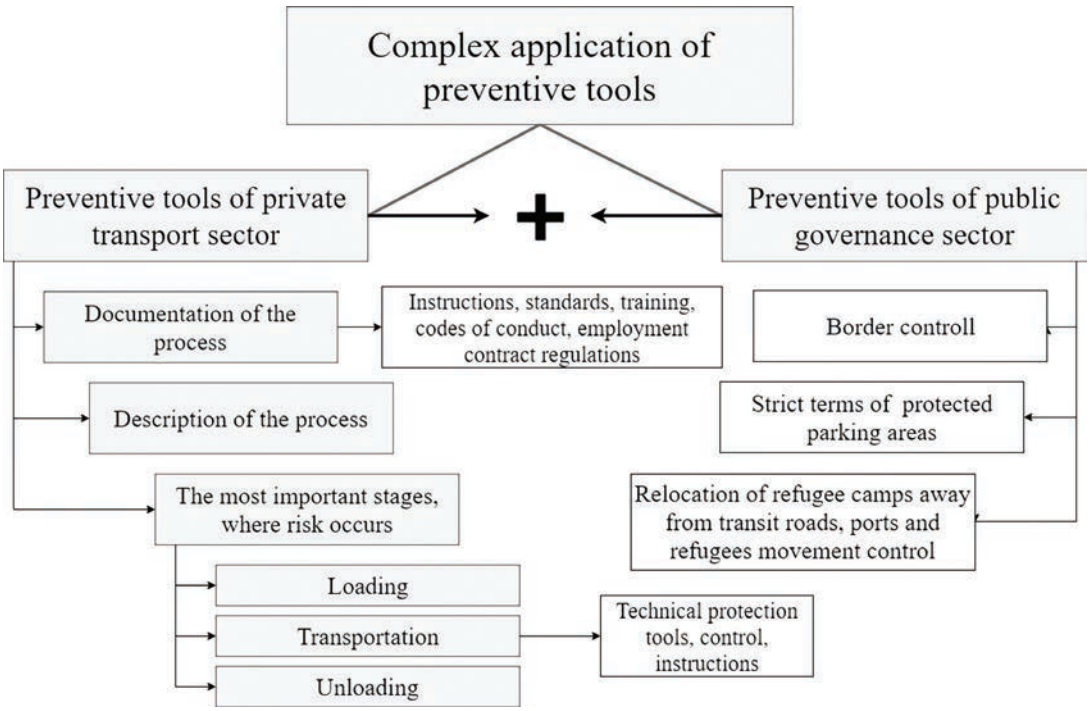

Fig. 6. Conceptual model for the elimination of losses of road freight transport operators (compiled by authors)

As we can see, besides the measures applied by road freight transport operators (private sector side) the model encompasses measures that private sector is expecting from the public sector side (government institutions). Among the main measures, which by the road freight transport operators are treated as of the greatest importance and urgency, tightening up of border control and protected parking areas conditions, as well as relocation of refugee camps from the main transit roads, railway lines and seaports, can be mentioned.

Conclusions

The European migrant crisis, or the European refugee crisis, is associated with the increased numbers of people from certain regions of Africa, Middle East and Asia arriving to the European Union (EU). After arriving to Europe's periphery, some of the refugees migrate illegally to more economically developed countries. As Europe is mainly covered by land, the illegal immigrants use land transport as a mean for movement across the Europe. 27% of illegal immigrants use road freight transport.

There are some evidences that intrusions into the road freight transport units became better organized and planned. European road freight transport companies complaining, that such illegal activities increase the risks of cargo loss, endanger drivers and transport units and, on macro level, affect performance of logistics systems and global supply chains, which, in turn, may have negative affect on the economic development of particular countries or wider regions.

Conducted research proved, that majority of transport operators, which transport units work on the route EU hinterland – United Kingdom and pass the port of Calais, had experienced intrusions of illegal immigrants, though this fact does not happens exactly at port of Calais or in its vicinity. There are far more geographical points where such incidents happen. This circumstance clearly shows that problem of intrusions of illegal immigrants into road freight transport units is a European – wide problem.

Road freight transport operators, who are concerned about safety of their drivers, transport units and cargo, are taking preventive measures (both administrative and technical) to reduce the number of such incidences or avoid intrusions at all; however private sector admits, that such measures are not sufficient and, therefore, road transport operators solely are not able to control the risks of illegal immigrants through its preventive measures. Private sector is in urgent need of actions from public sector.

All the facts presented above advocate for the necessity of cooperation between public and private sectors in order to cope with the problem of risks and losses for road freight transport operators associated with unlawful actions of illegal immigrants. Provided conceptual model is based on the expectations of road freight transport operators, and foresee common actions and basic measures from both, public and private, sectors, which are expected to have a positive effect on the elimination of problems caused by illegal immigrants.

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CHALLENGES TO NATIONAL DEFENCE
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CNDCGS`2018

PROCEEDINGS OF THE 1TH INTERNATIONAL SCIENTIFIC CONFERENCE
EDITED BY S. BEKESIENE AND S. HOSKOVA-MAYEROVA

ISSN 2538-8959 (on-line)

Chief Editor Svajone BEKESIENE
Cover Design by Laima Adlytė
Publishing by
The General Jonas Žemaitis Military Academy of Lithuania
Šilo g. 5 A, LT-10322 Vilnius