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Dear readers,

You are about to read the second edition of the Science & Military journal that we have been publishing for you for eight years. As the editor-in-chief, I am especially glad that the journal is becoming popular with more and more readers and experts from foreign countries as well as from Slovakia. It proves that the quality and attractiveness of the journal is growing.

By editing the journal Science & Military, the Armed Forces Academy created a new platform of critical and creative thinking development of professional soldiers and professionals that complements the attributes of the Armed Forces Academy as the highest educational institution in the Ministry of Defense of the Slovak Republic.

This periodical is one of few opportunities that enables regular publishing of original academic articles focused on basic and applied research in the fields of national and international security, economy and management of defense and human sources, weaponry, technology, communication and information systems, military logistics as well as other fields which are directly or indirectly related to military science.

Dear readers, the second 2013 edition contains 10 new and undoubtedly interesting scientific articles submitted by researchers and experts from the research institutes, academies and universities in Slovakia as well as in foreign countries. I would like to point out at least some of these articles.

The author Piotr Malinowski presents an article titled „Leadership in the military organization: How to change the relationships in valuable intangible asset". It summarizes different opinions on leadership in the last century and at present time and it also deals with application of contemporary perception of leadership in the military environment.

The authors Peter Spilý and Martin Nič present an article titled „Insurgency and Countersurgency" in which they analyse the possibilities of NATO troops deployment to areas of conflict. They emphasize the necessity of the US and NATO doctrines' reaction to insurgent activities and analyse insurgents' skills and tactics as well as consequences of their behavior for the Slovak contingent

The authors Vasile Carutasu and Daniela Carutasu present an article titled „Designing a virtual platform for armored vehicles through the LM using the IDEF0"in which they present the IDEFO method of iGrafx software.

The article written by Jan Furch and Josef Glos titled „Chosen aspects of military equipment maintenance under combat operations" introduces a container workshop project of performing maintenance of the Czech Republic's land combat vehicles under field conditions. The article presents organization and technical conditions essential for implementation of the system of military equipment temporary repairs for military technical support's functioning.

The article written by Viktor Ferencey, Juraj Madarás and Martin Bugár titled „Modeling and application of the electric generator drive through a vehicle microturbine for military system" describes the current situation in the field of electric generators use in military vehicles and systems. It describes real and conceptual applications of combustion microturbines for drive electric generators. The main part of the article is focused on the cooperation of the combustion microturbine and the electric generator for the military system, which is presented through an Unmanned Ground Vehicle.

The article written by Tomasz Smal and Kazimierz Kowalsky titled „Battle damage repair organization under combat operations"presents a concept of a battle damage (expedient, temporary) repair organization under combat operation. The proposed concept was drawn up on the basis of allied and national regulations and the study of battle damage repair systems that exist in other NATO armies.

Dear readers, I believe that you will find this copy of the journal Science & Military both interesting and informative and on behalf of all the members of the editorial board I would like to thank you for your interest and support.

Col. (Ret.) Assoc. Prof. Eng. Marcel HARAKAĽ, PhD.
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DESIGNING A VIRTUAL PLATFORM FOR ARMORED VEHICLESTHROUGH THE PLM USING THE IDEF0

Vasile CARUTASU, Daniela CARUTASU

Abstract: Designing a virtual platform for armored vehicles aims to optimize certain stages of the plm (product lifecycle management). The most important objective of this study is to optimize (maximize) the value of the weapon system potential, one of the performance indicators that can be used to provide an optimum cost-effectiveness ratio. The IDEF0 method and the software igrafx allows us the representation of the design stages and the links between them, starting from the general ones to the detailed ones, no matter the order of depth.

Keywords: Virtual platform. PLM system. IDEF0 method. iGRAFX software.

1 INTRODUCTION

The IDEF0 method allow the decomposition of the process from the higher level (A0), whose outcome is characterized by the following elements: inputs, outputs and control mechanisms. Also on this level are set purpose, objectives and performance indicators. It indicates the modalities through which the design / improvement must be made in order to optimize the construction of armored vehicles and reduce testing costs. The achievement of the model of a virtual platform of the armored vehicle design through IDEF0 method and iGRAFX software, through the PLM perspective, is a symbolic representation of the platform and of the elements that it contains. The use of symbols for representing the virtual platform of design of the armored vehicles determines the individual events, objects and relations among them, in an understandable manner.

In [1] were presented the main steps to be considered in designing armored vehicles and their level of detail, in order to identify the optimal order in which have to be considered the stages of the design/improvement of the armored vehicles through the PLM.

2 IDEF0 METHOD OF DESIGNING A VIRTUAL PLATFORM FOR ARMORED VEHICLES

Further will be presented the facilities offered by IDEF0 method through iGRAFX software in designing the virtual platform for. armored vehicles, starting from its main elements to the most detailed element considered necessary.

The main menu of the application, with activities represented sequential, is shown in Figure 1.

The first level of decomposition is detailed in Figure 2 where are presented the main modules of the platform. Components of the process are the sequences of organized activities that transform inputs into outputs, providing direction and necessary resources to operate the platform.

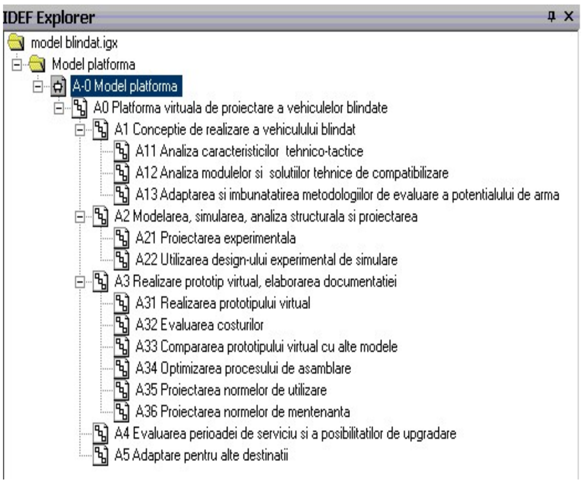

Fig.1 Decomposition of the activities within the platform

Entries are represented in this case by the requirement to adapt to market, customer requirements and market needs.

Outputs aims the optimizing of the construction process of armored vehicles, with a high level of performance and knowledge gained during the course of the modeling process.

Achieving a performant armored vehicle should be based on:

- A proper assessment of potential weapon;
- A comprehensive approach to all aspects of this endeavor;
- A series of studies on the modules from its composition;
- Technical solutions of their compatibilization;
- Performance of the vehicle as a whole.

The activities within the first module of the virtual platform "The conception to achieve of the armored vehicle" through the PLM are presented in Figure 3.

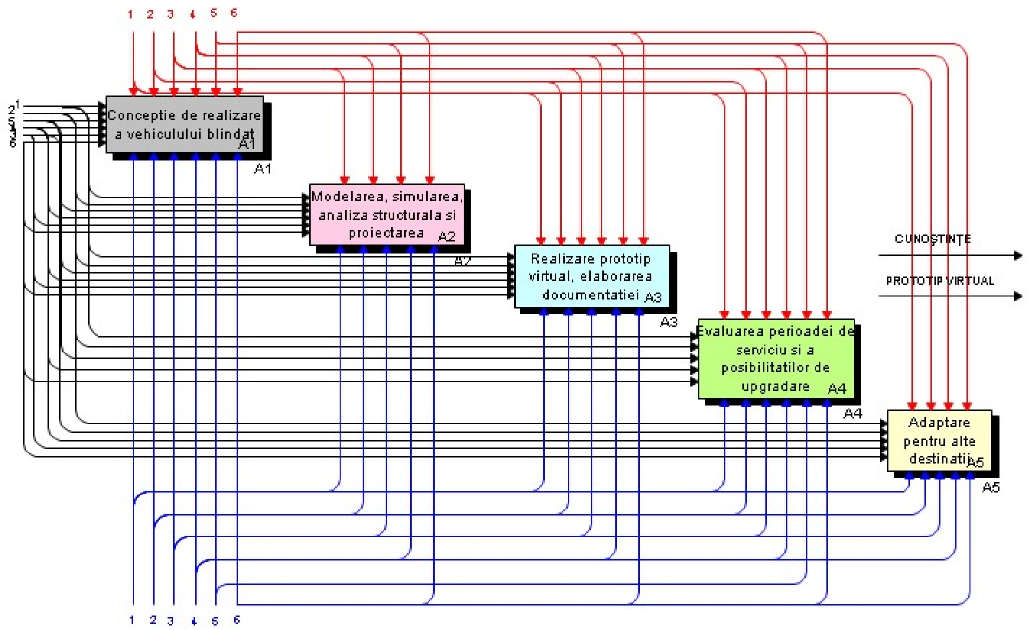

Fig. 2 The main modules from the composition of the platform (A0)

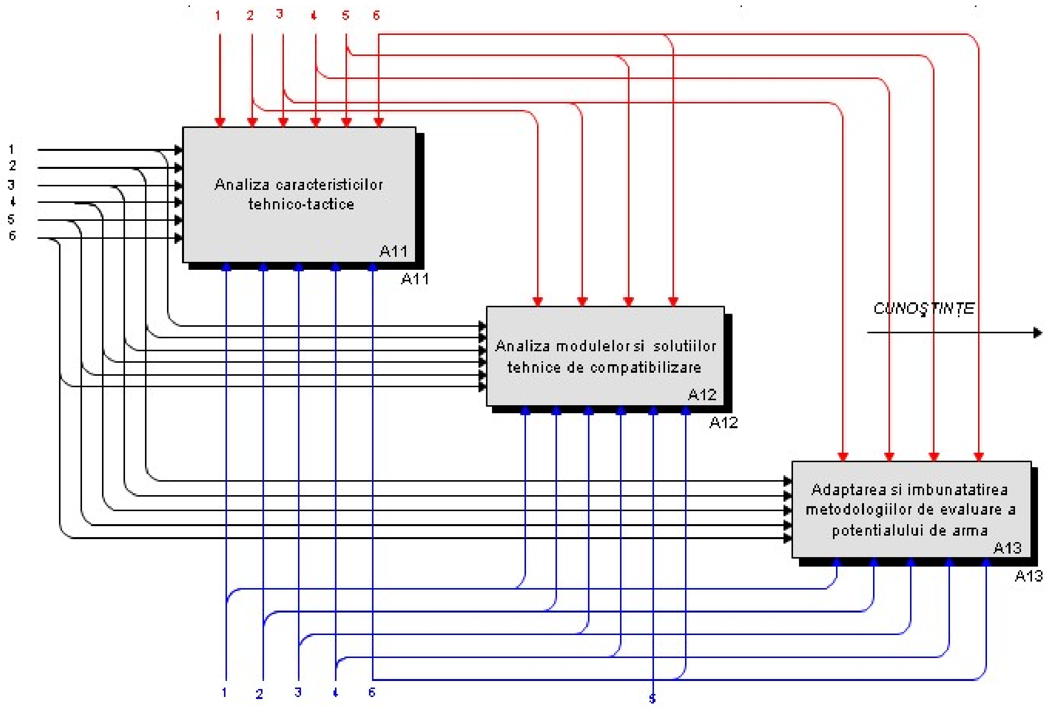

Fig. 3 The conception to achieve of the armored vehicle (A1)

The specific activities of "The analysis of the technical-tactical characteristics of armored vehicle", developed in phase (A11), shown in Figure 4, is based on:

- The trends in related fields;
- The analysis of the types of the missions;
- The threats to which armored vehicle is exposed;
- Factors that may influence its functioning within normal parameters.

Activities within stages (A12) and (A13) detailing the aspects to be considered when designing modules and evaluating weapon potential for the armored vehicles from that class.

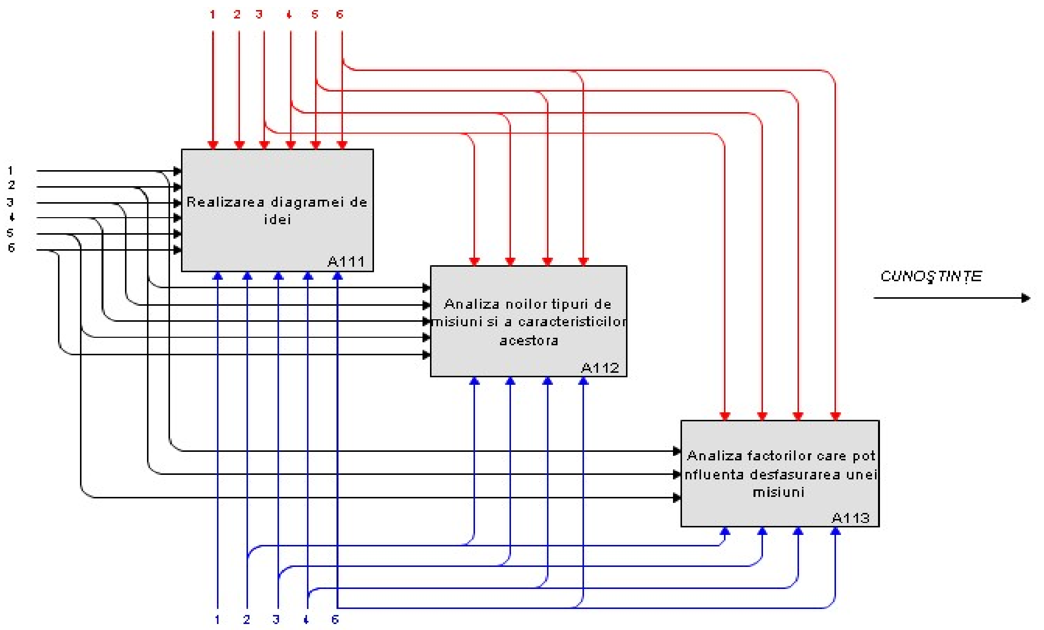

Fig. 4 The analysis of the technical-tactical characteristics of armored vehicle (A11)

Another important module "The modeling, simulation, structural analysis and designing of the armored vehicle" (A2), shown in Figure 5, aiming, through the activities from the composition, the determination of the optimal plan of experiments corresponding to the different settings of the constructive parameters.

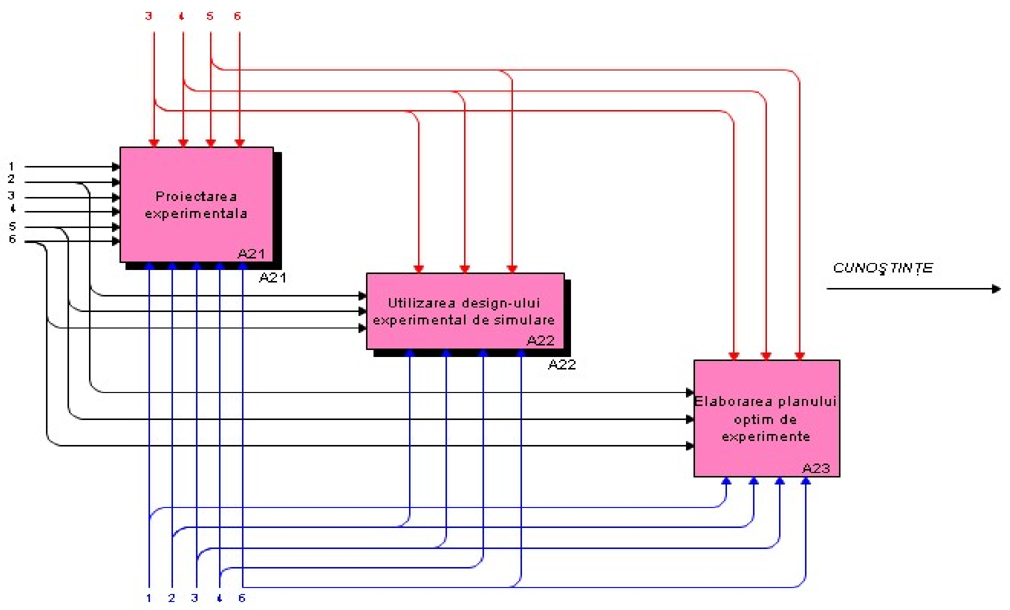

Fig. 5 The modeling, simulation, structural analysis and designing of the armored vehicle (A2)

In the experimental design, the most important elements, outlined in Figure 6, are related to the possibility of determining the relevant parameters of the armored vehicle, that can be subject of further analysis. Activities within stages (A22) and (A23) detailing other aspects of experimental design such as the achievement of the matrix of experiments, the simulation of the values of weapon potential for parameter settings that are not in the database etc.

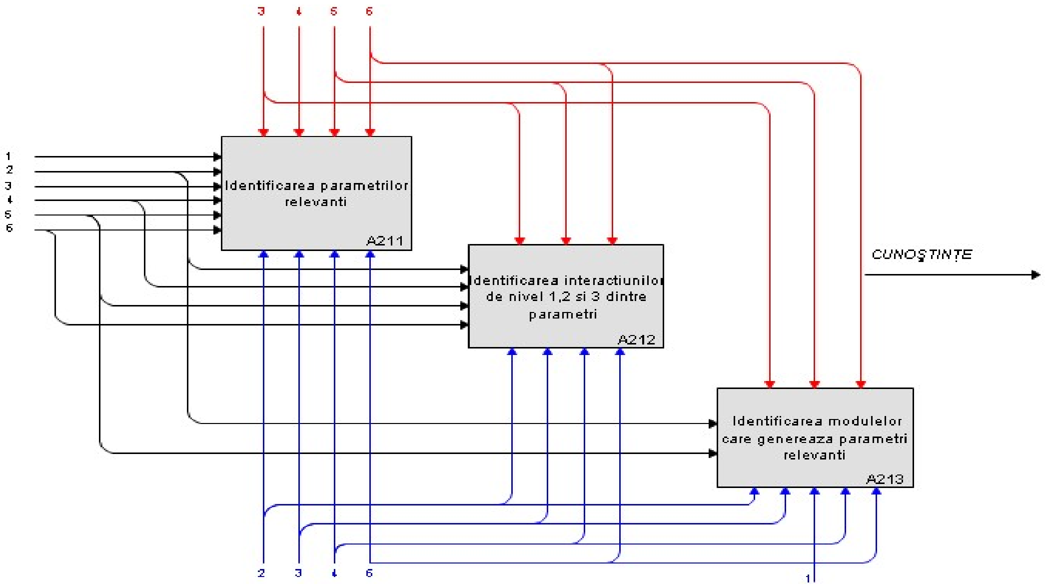

Fig. 6 The experimental design of the armored vehicle (A21)

The most important module within the platform, (A3), "The achievement of the virtual prototype and design of the assembly process" based on the results obtained in the first two modules provide the virtual prototype together with the analyzes of its performance compared to other models in the same class . As can be seen in Figure 7, this is composed of six stages, each of these being based in turn on 3-4 activities.

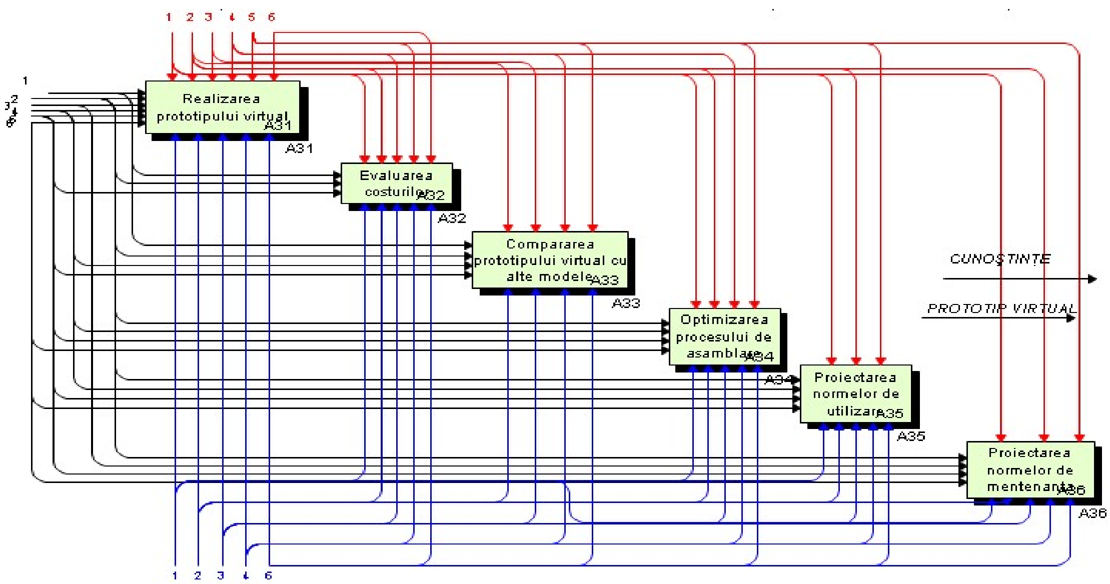

Fig.7 The achievement of the virtual prototype and design of the assembly process(A3)

This stage within the sub-module is the most important because within it is finalized the virtual prototype through the activities that can be viewed in Figure 8. Activities within stages (A32) and (A36) detailing other aspects regarding the:

- assessing the costs of production;
- comparisons with other models from the same class in terms of tactical-technical characteristics;
- comparisons with other models of the same class in terms of costs of production, of the works and maintenance costs.

It should be noted that at this stage, depending on the outcome of the conducted tests the following situations may occur:

- the virtual prototype can enter in the production phase and effective testing, if the results of the characteristics are as expected;
- it is retake the achievement process, if the of the characteristics are not as expected.

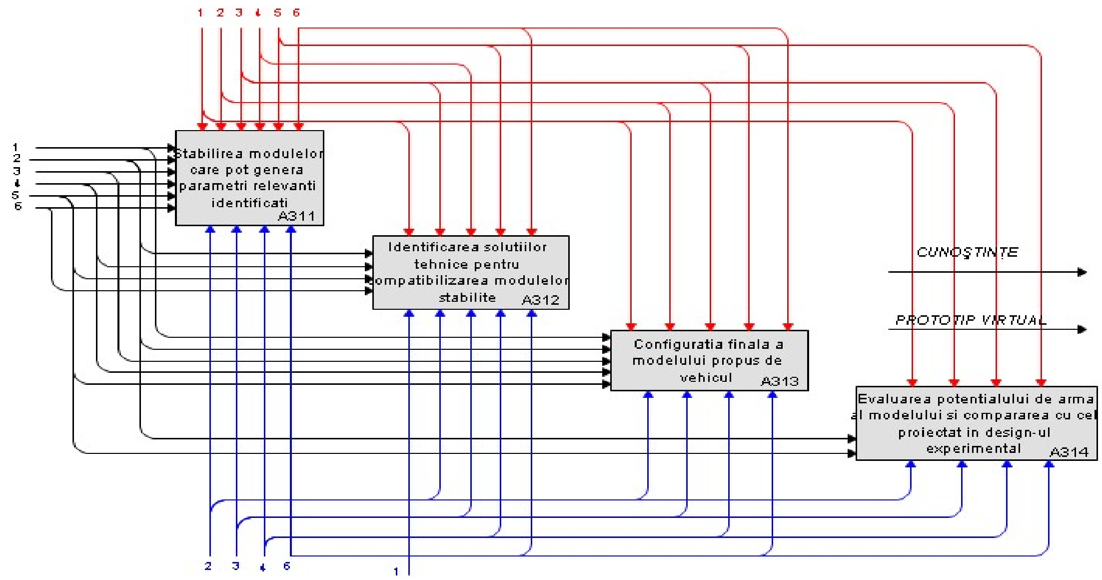

Fig. 8 The achieving of the virtual prototype (A31)

Module (A32), "Assessing the costs of achieving of the vehicle", is another important stage of the virtual platform, in which are established the costs of production, details regarding these activities being presented in Figure 9.

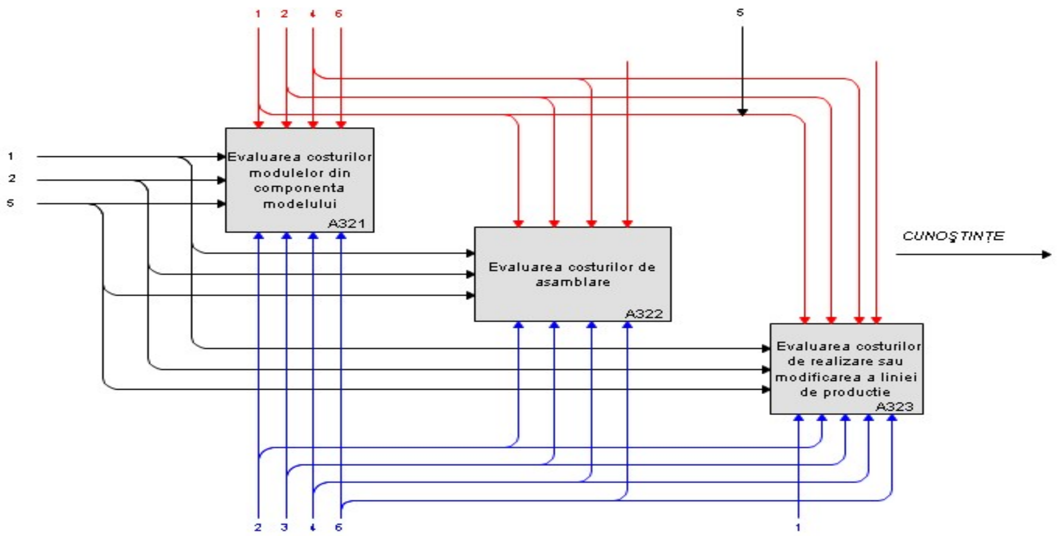

Fig. 9 Assessing the costs of achieving of the vehicle (A32)

The stage (A34) "Optimizing the assembly process of the vehicle", shown in Figure 10, presents the activities which must be carried out when the vehicle is going to enter in production, the main problem being the optimization of the production flow.

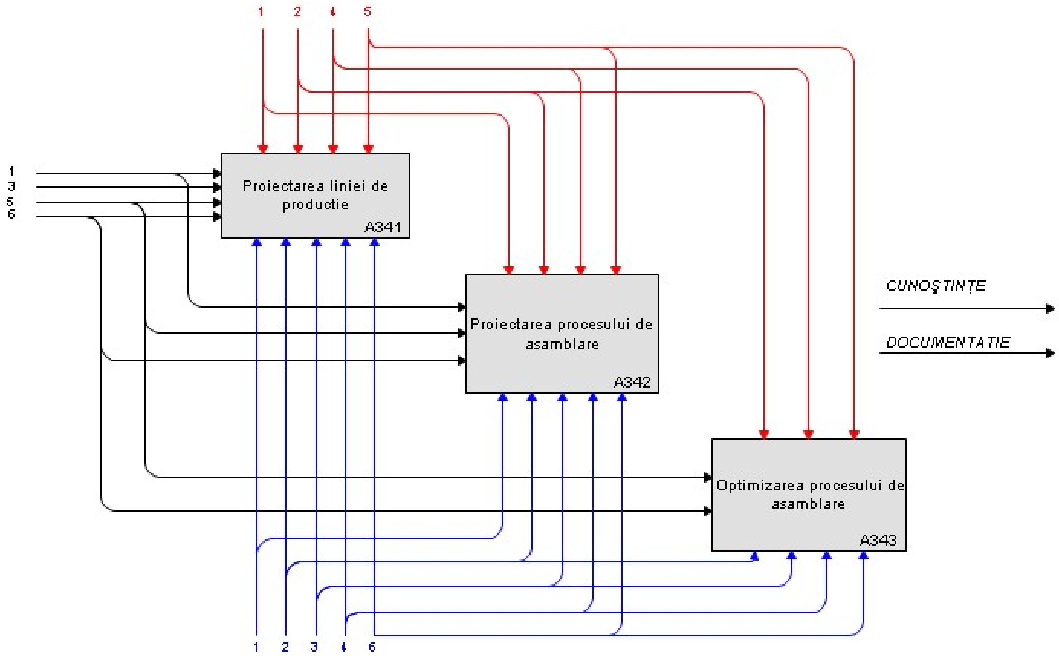

Fig. 10 Optimizing the assembly process of the vehicle (A34)

Module 4 "The evaluation of service period of the vehicle" (A4) is devoted to the assessment of service period and of the maintenance costs throughout the life cycle of the virtual prototype and the comparison of these costs with those of other models of armored vehicles on the market, from the same class. In Figure 11 are shown the steps to be taken within this sub-module.

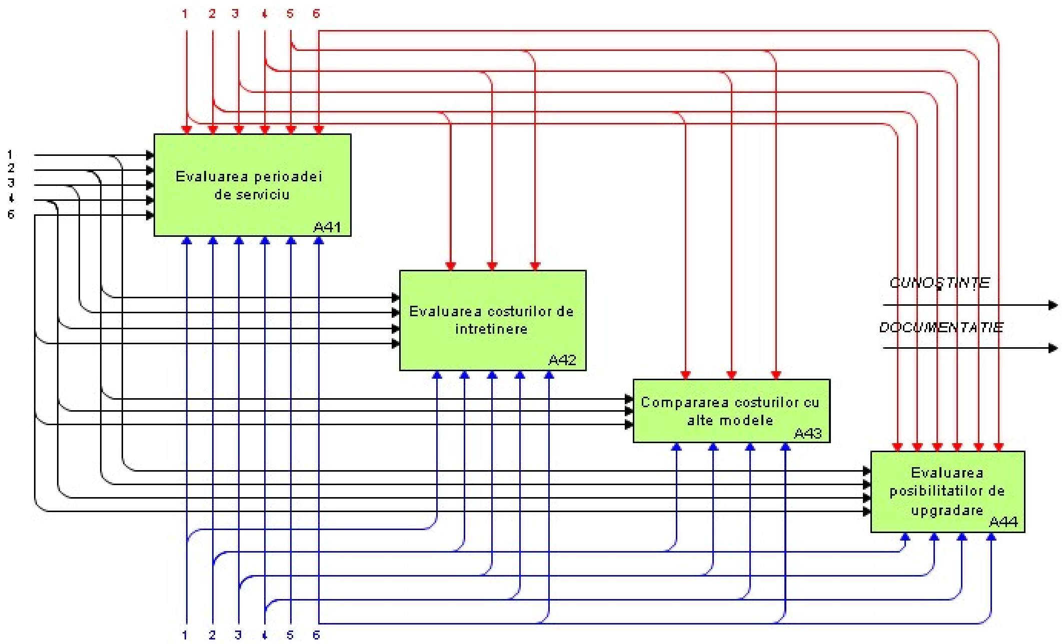

Fig. 11 The evaluation of service period of the vehicle (A4)

The last module "Adaptation of the vehicle for other fields of activities" (A5), is part of the recycling stage and aims the possible adaptations for other areas and the use of the components as spare parts (when the vehicle is obsolete). The stages of this module are shown in Figure 12.

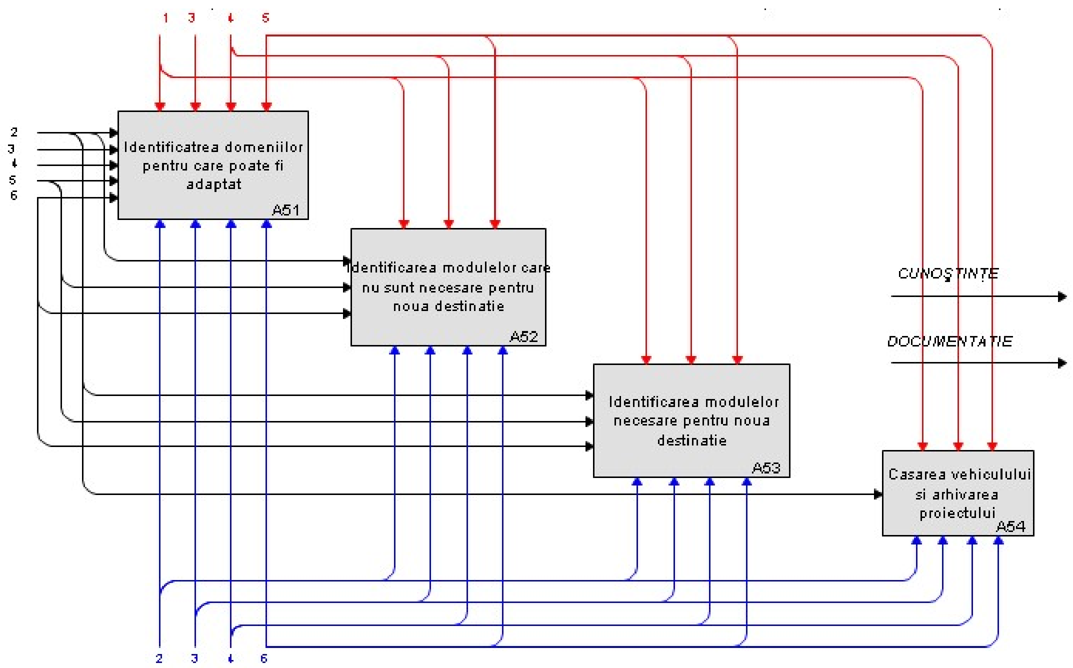

Fig. 12 Adaptation of the vehicle for other fields of activities (A5)

3 CONCLUSIONS

The proposed model of the virtual platform, for designing the armored vehicles, helped by the IDEF0 method and iGRAFX software captures all essential aspects in order to perform, in optimum conditions, the activities and specific processes.

An important aspect that should be considered in the design and development of a product is its modularity and the possibility of changing the destination according to needs. It is a trend that has emerged in the field of combat equipment, being made platforms on which can be mounted various types of weapons or logistical support elements depending on the type of military operations to which have to participate.

References

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BATTLE DAMAGE REPAIR ORGANIZATION UNDER COMBAT OPERATIONS

Tomasz SMAL, Kazimierz KOWALSKI

Abstract: The paper presents a concept of a battle damage (expedient, temporary) repair organization under combat operation. The proposed concept was drawn up on the basis of allied and nation regulations and the study of battle damage repair systems which occur in the other NATO armies. When creating the mentioned concept there an assumption was made that battle damage repair system will be set in operation of current standard maintenance system.

Keywords: Logistics systems. Combat service support. Battlefield maintenance. Battle damage repair. Expedient (temporary) repair.

1 INTRODUCTION

Polish troops conduct operations overseas fulfilling their tasks within the zones deprived of combat means and along with high exploitation of military equipment in harsh field and climate conditions. Such situation causes damages, which do not take place in day-to-day peace-aimed usage at home. Along with intensive utilization effects and combat damages, also accident-related failures can sharply grow, which is usually brought about as a result of the terrain obstacles, limited visibility and great dynamics of operation. Therefore, countries, which forces have been taking part in various military conflicts or peacekeeping operations, are improving their systems of a battle damaged repair (BDR) of weapon systems directly in the combat area. The Polish Land Forces do not implemented such system yet except for a few tests conducted during military exercises. As a result, our troops are not prepared to properly execute these kind of repairs although we are required to be able to do so according to Stanag 2418.

2 CURRENT STATE OF AFFAIRS

According to the current logistics doctrine [6], battlefield maintenance at the brigade level is organized from full-time maintenance elements, that is maintenance company and additional strengthen elements from maintenance battalion of higher level. There are organized 1-2 mobile recovery – repair sections (GER), technical reconnaissance team (PRTech) and evacuation team (GET). The other forces are included into unit maintenance collection points (UMCP) - Fig. 1.

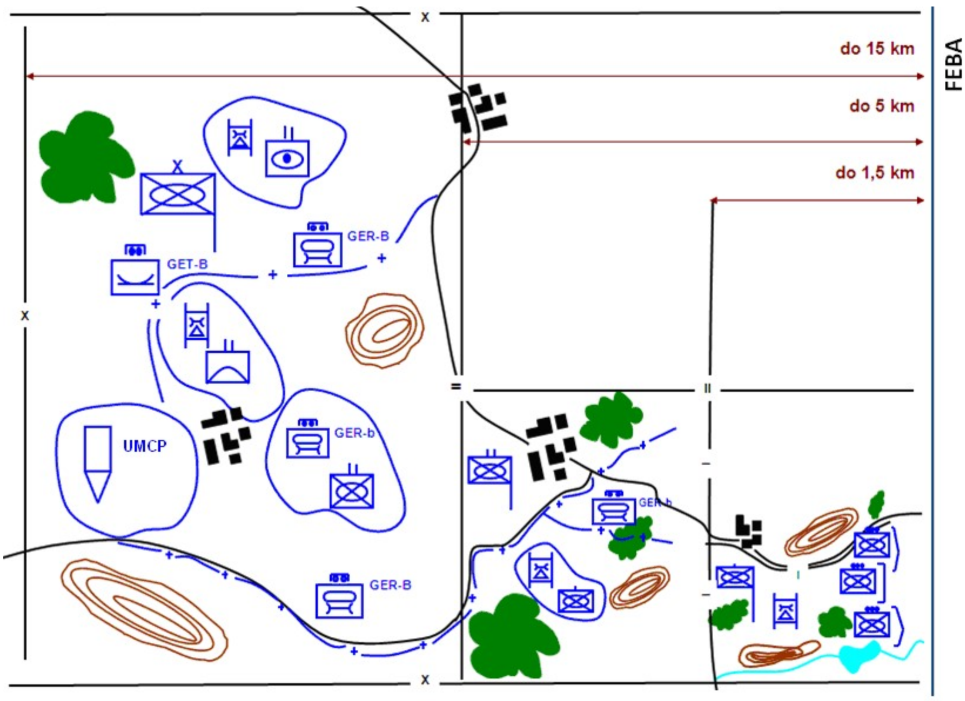

Fig. 1 Technical support system at the mechanized brigade level
Source: Authors' study.

The reconnaissance - recovery team (PRiPT) is the first chain of battlefield maintenance that based on evacuation squad of fighting company. It is located at 500-700m from forward enemy battle area in case of conducting attack and 800-1200m in case of conducting defense. An operating time (available time) of PRiPT should be as short as possible not to let this team fall behind in relation to a supported company [9]. It is assumed that maximum operating time should not exceed 0,5 hours. The main tasks of this team are as follows:

- permanent observation of weapon systems of supported unit;
- rapid remove disabled, mired and abandoned equipment and returning it to operation;
- providing first aid to crews and operators;
- retrieves equipment for repair and return to the user;
- prevents enemy capture of equipment;
- maintaining permanent communication with recovery-repair section and reporting about technical situation and.

A mobile recovery-repair section (GER) is organized on the basis of a maintenance platoon of a logistics company of fighting battalion. The section can be strengthen with forces from a maintenance company of brigade. In case of attack the section is moving at the distance of 1,5-2km from fighting companies and in case of defense 3-4km form forward enemy battle area. An operating time (available time) of GER section should not be longer than 1-2 hours. The main tasks of this section are as follows [9]:

- location of the damaged equipment on the battlefield and assessment of a damage range and required recovery, repairs or evacuation;
- spare parts and technical materials supplying to the damaged weapon systems;
- providing first aid to crews and operators;
- technical support in water obstacles overcoming;
- exchange information about technical situation between reconnaissance-recovery teams and command post of battalion or brigade.

An evacuation team (GET) is an element that is created temporarily by means of forces and resources of maintenance company of brigade. It depends on type and intensity of combat operation. Main tasks of an evacuation team includes evacuation and movement of damaged weapon systems to designated areas, unit collection points or stationary workshops, as well as, retrieval of units and parts from broken equipment and evacuation of enemy equipment, which can be used to support own forces [8].

An unit maintenance collection point (UMCP) is a place where field repairs are executed. It is deployed by the main forces and means of maintenance company of logistics battalion and should be created with use of stationary technical infrastructure near logistics roads of evacuation. It is located at the distance of 8-10km from forward enemy battle area in case of attack and 12-15km in case of defense.

Prediction of weapon systems damage losses based on daily rates which are assumed on the basis of lessons and conclusions from contemporary wars and military conflicts as well as fire power of opponent's weapon system is considered [3]. It is estimated in references that the daily losses of military equipment, depending on the type and pace of operation and many other factors, will vary from 10 to 40 % [3] [12] [15]. However, among the damaged weapon systems only a part of them will be irreparable. The rest will qualify to different levels of repair with regard to repair effort. Considering repair capabilities of current deploying mobile maintenance elements it is assumed that PRiPT will not be able to conduct any repair but only recovery tasks, GER will conduct 1. level repairs of low repair effort (2-4 hours) and maintenance companies that deploying UMCP will execute 1. level repairs of average repair effort (to 12 hours). The 2. levels repair will be executed only by maintenance battalions deployed at the division levels [3]. The conducted analysis proved that maintenance units and mobile support elements being deployed by them are neither prepared nor able to carry out expedient (improvised) repairs of weapon systems considering their special repair equipment, guidelines and instructions for operating in combat operations, as well as, trainings programs for logistics specialists [11] [14]. In terms of research mentioned in previous chapters, it was noticed that lack of such solutions in the current battlefield maintenance system significantly reduced its repair capacities and elasticity and; thus, it resulted in abilities to recover and restore combat power of fighting units. Additionally, there are numerous evidences that some of damaged equipment can be rapidly restored to the combat with a use of improvised methods [1] [4] [5], which will result in extending the fighting unit abilities to carry out operation and; therefore, lead to superiority over an opponent. The system of BDR is also indispensable in case of conducting operation in the long distance from their own logistics support and supply sources (peacekeeping operations and reconnaissance or sabotage operations, etc.) [10]. On the basis of the foregoing considerations, it has been decided to propose the concept in which the current maintenance system of land forces military units during tactical operations will be modified and supplemented with BDR system. In this way the execution of improvised (temporary) repairs will be gained starting from a single military vehicle or other weapon system without losing opportunities to conduct standard recovery operations. The main principles and assumptions of proposed concept are as follows:

- The BDR system will be set in operation of current standard maintenance system and will operate on three levels, that is the 1. level of weapon system operator/crew (for example a tank or armored military vehicle), the 2. level of mobile recovery team (currently it is PRiPT or GER) and the 3. level of maintenance unit conducting repairs in a unit maintenance collection point (UMCP);
- Appropriately selected tools and repair materials will be applied at each level of the BDR system that provide maximum versatility of their use in relation to the possible extend of damage at the given level of repair;
- In addition to the general BDR doctrine at the level of land forces, which should be implemented primarily, specific instruction and procedures will be developed dedicated to specific weapon systems as well as instruction regarding the use of BDR kits on the various level of the system;
- A training system will be created, which allow to train soldiers in the rules of expedient (temporary) repairs and proper use of BDR tools and materials that will be used on their level. As a result, a course should be provided for all drivers and crews (1. level), recovery teams and mobile recovery – repair sections (2. level) and specialists of BDR squads of maintenance units (3. level);
- The BDR system will be flexible and modifiable in terms of taking into account changes in current tasks and equipment of troops as well as needs and comments from the system users.

3 A SYSTEM DIVISION ON THE TACTIC LEVELS

3.1 The 1. level of BDR system

The 1. level of BDR system – operator/crew of a weapon system occurs in most NATO armies. The idea of that level is to include a special set of repair tools and materials in the certain type of weapon system like armored vehicle, tank or self-propelled cannon. The dedicated BDR kit can be used by operator or crew to restore broken equipment to an operation with fast and expedient methods (Fig. 2). It is assumed that the direct user of a weapon system should be preferably skilled person with regard to its condition. The person is also closest to the failed system; therefore, he/she should take proper measures; first of all, to restore its technical efficiency. The conditions for the effective implementation of this level are: developing of BDR repair manuals for certain weapon systems, very good knowledge of construction and operation principles by operators/crews and their additional training concerning expedient (temporary) repairs with BDR kit, as well as, defining the operation procedures for operators/crews regarding opportunities and limitations of applying expedient (temporary) repairs in a particular military operation. The conducted exercises proved that a soldier, who knows his/her weapon system and can perform a standard repairs, is able to master BDR procedures and methods very quickly [7].

The 1. level BDR kit should fit in one bag or box and it should include tools and materials grouped by the purposes, such as: basic tools, regenerating taps, a repair kit for electrician and hydraulic installations, universal clamps, bands, pins and gaskets, composite adhesives of „rapid” group (curing time limited to 15 minutes) and chemical fluids for cleaning, sealing installations and loosing joints.

3.2 The 2. level of BDR system

The 2. level of BDR system has a different character in various armies of NATO [13]. In some countries it is based on a recovery vehicle which is equipped with special repair kits, in the others a dedicated vehicle is used as a t a carrier of BDR tools and materials (mobile workshop with BDR equipment). In the proposed concept, this level will involve the inclusion of properly prepared BDR kits to standard equipment of currently used reconnaissance - recovery teams (PRiPT) and mobile recovery – repair sections (GER). A PRiPT means combination of a trucked or wheeled recovery vehicle, as well as, a special equipment to conduct recovery tasks and BDR kit and well-trained crew. The mentioned team should operate at the company level and cooperate with operators/crews of a single weapon system and mobile elements of maintenance platoon of battalion logistic company (Fig. 3).

The main advantage of this approach is that the recovery team will be able to perform the entire spectrum of rescue tasks during combat operations in difficult to access terrain. The flow chart of recovery team operation is presented in Fig. 4.

The 2. level BDR kit should be placed in a few bags or boxes and it should include sets similar to 1. level kit tools and materials and additionally such sets and devices as: compressed air (e.g. lifting bags), welding and cutting (e.g. oxygen lance), auxiliary power generator, load safety equipment and composite adhesives of „rapid” and „elastomers” group (to repair rubber elements and insulation).

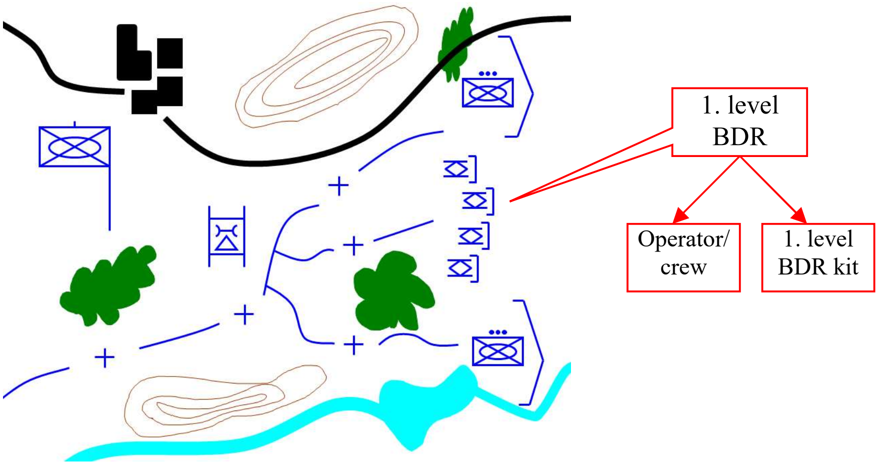

Fig. 2 The 1. level of BDR system
Source: Authors' study.

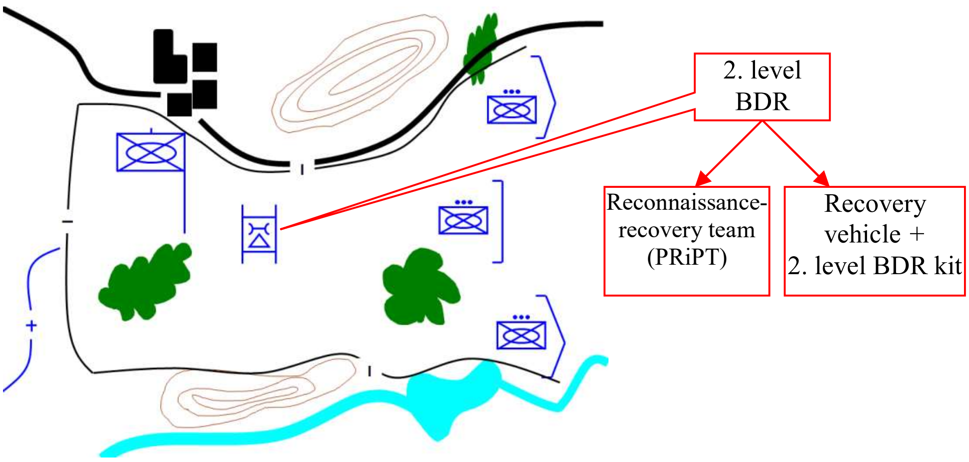

Fig. 3 The 2. level of BDR system
Source: Authors' study.

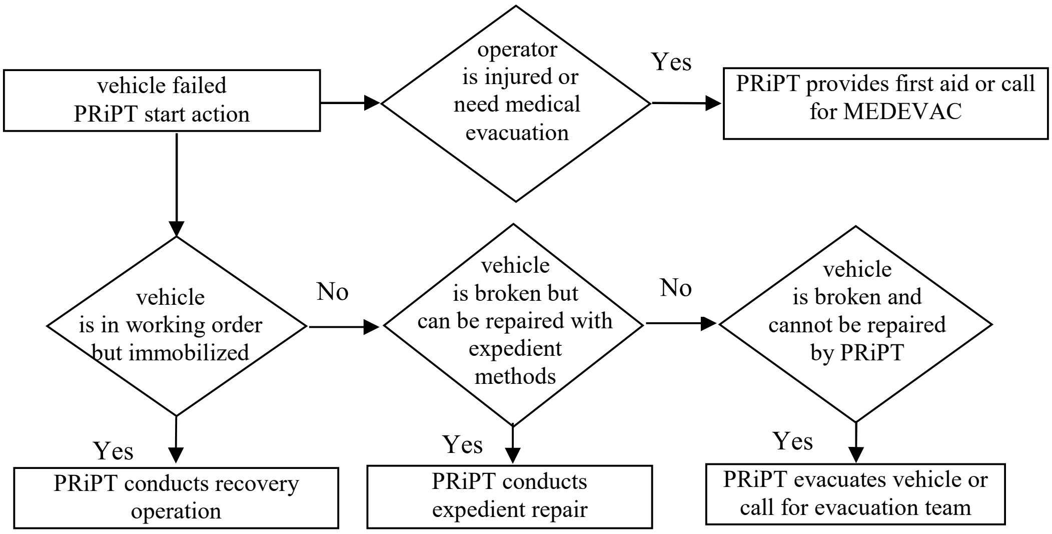

Fig. 4 Flow chart of reconnaissance-recovery team operation
Source: Authors' study.

3.3 The 3. level of BDR system

The third and last level of BDR system will perform its tasks at the depot level of logistic support, which is a level of a maintenance unit conducting tasks in a UMCP. It could be both a level of maintenance company that is included in logistic battalion of fighting brigade, and maintenance battalion that is deploying its collection point in the back area of fighting division. The essence of that level would be maintenance unit complementing in a BDR squad or section and container workshop with proper repair sets starting from maintenance company (Fig. 5). The BDR kit of this level could be more complex than in the previous levels and it should also include composite adhesives of „super metals" group, which have better properties and longer curing time.

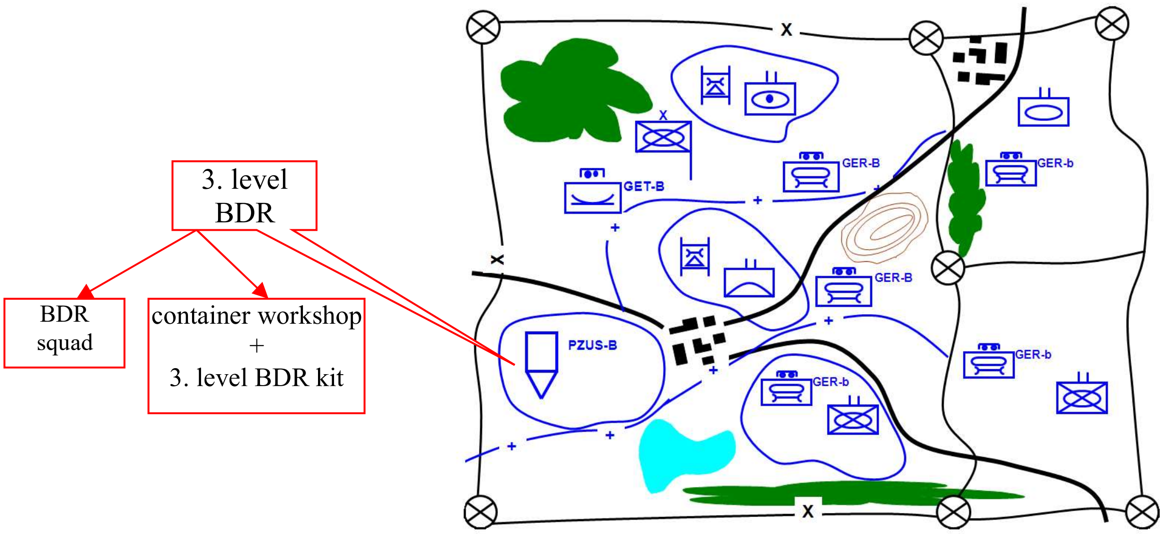

Fig. 5 The 3. level of BDR system
Source: Authors' study.

The BDR section/squad would be the highest chain of BDR system and it should be deployed separately or in areas of unit collection points. Its main task would be professional verification of damaged weapon systems and their components in order to apply quick and improvised repairs. The mentioned repair would be conducted regarding standard repair is not possible due to lack of spares or too long time of its execution. This squad could act effectively during logistic support of peacekeeping operations. The U.S. troops experiences obtained during former operations have shown that many broken parts and components are unnecessarily sent to the country in order to carry out standard repairs although they could be effectively repair in the area of operation [2].

4 CONCLUSIONS

The presented in the article analyses enable to formulate the following conclusions:

- The Polish Armed Forces as a member of NATO should not only ratify but also implement standardization agreements in order to properly fulfill their tasks under any combat operations.
- The maintenance units and mobile support elements being deployed by them are neither prepared nor able to carry out expedient/battle damage repairs of weapon systems considering their special repair equipment, guidelines and instructions for operating in combat operations, as well as, trainings programs for logistics specialists.
- Current technical support system of the Polish Land Forces at the tactical level should be supplemented and reinforced by the properly designed and prepared elements of BDR system.
- The proposed concept of BDR organization should enable to; firstly, obtain the ability of executing expedient repairs from the lowest level, that is, from a driver or a crew of a weapon system vehicle; secondly, achieve synergy of actions resulting from supplementing the abilities of the current evacuation and repair potential of new; so far unemployed, technical and organizational solutions.

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OPERATIONAL RELIABILITY AND THE SURROUNDINGS EFFECT

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Abstract: Operation of devices and machinery under various climatic conditions has an impact on determination of operational reliability parameters in designing, projecting and construction of devices and machinery.The work deals with determining the criteria of the special technique (selected electrical parts) operation under extreme conditions.The end of the work summarizes experiences by servicing and repairs of the special technique (selected electrical parts) under climatic conditions out of Europe.

Keywords: Reliability. Failure-free operation. Diagnostics. Climatic conditions.

1 INTRODUCTION

One of prerequisite for a possible commissioning of the machine, equipment into operation is a provision of quality and reliability of the machine, equipment within operational parameters. In practice of operation of special equipment, e.g. machines and equipment (engineer-sapper equipment) in recent years the repair-men a operators have assumed a task to create conditions to use selected equipment, e.g. electric machines and equipment in crisis situations, e.g. in emergency situation and removing its consequences, as well as in meeting tasks abroad in humanitarian relief, military and peace observer missions of international organizations or within international exercises. As in such activities, almost always a deployment of machines and equipment is needed, including electric appliances; the experiences in this area have been generalized as a background for development of technical set up for next missions and their logistic support.

2 DUALITY AND OPERATIONAL RELIABILITY AS DEFINING CRITERIA TO ENLARGE THE POSSIBILITIES FOR OPERATION OF MACHINES AND EQUIPMENT IN A LARGER NOTION

Under a term of duality and an operational reliability in the paper we consider duality of a whole technological cycle, duality of a machine and equipment as a whole.

Operational reliability in literature is characterized as a feature of a product, which enables meeting defined functions within admissible limits in given operational conditions and requested time period of operation. [1] An operational reliability of the product, equipment, and machine involves especially the capability:

- to operate permanently within admissible limits of requested parameters,
- to keep its reparability (to preserve a possibility to remove the failures),
- to withstand a short- term overloading (a product resistance),
- of the product to operate with small damages, i.e. with aggravated operational parameters (product ´s viability),
- undemandingness of servicing and its small range (service optimality and effectiveness).

From a user point the reliability is perceived as an integral set of technical, qualitative, economic, ergonomic and other features of the product, affecting its total technical life. [2]. These features in practice are reviewed through a testing system at manufacturer, or in state testing facilities and through a testing system for an operational reliability during a testing or real operation in defined conditions. Within the army, or in conditions of the armed forces as for specific conditions of operation, there existed a system of quality monitoring, within it the field testing were performed on meeting specific parameters, including its operational reliability before having commissioned the product into military practice. Together with classical and dismantling less diagnostics, being used especially during periodic testing and repairs and simulation models and methods defining a course of random values, which are used in theory of reliability, they have served for an optimization of a preventive maintenance from technical and economic point of view. [3]. Nowadays the quality of a product is assessed not only from a view of its technical life, but also from a point of the product moral obsolescence. Within the Defence department the Standardization, Codification and Government Quality Assurance Authority in Trenčín has been established, which deals with issues of quality of special equipment in the future and there is a supposition that it will be accepted by international community, being involved in NATO. [4]. The terms of theory of reliability, terminology and standard reliability testing methods, being used in technical practice and within practice with special equipment are standardized in STN [5]. With regard to the process of admission to EU and Transatlantic structures the globalization process in testing area takes place in our country in accordance with the Standardization Agreement STANAG 4108.

Within the theory of reliability we specify:

- features,
- areas being reviewed and their basic characteristics,
- phenomena, conditions and activities,
- working valuable values,
- failures,
- reliability indicators,
- failure-less operation indicators,
- operational life indicators,
- storage stability indicators,
- maintainability indicators,
- complex indicators,
- testing,
- back-up.

Within the operational practice of the armed forces we paid attention to the reliability, failure-less operation, lifetime, maintainability in relation to a particularity of climate conditions of European and non-European countries, where special equipment – machines and equipment have been operationally deployed.

3 SPECIFICATION OF CLIMATE CONDITIONS FOR NEEDS OF QUALITY ASSESSMENT AND OPERATIONAL RELIABILITY OF SOME SPECIAL EQUIPMENT CLASSIFIED AS „MACHINES AND EQUIPMENT (ENGINEER-SAPPER EQUIPMENT) “

As extreme climate conditions are considered all those conditions, which are beside values typical for Central European mild climate zone. In literature [6] this environment is defined with values shown in Table 1.

Table 1 The characteristics of a mild climate zone

The lowest air temperature	-40ºC
The highest air temperature	+40ºC
The highest relative humidity	95 %
The highest absolute humidity	60 $g.m^{-3}$
The highest intensity of solar radiation	1120 $W.m^{-2}$
The lowest intensity of solar radiation	600 $W.m^{-2}$
The highest air speed	20 $m.s^{-1}$

The area, in which the selected machines and equipment were reviewed is characterized as an environment with an increased corrosion aggressiveness, the environs dusty with nonflammable dust but the one deteriorating a relative dielectric permittivity and electric break over resistance due to its conductivity, environs with vibration and environs with biological vermin. Such characterized environs, due to extreme climate conditions, influences especially on a corrosion resistance of materials. Additionally it affects in non-omissible way also the parameters of electronic parts and parts sensible to an electrostatic charge, to conductivity of environs, being a part of machines and equipment. Furthermore it is necessary to take the influence of faster spread corrosion on electric contacts into account, as well as interface and contact fields, if they are not especially adjusted for such environs. Non-conducting layers occur resulting in sparkling and creation of electric arcs (transitional actions). Likewise is in corrosion affected collectors, where sparkling and abrasion occur on non-conducting corrosive layers as well as choking of worn particles into a coil through air venting.

To assess quality and an operational reliability of selected special equipment as a variable dependent on climate conditions it is suitable to choose those values which are measurable or quantifiable ones during monitoring. For example in above mentioned climate conditions from deteriorating processes it is suitable to assess an atmospheric corrosion of metals on supporting parts of constructions by measuring its range, a depth of penetration, by assessment of a mass reduction of metal per a surface unit etc. It is necessary to assess a time flow of corrosion with relation to a relative humidity and temperature, to a rate of air pollution. From a point of atmospheric ageing of organic materials it is suitable to choose such data for parameters being assessed, that provably affect their functionality and operational capability of the equipment as a whole. For example, in operating the electric appliances in extreme climate conditions the cases on control voltmeters made of organic materials have showed as faulty due to atmospheric ageing. From a point of view of atmosphere pollution in locations being reviewed it was necessary to take into consideration the atmosphere pollution ranging:

- sulphur dioxide from 17 to 45 [mg.m-2.d-1],
- chlorides from 0, 20 to 0, 30 [mg.m-2.d-1].

In assessing the effect by humidity there was an initial knowledge, that a metal surface gets moist in form of dew due to a contact of a colder air with humid air of a higher or an equal temperature at a relative humidity higher than 60 – 70 %, which is to be taken into consideration at relatively large changes of temperatures day and night in extreme climate conditions.

This paper is not aiming at performing the measurements for climate charts neither to assess macroclimate areas.

4 POSSIBILITIES TO SIMULATE EXTREME CONDITIONS

The effects, having impact on parts during operation can be divided in mechanical and climatic ones. The effects of particular environs have to be taken into consideration in stating a sequence of particular tests, as well as their intensity, an impact on a particular product, equipment or machine. It is necessary to obtain the most possible information on a state of a component part before its destruction. It is appropriate to simulate such consequence of effects by particular environs as the environs will have an impact on a component part in a real application.

Several types of simulation chambers are used in simulating the environmental effects on component parts and equipment. Inside the chambers the environment is created simulating environs, in which the application of products is supposed, e.g.:

- testing through humid heat – a cyclic mode,
- testing through humid heat – a non-cyclic mode,
- testing through mildews,
- sealing test,
- testing through solar radiation,
- testing through an atmospheric pressure,
- testing through temperature alternation,
- testing through freezing temperatures,
- testing through dry heat,
- testing through a salt haze,
- low pressure testing,
- dust testing.

In case that the equipment is deployed e. g. in conditions of the environs with an increased air pollutant concentration and in coastal areas we recommended the following tests:

- corrosion test in a condensation chamber – to validate a resistance of materials and surface protection, if relates to an effect by an increased humidity or an increased concentration of SO2 with no influence by other factors,
- a corrosion test in salt haze – to verify a resistance of materials and surface protections in a seashore atmosphere with a decisive agent an aerosol of sea water,
- solar radiation testing – to verify a resistance of the product against effects of light and thermal effects of solar radiation,
- dust and sand testing – simulation of desert conditions,
- dry and wet heat testing,
- mildew testing – simulation of biological attack on a material,
- vibration testing.

The above mentioned tests have proved themselves in practice with respect to a subsequent operation of the equipment and material e.g. in areas of Equatorial Africa and on the Cyprus island.

5 SPECIFICATION OF ENVIRONS

The equipment being reviewed was located in environs of equatorial Africa and in Mediterranean Sea, on the Cyprus Island. The testing on equipment has been performed during a month after a rainy season had finished.

Table 2 Overview of operation places with description of conditions

Place of operation	Height above sea level [m]	Description of conditions
Eritrea Adi - Quala	2300	Surrounded by cultivated agricultural land
Eritrea Assab	0	Distance from shore about 2 km, surrounded by desert
Eritrea Barentu	1700	Surrounded by grazing land bushy grown –with many biological vermin
Eritrea Gergera	2100	Surrounded by mountain terrain, grass and low bushes
Eritrea Schilalo	1500	Surrounded by grazing land grown by bushes
Cyprus Famagusta	0	Seaport town, equipment located about 5 km from a seashore

6 SPECIFICATION OF EQUIPMENT BEING REVIEWED

The equipment being reviewed were parts of machines and equipment focusing on electric power generator and pressure-operated equipment. About 100 pieces of equipment were reviewed being operated in terms of environs – Table 2. The equipment was manufactured in Slovakia (Bratislava, Martin) and in Ireland (a part of equipment, see Table 3.).

7 ANALYSIS OF ACHIEVED REVIEWED RESULTS OF AN OPERATIONAL RELIABILITY FROM A VIEW OF ENVIRONMENTAL EFFECTS

With respect to the fact, that we have been reviewing renovated objects, we chose the characteristics of failure flow and renovation as an operational reliability criterion. The features of renovated objects are presented by a value of $\overline{\mathrm{H}}(t)$, a mean number of failures of a renovated object for a time period t:

$$\overline{\mathrm{H}}(t) = \frac{1}{N}\sum_{i=1}^{N} n_i(t), \qquad (1)$$

where $n_i(t)$ is a number of failures of the i-th renovated object for an operation time period t, N is a number of objects being reviewed.

From a statistics point of view it is suitable to use characteristics of a failure flow parameter, which is expected in a short time period Δt. This characteristic is defined by a relation:

$$\hat{h}(t) = \frac{\Delta \overline{H}(t)}{\Delta \mathrm{t}} = \frac{\sum_{i=1}^{N}\left[n_i(t+\Delta t) - n_i(t)\right]}{N.\Delta t} \qquad (2)$$

where $\Delta\overline{\mathrm{H}}(t)$ is an augmentation of a mean number of failures in a short time period Δt, or a mean number of failures in a time interval (t,t+Δt). In calculations we could take into consideration, with regard to a statistic assessment of real number of failures for an operational time period of 1 year that the failures of a renovated object are ruled by a distribution rule with an intensity of failures λ. In a particular situation, Table 3, a value of a mean number of failures of a renovated object for an operational period of 1 year (the tests have been performed for 1 month after a rainy season) achieved a value from interval (0,1 – 0,4) in a so called steady state of reliability (a running-up state was performed before its exportation abroad, we do not recommend an exploitation of the equipment abroad during its ageing state).

A factor of a technical exploitation:

$$K_{tv} = T / \left(T + T_p + T_o\right), \qquad (3)$$

and a readiness factor:

$$K_p = T / \left(T + T_o\right), \qquad (4)$$

where T is a mean period between failures of a renovated object,
T_p is a mean period of shut-down,
T_o is a mean repair period.

It is needed, based on lessons learned and studies, measurements, statistic records made in extreme climate conditions, to keep regular cycle of equipment and material servicing but decreased in 20 % in regular time periods and in time periods defined after climatic changes (e.g. rainy season, sand storm, a monsoon season etc.) on the level of a medium military field repair regardless its operational period. So we ensure that we keep an ergodic mode on the equipment and machine and we delay an exponential increase of failure intensity. As an important lesson learned has been proved a fact, that equipment, machines and mechanisms are to be exported and operated in extreme climate conditions only after their running-in period, or to create conditions, that a running-in is performed in stable and standard climate conditions. In indispensable cases (after larger repairs directly in the field, it is needed to simulate such conditions in the field after having performed a repair). After having calculated the period of the equipment deployment after the repair, this fact is to be respected. If not respected, the period from the commissioning until the first failure after the repair will be shortened.

Based on this experience it would be suitable to arrange the reliability characteristics of the exported machines, equipment, mechanisms and materials or to design them through a simulation method or modeling for extreme climate conditions.

Table 3 Overview of failure rate of some machines and equipment operated in extreme climate conditions

Ser.	Place of opera tion	Type of equipment	Manufacturer and production serial number	Model year	Mh	Coverage	Voltage system	Specific output [kWl	Defects found
1	Eritrea Adi – Quala	EC - 60 - 3 - 400 ČSAD	BEZ Bratislava 297 728	1982	1292	IP23b	3 + N + PE 400/231 V 50 Hz	60	A defective alternator BGC - 9104, a defective voltage controller R059, a defective voltmeter FP 80/S 0 - 500V, Hot contacts on a socket CEG 6343, hot insulation on a connecting block I_n=108A
2	Eritrea Barentu	EC - 60 - 3 - 400 ČSAD	BEZ Bratislava 210 208	1970	4044	IP23b	3 + N + PE 400/231 V 50 Hz	60	A defective ampere-meter FP 80/S 0-300A, a defective tracer of insulation condition M128E, a broken coil of an under voltage protection of a major J2 RUS1-E13108 A breaker
3	Eritrea Gergera	EC - 60 - 3 - 400 ČSAD	BEZ Bratislava 3713	1985	2243	IP23b	3 + N + PE 400/231 V 50 Hz	60	A defective socket CEG 6343 (hot contacts), a defective tracer of insulation condition M128 E, inaccurate voltmeter FP 80/S 0-500V
4	Eritrea Adi - Quala	MP - 250 L	TTS Martin s.r.o. G231	2001	12799	IP 40/20	3 + N + PE 400/231 V 50 Hz	200	A defective MXT,case for fueling, a defective voltmeter switch, a lot of dust inside the switch board and an alternator
5	Eritrea Barentu	MP - 250 L	TTS Martin s.r.o. G180	2000	11800	IP 40/20	3 + N + PE 400/231 V 50 Hz	200	A defective counter of Moto-hours, a mechanically damaged insulation of power conductors on a main connecting block of an alternator
6	Eritrea Assab	MP - 250 I	TTS Martin s.r.o. G230	2001	10500	IP 40/20	3 + N + PE 400/231 V 50 Hz	200	A defective thermometer and a cooling liquid switch, a defective controller of voltage in an alternator to charge accumulators, dust on electric appliances
7	Eritrea Schilalo	P 36 X	F.G.Wllaon Ireland Y8008/D/229	illegible	8680	IP23	3 + PEN 380/220 V 50 Hz	28,8	A defective main switch SCHRACK C 63/63A
8	Eritrea Assab	EC-30kVA vibration	MEZ Frenštát 30 442	1961	16,8		3 + PEN 400/231 V 50 Hz	24	Rusted clamps and surface of wire-wound resistors, rusted sockets, dust everywhere inside
9	Eritrea Gergera	EC - 30 kVA vibration	MEZ Frenštát 30 801	1962	58,1		3 + PEN 400/231 V 50 Hz	24	A defective manual voltage controller , rusted surface of wired-wound resistors and sockets
10	Eritrea Gergera	EC-6-3-400 ČSAD	BEZ Bratislava 252 667	1984	50,1	IP23b	3 + N + PE 400/231 V 50 Hz	6	Failure less
11	Eritrea Adi - Quala	EC-6-3-400 ČSAD	BEZ Bratislava 252 667	1979	1116	IP23b	3 + N + PE 400/231 V 50 Hz	6	A worn crank gear of a combustion engine, everywhere dust inside
12	Eritrea Adi - Quala	EC-6-3-400 ČSAD	BEZ Bratislava 214380	1974	422,4	IP23b	3 + N + PE 400/231 V 50 Hz	6	A defective voltmeter FP 80/S 0-500V, a defective fuel gauge
13	Eritrea Adi - Quala	6 - 3 - 400 ČSAD	BEZ Bratislava 1215	1984	12,2	IP23b	3 + N + PE 400/231 V 50 Hz	6	A defective Moto-hours counter SHS -1
14	Eritrea Adi - Quala	6 - 3 - 400 ČSAD	BEZ Bratislava 209 793	1973	100,2	IP23b	3 + N + PE 400/231 V 50 Hz	6	Failure less
15	Eritrea Adi - Quala	6 - 3 - 400 ČSAD	BEZ Bratislava 209 786	1973	23	IP23b	3 + N + PE 400/231 V 50 Hz	6	A defective voltage controller GN 011 (tiristor one), a defective voltmeter FP 80/S 500V
16	Eritrea Adi - Quala	4-3-400 ČSAD	BEZ Bratislava 446	1989	2,4	IP23	3 + N + PE 400/231 231/134 V 50 Hz	4	A defective tracer of insulation condition M126

Ser.	Place of opera tion	Type of equipment	Manufacturer and production serial number	Model year	Mh	Coverage	Voltage system	Specific output [kWl	Defects found
17	Eritrea Adi Quala	4-3-400 ČSAD	BEZ Bratislava 4922	1986	2,6	IP23	3 + N + PE 400/231 231/134 V 50 Hz	4	Failure less
18	Eritrea Adi - Quala	4-3-400 ČSAD	BEZ Bratislava 3770	1985	124,7	IP23	3 + N + PE 400/231 231/134 V 50 Hz	4	A defective voltmeter FP 80/S 0-500V, dust inside
19	Eritrea Adi - Quala	6-3-400 ČSAD	BEZ Bratislava 4278	1988	2,7	IP23	3 + N + PE 400/231 V 50 Hz	6	A defective voltmeter FP 80/S 500V, a defective voltage regulator GN011
20	Cyprus Famagustia	4-3-400 ČSAD	BEZ Bratislava 3056	1985	101,9	IP23	3 + N + PE 400/231 231/134 V 50 Hz	4	A defective Moto-hours counter, a non-functional testing trigger of a voltage breaking piece

8 A BACK-UP METHOD AS A POSSIBILITY TO IMPROVE A RELIABILITY OF MACHINES AND EQUIPMENT BEING OPERATED IN EXTREME CLIMATE CONDITIONS

Backing-up is one of basic methods of improvement of machines and equipment reliability. Connecting one or more element, especially in parallel connection to certain, less reliable element, module, on which depends a reliability of the system, machine, improves a reliability of the system. The following relation is valid for a parallel connection of elements (Fig.1):

$$R_p(t) = 1 - \prod_{i=1}^{k} 1 - \exp\left[-\left(\frac{t}{a_i}\right)^{b_i}\right] = 1 - \prod_{i=1}^{k} F_i(t) \quad (5)$$

where

$R_p(t)$ is failure less operation of a parallel system,

$F_i(t)$ probability of a rise of failure in particular elements of the system.

Relationship of increase of system reliability with number of elements in a parallel arrangement [1] is shown on the Fig. 2.

Even though a back-up results in an increased complexity, and so to increased costs for its purchase, this method has proved as a suitable in an expected deployment for special tasks in extreme climate conditions.

As an example in respect to the failures we can show the proposed and implemented measures, which resulted in a requested effect of a possible exploitation and an operational reliability in the Tab. 3 with regard to the mentioned environs - backing-up of defective gauges with electronic tracers and interlocking circuits, relay circuit backed-up with thyristor ones and triacs, contact and contact fields with electronic contactless switches, backing-up of control and regulation elements with optoelectronic elements, backing-up of sensors with elements based on different physical principles etc.

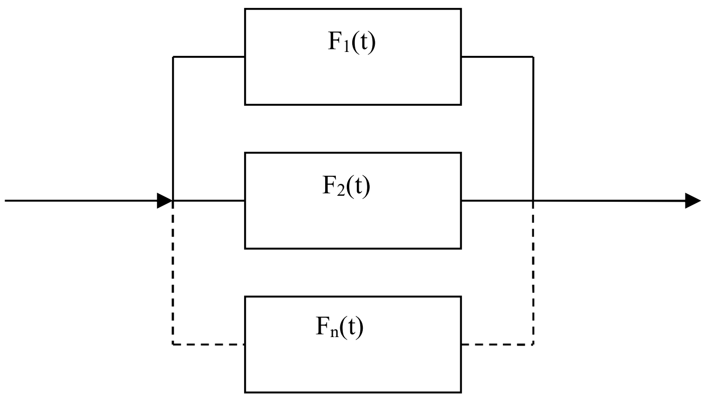

Fig. 1 System of elements with a parallel arrangement of elements

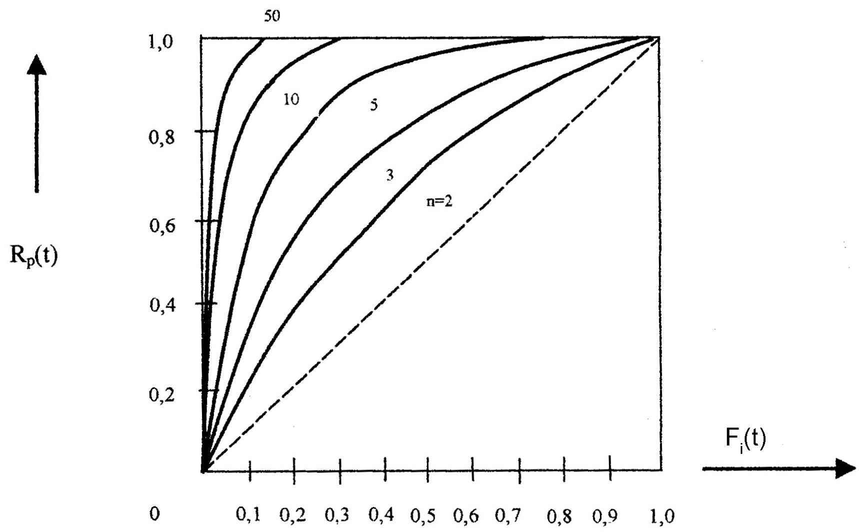

Fig. 2 Relation of the probability of failure less operation of a parallel system and a number of elements

9 CONCLUSION

It is not possible to expect a design of an all-purpose solution or a recommendation of a requested operational reliability regardless the environs effects. By evaluating lessons learned from exploitation of equipment, especially in extreme climate conditions, by modeling and simulating the possible effects of the environs and operation of machines and equipment within, we can work out criteria for assessment of quality of machines and equipment being reviewed with respect to a possibility to operate them in these conditions. The lessons learned have proved the possibility to export and to deploy the machines and equipment of the SR Armed Forces armament and SR crisis management into extreme climate conditions, e.g. out of Europe. With respect to the development in the area of conducting the combat activities, where a use of single equipment is pursued in different climate conditions, an importance of solving issues relating adjustment of equipment for its application in different conditions has been still increasing. This adjustment is to be taken into account not only in designing the equipment, but also in a logistic support of its operation, in designing technologies and a plan of its exploitation. The published lessons learned showed a possible economical approach as well, e.g. a possible extension of a lifetime for some technical equipment (pressure-operated equipment, heavy-current equipment, and lifting equipment) in keeping a needed operational reliability.

The issue being published relates with a need of implementing a single system in assessment of quality, codification and standardization with regard to an admission to the security structures. In this area it will be necessary to pay attention also with respect to unification in assessing the operational reliability of special equipment.

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CHOSEN ASPECTS OF MILITARY EQUIPMENT MAINTENANCE UNDER COMBAT OPERATIONS

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Abstract: The paper introduces a container workshop project of performing maintenance of The Czech Republic's land combat vehicles under field conditions. The presented workshop consists of two ISO 1C size range containers with special equipment. The first container is called a "working unit" and the other one is a "special purpose unit". During combat activities the containers would be arranged in L shape with rolled out roof. The article presents organization and technical conditions essential for implementation of the system of military equipment temporary repairs for military technical support's functioning. Furthermore, the article mentions such issues as unification and adjusting the equipment in a design and production processes, pro-active diagnostics, procedural conditionings, technology and temporary repair. Each issue is discussed considering possibilities and needs of temporary repairs system implementation.

Keywords: Logistics. Operation system. Field repairs of the military equipment. Telemetry maintenance system. Temporary repair. Container workplace. Battle damage repair kit. Combat service support. Maintenance of vehicles. Field repair.

1 INTRODUCTION

A problem of unscheduled field repairs gains special importance in conditions of military operations during which the dominant source of equipment loss is combat and operation damage.

As the history and experiences of the last armed conflicts have shown, the enemy's use of modern agents of destruction is causing more and more military equipment losses. In case of an army system, the significant part of this damaged equipment is recovered and thanks to its repair directly included in further operations within the area of operations. This is a basic source of providing units with equipment; especially in the conditions of peaceful and stabilization missions.

Temporary repairs process is executed under the field conditions and consists of the following stages:

- range of damage assessment,
- selection and elaboration of damage repair technology,
- making a decision concerning the repair providing that the repair can be done in an appropriate time period,
- execution of the repair in the field conditions or having the damaged equipment repaired in a parent unit or in a repair plant.

To make this process fully effective and to make the executed repairs low-cost, easy to perform, and sufficiently durable, requirements described in the below chapters should be met.

2 PROACTIVE DIAGNOSTICS

Maintenance based on technical conditions was gaining importance in the past decades with the expansion of technical diagnostics. It is especially preventive maintenance comprising of monitoring performance or parameters and of consequent measures. Its main benefit resides in consistent removal of failures. Particular worn parts and parts or whole assemblies in the risk of failure are repaired or replaced optimally in advance. Thus, failure occurrence is prevented.

Proactive maintenance is considered as another higher level of maintenance. It is completely based on the previous predictive maintenance. This core is improved by utilization of more complex technical diagnostics. Basically it is the top current version of predictive maintenance based upon actual condition of the item operated. It is analysed in detail in the following chapter.

Proactive maintenance arose from the predictive maintenance type as a reaction especially to long-term findings that a certain group of failures repeats periodically upon clear causes. Known causes include mainly the following:

- Incorrectly organised maintenance work;
- Incorrectly performed maintenance (technical operation in the vehicle);
- Unqualified operators and maintenance personnel.

The proactive maintenance type is focused on keeping inherent reliability of the vehicle on an acceptable level. As a source of information is utilized technical diagnostics. The main objective of proactive maintenance are:

- Further reduction of maintenance and operational costs;
- Prevention of failure occurrence and thus extension of an interval to preventive maintenance, meaning extension of the vehicle durability;
- Statistic control of accidental and systematic influences affecting the vehicle operability [1].

An important feature of temporary repair system is information about fault occurrence given as soon as possible. Knowledge of size and place of damage, as well as its impact on further operation of military equipment, has a direct influence on further actions that aim is restoring the equipment's efficiency. The modern military vehicles use the civilian technology based on the CAN (Controller Area Network) bus for data transmission. However, for the needs of NATO armies, MilCAN system was created in 1999 dedicated to the newest and the most advanced armoured fighting vehicles manufactured in the NATO states.

The latest trend in the maintenance area is called "telemaintenance", which may be explained as remote-controlled maintenance employing the proactive maintenance principle. In some publications, the term "Remote Diagnostics & Maintenance (RD&M)" is used [1]. It is based on wireless transmission of technical data of the vehicle. This manner is mostly used by companies specializing in long-distance transportation and also by military. This method enables on-line monitoring of parameters by sensors integrated in the vehicle and wireless transmission of the information to a remote computer. This is very helpful especially for securing missions on a foreign territory.

Telemaintenance may be divided into the following four levels:

1. Diagnosed vehicle with a driver;
2. Support logistics centre where a computer processed diagnostic information is located;
3. Experts performing the maintenance on the vehicle;
4. Vehicle manufacturer who supplies a technical database including drawings and technological procedures for maintenance [1].

Figure 1 shows a schematic telemaintenance system based on wireless transmission of diagnosed data from the vehicle to the telemaintenance logistics centre and to the vehicle user. The vehicle electronic control unit makes performance indicators and error codes accessible for an analysis; these are sent to the logistics centre.

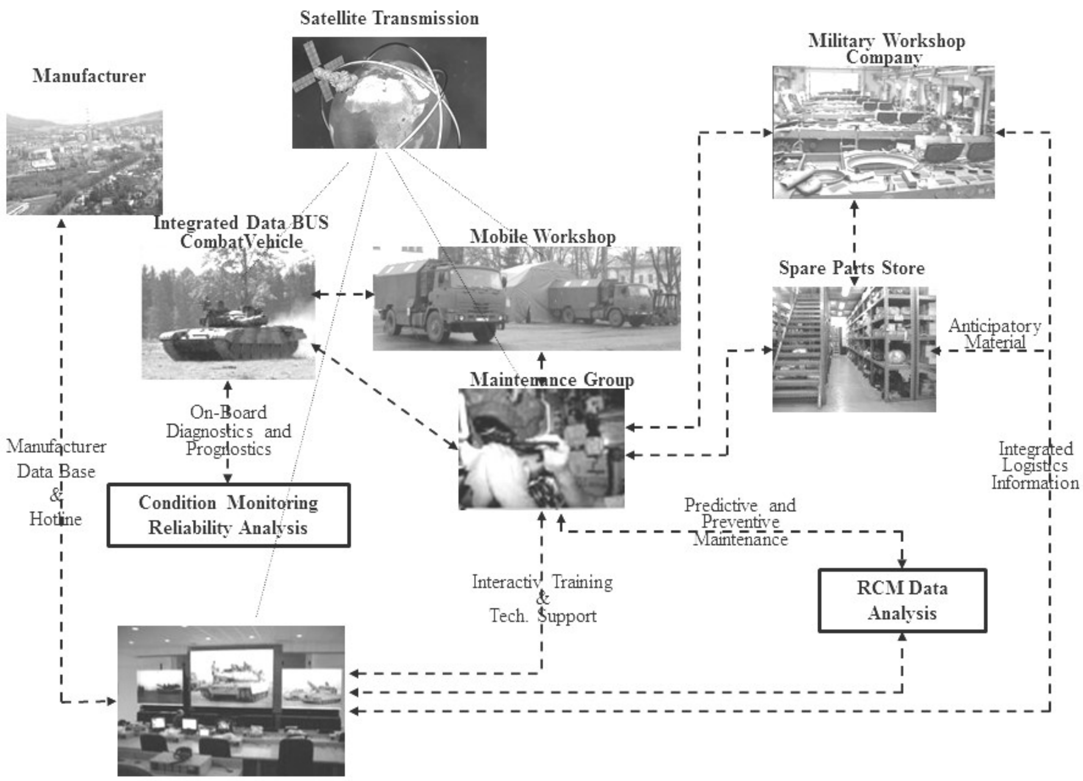


Fig. 1 Design of telemetry maintenance system in battlefield [1]

In case of error messages an advisor informs the driver about the problem severity and advises on possible problem removal or provides necessary service support.

It means that the advisor ensures the vehicle maintenance or field repair with the use of a mobile workshop, or arranges maintenance in the maintenance and repair centre. If necessary, the logistics centre communicates with the vehicle manufacturer who supplies the centre with new data materials for particular vehicle types.

3 DESIGN OF A CONTAINER MOBILE WORKSHOP

3.1 General description of a container mobile workshop

1) Determination of a container mobile workshop

A wheeled container workshop (a functional module) along with a special tool store is designed for the repair level 2 and 3, namely:

- the chassis of the car model range Tatra (815, 810),
- the chassis of the automobiles Land Rover etc.,
- the chassis of the wheeled armoured vehicles PANDUR II, Dingo a Iveco.

A tracked container workshop (a functional module) along with a special tool store is designed for the repair level 2 and 3, namely:

- the tracked combat vehicles BVP and T-72 M4CZ.

Crew structure and the technical skills of the crew members are selected according to the types of supported combat vehicles and can change. We recommend for this workshop a 6-member crew consists of a crew leader - an auto mechanic – a welder, a senior auto mechanic, an auto mechanic – a welder, a senior mechanic, a senior auto electrician, and a senior electrician [2], [3].

2) Standardized workshop solution

The container workshop is made from two pieces of ISO 1C size special containers arranged in an L shape (Fig. 2).

The workshop consists of two container workshops. First workplace is created with the working module which is universal for the maintenance of tracked and wheeled combat vehicles. The working module is placed in one ISO 1C container and is heat insulated with sandwich panels. Second workplace is created with the functional module. This means that it might be used for the maintenance and the repair of wheeled combat vehicles as well as tracked combat vehicles, which depends on internal facilities which might be changed according to the kind of supported vehicles. In the ISO 1C container there is a special tools´ store which is actually a functional module equipped according to the kind of supported combat vehicles.

The tools might be combined for appropriate function. In certain situations the module can be equipped with extra tools used for the maintenance and the repair of armaments, communication equipment, etc. An outdoor workplace intended for the repair of land combat vehicles is designed with a roof which might be rolled out in the space between containers, see Fig. 2.

3) Basic tactical and technical properties of a workplace

The body of containers will be welded using steel sections and trapezoidal metal plates which will make a covering for the containers. The upper and bottom corner container elements of ISO 1C size will be built into basic bodies. The container panels themselves (peripheral and roof ones) will be filled with 40 mm thick insulating sandwich panels made of Elastopor SH 226/003 polyurethane foam which has been authorized to use in the Army of the Czech Republic after long-term tests. As for the covering material of insulating panels, it will be a 0,8 mm thick surface-modified aluminium plate.

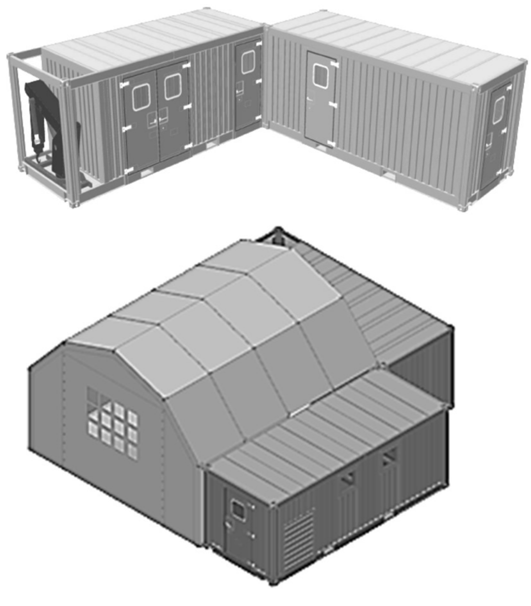


Fig. 2 A container workshop project arranged in an L shape

A container floor will be made from isothermal floor panels with a plywood, and covered with anti-slip PVC. The floor panels will be filled with the same Elastopor SH 226/03 polyurethane foam. The floor panels will be 50 mm thick. Entry doors to the containers will be equipped with a special door lock with the possibility to be locked by locks, and rigid clips for sealing.

General outside dimensions of 1C container are standardised. The mass of projected workshop modules will be as follows [2], [3]:

1. A working module
   a) service weight................................... 3 000 kg,
   b) effective weight.......................... to 16 500 kg,
   c) total weight..................................... 19 500 kg.
2. A special tools store – a functional module
   a) service weight................................... 2 730 kg,
   b) effective weight.......................... to 22 000 kg,
   c) total weight..................................... 24 730 kg.

The workshops can be used for the work [2], [3]:

a) in mild climate zones, i.e.
   - in the areas of average monthly temperatures from -15 °C to 25 °C,
   - with the lowest temperatures rarely below 32 °C, and the highest above 44 °C,
   - with extreme temperatures -40 °C and 50 °C,
b) with relative air humidity to 90 % and a temperature of 33 °C,
c) with air dustiness to 1,5 $g \cdot m^{-3}$ taken 0,5 m above the ground level,
d) with the speed of air flow to 20 $m \cdot s^{-1}$,
e) with atmospheric precipitation such as rain, snow and hail,
f) at above sea level to 3 000 m (to 4 000 m for a short term).

Driving fuel supplies are big enough to provide currently:

a) heating operation for 48 hours,
b) power source function for 20 hours,
c) hot-air heating operation in a workshop tent for 10 hours.

The requirements regarding the work in a workshop are as follows:

a) the concentration of harmful substances will not exceed during 12-hour work 20 mg/m^3 of carbon monoxide, 200 mg/m^3 of oil fumes, 70 mg/m^3 of petrol fumes, and 0,3 mg/m^3 of sulphuric acid fumes,
b) there will be provided natural light as well as artificial light in the workshop,
c) the workshop will be equipped with lamps for main, spare, local and cover illumination according to the ČSVN 83 960,
d) illumination level will be at least 50 Lx in the check points 1m off the ground and 0,5m off the wall. The most illuminated place to the least illuminated place ratio will be bigger than 1 to 3,
e) the illumination of the workplace in a tent will be provided with a 230 V portable illuminating set with a screening slide.

For concealing the container workshop a fish net of 12 x 15 m is used with supporting components and needles. In order to fasten a camouflage cover, the containers are on the sides equipped with clips for supporting components holding stability against wind. It takes approximately 20 minutes to conceal the container, and 15 minutes to remove the camouflage [2], [3].

3.2 Equipment of a working module and a functional module

1) Equipment of a working module designed for the maintenance of wheeled and tracked combat vehicles.

Working module was divided into two basic rooms:

a) Sealed (work-related) – is the main room for a functional workplace where work might be done.
b) Non-sealed (technological) – is the room intended for placing basic technological equipment consisting of the filter and ventilation plant FVZ 98, the air handler K 4A, the independent hot air heating D5LC, sources and electric and light distribution [2], [3].

2) Equipment and main parameters of a functional module designed for the maintenance of wheeled or tracked combat vehicles

In the functional module we suggest putting a welding equipment used for welding by a welding arc, and charging accumulator batteries; a set for gas welding (1 piece of an acetylene bottle, 2 pieces of an oxygen bottle, a bottle trolley, a welder set); a tent fly; portable oil firing; drive-up ramps, crane facilities (suspension tools), a hydraulic jack for 8 t and 25 t; expendable supplies and selected spare parts.

Apart of that, there is in the functional module a hydraulic swing crane placed at the front wall of the container to the left of an entry door. It is fixed on a special traversing bridge. Drawing out and retracting the crane is provided by a linear hydraulic motor connected to a crane hydraulic circuit. Two linear hydraulic motors providing the stability of a crane in a protruded position also will be connected to the hydraulic circuit [2], [3].

In the functional module there is advisable to place also the set of coupling and suspension tools used for manipulating with the systems and subsystems of supplied technical equipment when dismantling and mounting vehicles. The tools are chosen from the unified set introduced within the Army of the Czech Republic.

In the mobile container workshop we suggest putting also the sets of battle damage repairs kits such as: metallurgical material, connection accessories, electrodes for electric arc welding, welding material for flame welding, soldering process, adhesives materials and materials used for repairing tire tubes and tires.

4 PRINCIPLES OF TEMPORARY REPAIRS

According to Alliance documents „temporary repair is repair, which may be temporary, to restore an equipment to a specified condition by non-conventional/improvised repair, both deployed and in-barracks, bounded by legal constraints". Similar formulation of the problem was presented in European Standard EN 13306 where is said that temporary was defined as: „physical actions taken to allow a faulty item to perform its required function for a limited time interval and until a repair is carried". In the past the temporary repairs of military combat vehicles proceeded spontaneously and depended on the circumstances to be dealt with. The repair progress was influenced by experiences, the level of combat vehicle complexity, technical facilities and individual skills. Applying a different technology, using a reproduction part, or performing a repair by a serviceman without the competence is typical features of temporary repairs.

4.1 Theoretical principles of temporary repairs

It is beneficial to realize that the temporary repair of combat vehicles cannot adequately substitute the repair performed in compliance with technical conditions and that is the reason why the next repair should be carried out in the shortest term. The reason for performing a regular repair is that a nonstandard procedure does not provide dependability. In spite of all drawbacks, the temporary repairs can play an important part in a combat operation.

a) Temporary repairs in peace time

The aim of a temporary repair in peace time is to renew or partly renew mobility and to prevent from more extensive damage, as for example environmental pollution caused by the leak of hazardous substances, safety threat by making a trouble in operation, or the devaluation of a transported material.

Operating costs are not expected to be increased due to the temporary repair, therefore, when deciding whether to perform it, economical factor will be the main criterion.

b) Temporary repairs under field conditions

The difference between the temporary repairs of combat vehicles performed in peace time and under field conditions is that we follow not only economical factors which are the most important in peace time, but also the provision of combat vehicle main functions, e.g. a weapon system, vehicle mobility and communication. The survival time of a vehicle (a crew) in a battle fields crucial for deciding whether to perform the temporary repair. To put it simply, the recovery process of combat vehicle fighting power might be viewed as a geometric sequence [4]:

$$n_t = n_0 q^{t-1}, \tag{1}$$

where n_0 is the number of combat vehicles before the operation began, n_t is the number of combat vehicles at the beginning of the day t, q is a sequence quotient, t – the number of days.

The magnitude of the sequence quotient q can be described as the ability to repair damaged combat vehicles with the extension of loss z, combat vehicle repairability ψ, and when considering the capacity and technical possibility of performing the repair with repair units ε.

Therefore

$$q = 1 - z + \psi \varepsilon z. \tag{2}$$

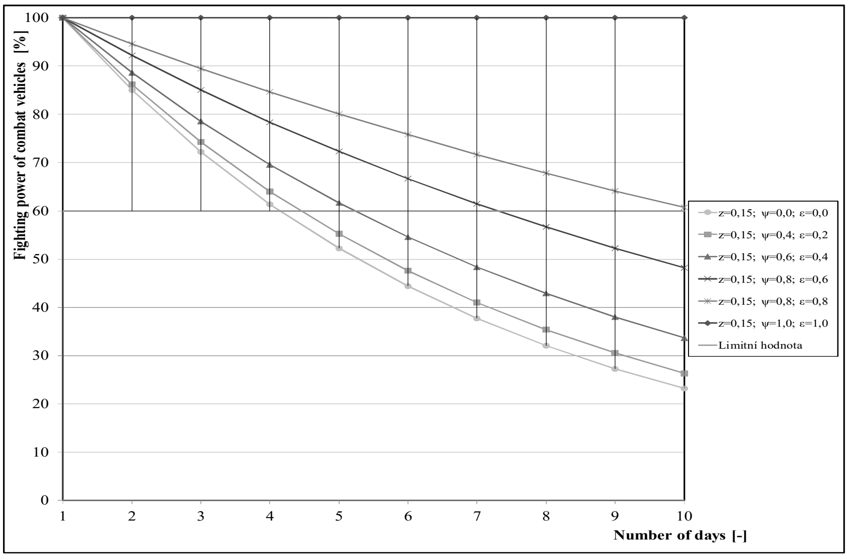
Then, sustainability time is given by a decrease in the number of combat vehicles at an acceptable level n_x

$$n_x = n_0 \cdot q^{t_x - 1} \tag{3}$$

and therefore

$$t_x = \frac{\log n_x - \log n_0}{\log q} + 1, \tag{4}$$

when reaching the time t_x a unit must be replaced or supplied by another combat vehicle [4].



Graph 1 Fighting power of combat vehicles with 15 % daily losses

Performing temporary repairs helps increasing of the capacity of repair units by labour saving, overcoming downtime due to the lack of spare parts, or involving crews in the repair process. This will be manifested in the rise in coefficient value ε.

Graph 1 shows the courses of the decrease in fighting power with average 15 % daily losses z the limit of 60 % fighting power and different magnitudes ψ and ε.

The courses of single curves show that extending the capacity of repair units has a positive impact on the fighting power time of supplied units, e.g. when performing temporary repairs.

4.2 Temporary repairs technology

The aim of a temporary repair system is to increase the level of professional personnel and workshop specialist readiness for the recovery of combat vehicle fighting capacity and to prepare the means of logistic support to provide this repair.

The system takes into account the development and verification of technologies which can be used for performing temporary repairs including their material support. The temporary repair system should be targeted at well-arranged technological procedures focused on the temporary repairs of important nodes with labour input time evaluation, necessary tools and material [4].

We suggest that general procedures should be subdivided per systems or parts common for combat vehicles. In the text below there is a division scheme and the possibilities of performing temporary repairs [4].

Tanks:

- smaller ruptures and leaks which might be fixed by bandaging or cementing with the use of fast-setting two-part sealants,
- disruptive breakdowns which might be repaired through a combination of bandages and packing, or packing made of different material,
- damaged tanks which might be replaced by connecting barrels, canisters or heat resistant cases capable of being closed with a specific medium.

Condensers:

- leakage which can be stopped using substances added to a cooling liquid which solidify during the leak from a cooling system, or fast-setting sealants used in the place of the leakage or nearby,
- disruptive breakdown which can be fixed by squeezing a tube with pliers and then filling the hole with a sealant or hot lead,
- damaged condenser which can be isolated for a short time and a cooling system might be interconnected without the condenser, or the condenser may be replaced by another part, e.g. a barrel or a demountable fuel tank.

Pipe:

- minor damage and the leak of a low-pressure pipe which might be repaired by bandaging or using two-part workable sealants,
  more serious damage to a low-pressure pipe (not including exhaust pipes) which can be solved by replacing a damaged part with a rubber hose fastened with a sleeve or a band,
- damage to a high-pressure pipe which can be mended by pipe's offset and cementing the ends with anaerobic sealants, or by complete replacing the pipe using a high-pressure hose with endings.

Air and hydraulic systems:

- damage to the part of a system which might be disabled by blanking of a particular part, or providing a by-pass around a damaged part using hoses with endings.

Rods and shafts:

- cracked rods can be joined by a thicker bond sheet metal, the ends of which will be drilled and screwed together, or there will be used a sleeve welded at the end,
- cracked shafts will be joined by welding to a sleeve where applicable.

Windings:

- minor damage can be mended by using a threaded coupling with an anaerobic sealant,
- damaged internal thread might be fixed by drilling off and using threaded insets which renew the original winding.

Electric cables:

- visible local damage might be repaired using insulation with both ends twisted and insulated by an insulation tape, or the joint is welded,
- damage difficult to detect can be fixed by bridging a proper circuit using a new cable, or, in case of power supply, by connecting with a cable assembly with nominal voltage [4].

5 DESIGN OF A BATTLE DAMAGE REPAIR KIT OF LAND COMBAT VEHICLES IN FIELD CONDITION

Repairs of land vehicles under the field conditions are not only accomplished by using the mobile workshops but also by using of temporary repairs.

We proposed a battle damage repair (BDR) kit (Fig. 3) for the temporary repairs implementation in the Czech Army. Dimensions of BDR kit bag are 50 x 32 x 15 cm and weight is 8.1 kg. The bag is divided in to three separate boxes, in which the material for the temporary repairs of the land vehicles is placed. First box contains adhesives and cements. There are tubes, adapters, connectors and plugs in the second box. In the third box there is material for repairs of the land vehicles electrical systems, for instance shielding, wire, crimping pliers, tin solder etc.

Fig. 3 Battle damage repair kit for repair land combat vehicles

6 CONCLUSIONS

The paper presents the project of the container workplace designed for the maintenance of wheeled and tracked combat vehicles under the field conditions. The quick and cheap replacement of functional module equipment according to the type of supplied technical vehicles is one of the advantages of this project. With replacing internal facilities, the wheeled version module might be changed into the tracked one and vice versa. Using a unified workplace module for the maintenance of both wheeled and tracked combat vehicles is another advantage of the paper. The real benefit of the project lies in achieving the unification and reducing the number of mobile workshops within the Army of the Czech Republic, because at present there are about 80 kinds of them in the Czech Army.

The analysis conducted within the framework of the paper concerning possibilities and needs' analysis in a scope of arming systems' temporary repairs' implementation allows formulating the following conclusions:

- The military equipment temporary repairs executed directly in the operation area can be a significant source of retrieving damaged military technology and have a direct influence on combat ability of forces.
- Army systems' survivability and field repairs should be formed already at the stage of equipment designing and manufacturing.
- Procedural conditionings are essential for directly executing of repairs in operation areas. Operation equipment and instruction procedures must precisely determine possibilities of using the temporary repair in the particular circumstances, which can ultimately contribute to further damage but still, it enables task finishing or even saving human life on the spot.

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MODELING AND APPLICATION OF THE ELECTRIC GENERATOR DRIVE THROUGH A VEHICLE MICROTURBINE FOR MILITARY SYSTEM

Viktor FERENCEY, Juraj MADARÁS, Martin BUGÁR

Abstract: Work describes current situation in field of use electric generators in military vehicles and systems. Describes real and concept applications of the combustion microturbines for drive electric generators. The main part of the work is focused on the cooperation of the combustion microturbine and the electric generator for military system, which represents Unamnned Ground Vehicle. The geometrical model in the program CATIA® environment designed is. Model, simulation and control algorithm for this serial hybrid drive is designed in Matlab/Simulink environment. The results of simulations and graphical outputs are evaluated.

Keywords: Combustion microturbine. Generator. Electric energy. UGV. Operation time.

1 INTRODUCTION

The operational goal for all unmanned, ground, robotic systems will minimize close combat (larger distance from the enemy's forces) and increase the protection of own forces spread through sensors that keep excellent situational awareness, possibly with using a "stand-off" weapons systems.

Digitizing (concept NEC) to help win the info war and give the flexibility to build up a coordinated action at the specified time and place better than the current tactics based on the mass forces. More and more are the importance methods of neutralizing the OPFOR (Opposition Force) at avoiding losses of the noncombatants, dominance in all dimensions of the battlefield, maneuver and security in urban areas. Currently, in urban areas is very difficult to promote technological superiority against the OPFOR forces that are often at a lower level of technology. Using specific robotic systems can reverse this situation and ensure the initiative on our own forces. For example, the use of large unmanned, ground, robotic systems (maternal carriers) can ensure the rollout of micro robots, static sensors and micro-unmanned aircraft (UAV) that will enable extensive dispersion of sensors and sources of information and precision attack on the reach of conventional fire and missiles.

Inherent characteristics of robotic systems allow us to anticipate the increased use of airspace, but also on the surface and underground areas, in all military operations, the surveillance / detection and neutralization task as well as to obtain environmental data in hostile or unfamiliar areas or gathering intelligence information.

Those unmanned, ground vehicles could occupy in the more or less near future, a predominant place in mine clearance. Mine warfare is, in fact, an area of combat that is particularly ready for the use of these types of machines, because the mines are "immobile" threat (speed of vehicles is not an essential parameter), which requires considerable risk-taking to identify and neutralize. It is therefore possible that in the future, autonomous vehicles can be able to perform all tasks using mines (detection, classification, identification, neutralization, sweeping, mining).

This does not mean the end of human intervention in various fields using robotic systems. In fact, the presence of man "in the loop" will continue to be necessary, even if only for planning the deployment of these machines and responding and interference in unpredictable situations.

In different areas raises the question of arming unmanned, ground, robotic systems (guns, mines, rockets or missiles). Moreover, this question is relative to a vehicle that can also be used as "mobile" mines or missiles. However, the requirement is to ensure complete control of the effects of these weapons.

The use of unmanned, ground, robotic systems seems to be especially important for [1]:

- Supervision of ground and underground spaces (in addition to air the segment);
- Providing early warning of forces in favor of the population;
- Implementation of the survey identified areas and buildings and in particular assess the effect of the use of weapons;
- Identification of suspicious objects or vehicles, possibly provoking a response from them to increase classification capability;
- Contributing to the protection of dismounted soldiers;
- Protect their own vehicles or troops against terrorist attacks;
- Analysis of environmental space, assuming the use of chemical, bacteriological and nuclear agents.

This is not how to replace human by unmanned, ground robots in combat phases, but do all that human effort involved in direct combat in the best possible conditions. This is especially true in very compartmentalized areas or in areas where transmission of information is complicated. This is especially true for urban and mountainous environments.

2 ENERGY REQUIREMENTS OF THE UGV

On Fig.1 is also shown energy requirements of traction, control system and subsystem which are used in UGV. UGV generally contain these main systems:

1. Traction system:
- Traction electric motors/generators;
- Invertors (control power units for electric traction motors/generators);
- Auxiliary unit (auxiliary unit with fuse box);
- DC/DC Bus (stabilization power circuit with power relays).
2. Energy system:
- Primary energy system (rechargeable battery system);
- Secondary energy system (supporting energy system – supercapacitor system).
3. Control and information system:
- Embedded control system (battery management system - BMS and supercapacitor management system - SMS);
- Main control system (Control processing unit which processes data from embedded system and communicates with autonomous control system of the mobile robotics system).

Based on the energy requirements UGV (Fig. 1) and available technology advanced battery systems, the whole energy requirement during operation ensures the battery system.

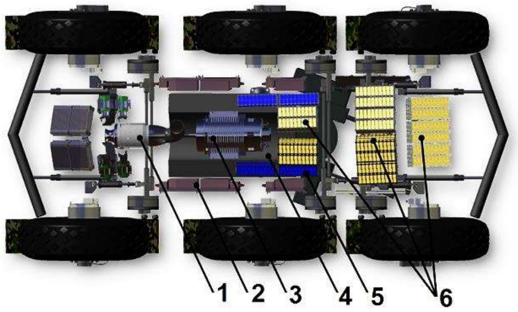

Fig. 1 Model of traction and energy system of the UGV
Where: 1 - combustion turbine, 2 - electric motor/generator controller 3 - DC synchronous machine (generator), 4 – fuel tank, 5 – supercapacitor system, 6 – traction battery system

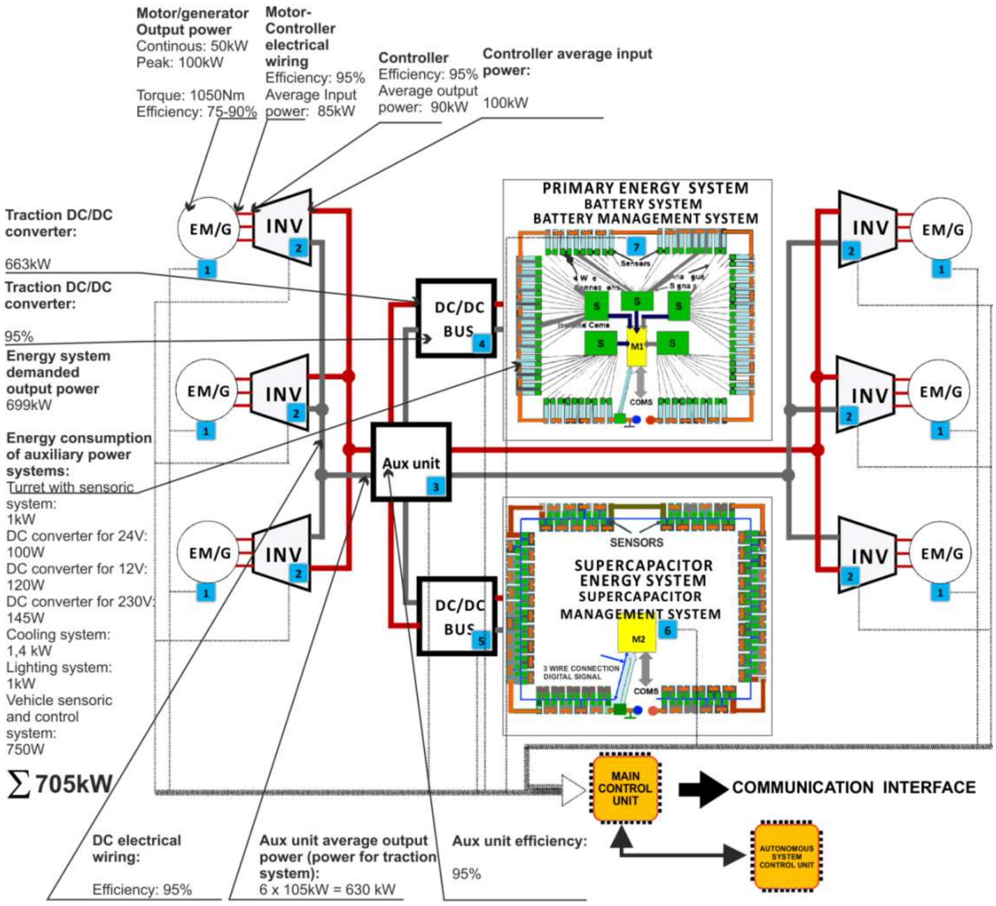

Fig. 2 Topological model of traction and energy system of the UGV
Where: EM/G – Electric Motor / Generator, INV – Invertor, Aux unit – Auxiliary unit, DC/DC Bus – Supervisory DC/DC power control unit of electric energy source, S – Supervisory control of the battery management unit, M1 - embedded control unit of the battery management system, M2 - embedded control unit of the supercapacitor *management system, MAIN CONTROL UNIT – main electronic control unit*

Therefore it is appropriate to include in the energy system has been implemented serial hybrid system, which is a system that is able to charge the battery system and which in the case of discharge to the critical value, the rechargeable battery or damage of the system is able to cover the power requirements.

Based on the energy requirements UGV (Fig. 2) and available technology advanced battery systems, the whole energy requirement during operation ensures the battery system.

Therefore it is appropriate to include in the energy system has been implemented serial hybrid system, which is a system that is able to charge the battery system and which in the case of discharge to the critical value, the rechargeable battery or damage of the system is able to cover the power requirements.

$$M_{ES} = \frac{C_{RC}}{E_{SEBS}} \qquad (1)$$

Where: M_{ES} – Mass of the Energy system (kg), C_{RC} – Rated Wh Capacity of UGV system / Energy requirement /(Wh), E_{SEBS} – Specific Energy of battery system (Wh/kg).

Final mass of energy system is the 1.3 tons. Charging the energy system will provide high speed PMSM generator with an output 315 kW drive through C200 combustion turbine, consumption combustion turbine "C200" is 10900 kJ / kWh.

From the relationship:

$$E_{cons\_turb} = C_{RC} \cdot V_{cons\_turb} \qquad (2)$$

Where: E_{cons_turb} – Rated energy consumption of the turbine (kJ), C_{RC} – Part of the rated capacity of UGV system - energy requirement (kWh), V_{cons_turb} – Consumption of combustion turbine C200 (kJ/kWh) is calculated energy requirement for fuel to drive turbine.

Based on the heating value of diesel and relation

$$V_{tank\_cap} = \frac{E_{cons\_turb}}{h_{td}} \qquad (3)$$

Where: V_{tank_cap} – Fuel tank capacity (liters), E_{cons_turb} – Rated energy consumption of the turbine (kJ), h_{td} – heating value of diesel (kJ/liter) is calculated fuel tank capacity, which is 95 liters.

3 COMBUSTION TURBINES IN MILITARY APPLICATIONS

One options of the electric drive system is to use a vehicle combustion turbine. In the 50s and 60s of the last century were developed a number of concept cars that used to drive with system, that include combustion turbine or microturbine.

Combustion turbines in these concepts, however, are not used for hybrid vehicles, but to drive a vehicle. [15] This type of propulsion for road vehicles would not be effective, since the power control turbine was difficult. Turbines have high fuel consumption and have been technically difficult to transmit torque from the turbine to drive wheels. Therefore vehicles running through the combustion turbines in mass production have great success. [15]

In recent years it has been increasingly talking about electric vehicles with extended-range (Erev). These are also hybrids. Combustion engine are not intended to directly drive the vehicle, but only to generate energy for the electric generator. In practice, for this purpose mostly used internal combustion engines, but there are already some interesting concepts that drive the generator for electricity for the electric motor using micro turbine combustion. Microturbines in these vehicles operate at approximately constant load and speed, thus their emissions and consumption are very low. As can be seen from concepts, using the hybrid propulsion gas turbines are much more efficient than using the direct drive. Microturbine combustion turbine of small size and low power operates at high speed. Performance microturbines have performance range from hundreds of watts in small turbine to larger power output up to approx. 300 kW. Microturbines are increasingly used in distributed power generation and cogeneration. They are also one of the most promising technologies for use in hybrid electric vehicles.

Combustion turbines and microturbines are working with Ericsson-Brayton cycle. Pressure conditions in micro-turbines are larger, higher initial temperature and air temperature to the compressor is minimized. Shaft is mostly used. Foils bearing need lubrication oil. Since microturbines operate at high speeds around 90,000 – 100,000 revolutions per minute (rpm), the majority of the shaft connecting the compressor and turbine high-frequency generator. Parameters of electricity generated by high-frequency generator, it must be adjusted before using. It can also be used layshaft involvement, in this case the compressor on high speed on one shaft and turbine-generator at a time. When in this application is shaft involvement is not needed subsequent transformation parameters electricity, due to a number of rotating parts but such a system has a more complex structure. [4]

Life microturbines are estimated to range from 40,000 to 80,000 operating hours.

Change the desired power microturbines addresses the combination of changes in flow rate of working fluid heat circulation, thus changing the compressor speed and change of temperature of the inlet gas microturbines. Allowable load is changing fast. Microturbines are able to achieve maximum performance value for approximately 10-15 seconds.

Compared with internal combustion piston engines, however, respond to the load change more slowly. Reduce the burden turbines significantly decreases their effectiveness, so it is better to operate with a load of at least 50 % of their nominal value (Fig.3).

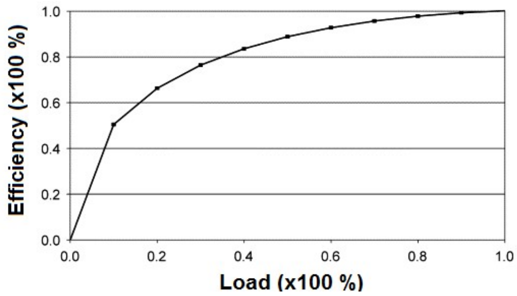

Fig. 3 Efficiency dependence on the microturbines load

4 ANALYSIS OF COOPERATION MICROTURBINE WITH ELECTRIC GENERATOR

Microturbines with electric generators have generally slightly lower efficiency (33-37 %) than conventional generators with internal combustion engines. Their structural simplicity and relatively are based on small number of moving parts, however, easier to install, have more reliable, generate less noise and vibration, have lower maintenance requirements. [8]

Microturbines are very well suited for various applications of distributed generation due to its flexibility in the methods of connection, parallel connection possibilities for a greater burden for reliable power generation while maintaining low emission values. They are suitable both for the combined production of electricity and heat, as well as a separate unit for electricity generation. They can also be connected to the distribution network. [9]

Gas micro-turbines are used to generate electricity and produced in several types of system configuration: as one shaft and more than shaft. In one system drives the compressor shaft and the same turbine generator. In a typical configuration, a single shaft turbine shaft turbine rotates at speeds of up to 90 000 rpm and driven by high speed generator.

The shaft system more generally one turbine drives the compressor and turbine next to the second shaft is driven through a gear mechanism conventional generator. [10]

5 NUMERICAL MODEL OF THE MICROTURBINE WITH ELECTRIC GENERATOR COOPERATION

The mathematical model microturbines addressed several authors who have applied mathematical models with varying degrees of complexity and accuracy. G. Ofualagba [8] in their work compiled mathematical model presented microturbines W. I. Rowena. This model has microturbine generator, which consists of speed control, temperature control, exhaust and fuel system. [14]

5.1 Speed control and acceleration

Speed is controlled by a differential between reference speed (proportionally unit – pu) and measured rotor speed (rpm). Management of acceleration is required, especially when running turbines to exceed the maximum permitted speed. Speed control is usually modeled using a transfer function or PID controller. (Fig.4)

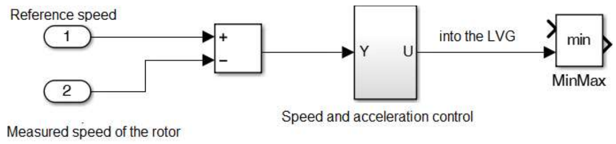

Fig. 4 Diagram of the speed control and acceleration

5.2 Compressor, combustion chamber and turbine

Compressor, combustion chamber and turbine are the main parts of the system and microturbines are modeled as a linear non-dynamic system (Fig. 5). The time constant of the τ_{CR} to the delay the combustion process, τ_{CD} is a constant delay the performance of the compressor and delay T_{TD} represents the time in which burned gases pass from the combustion chamber through the turbine.

The output from the system compressor, combustor and turbine exhaust temperature t_X and torque T_m. These values are calculated according to the following dependencies:

$$T_m = K_{HHV}.(W_{f2} - 0.23) + 0.5(1 - N_r)\ [Nm] \tag{4}$$

$$t_X = t_R - 700(1 - W_{f1}) + 550(1 - N_r)\ [°C] \tag{5}$$

Where: K_{HHV} - heating value of the gas flow in the combustion chamber, and t_R is the reference value (maximum) fuel temperature. Constants K_{HHV} and 0.23 in the equation of torque provide linear power

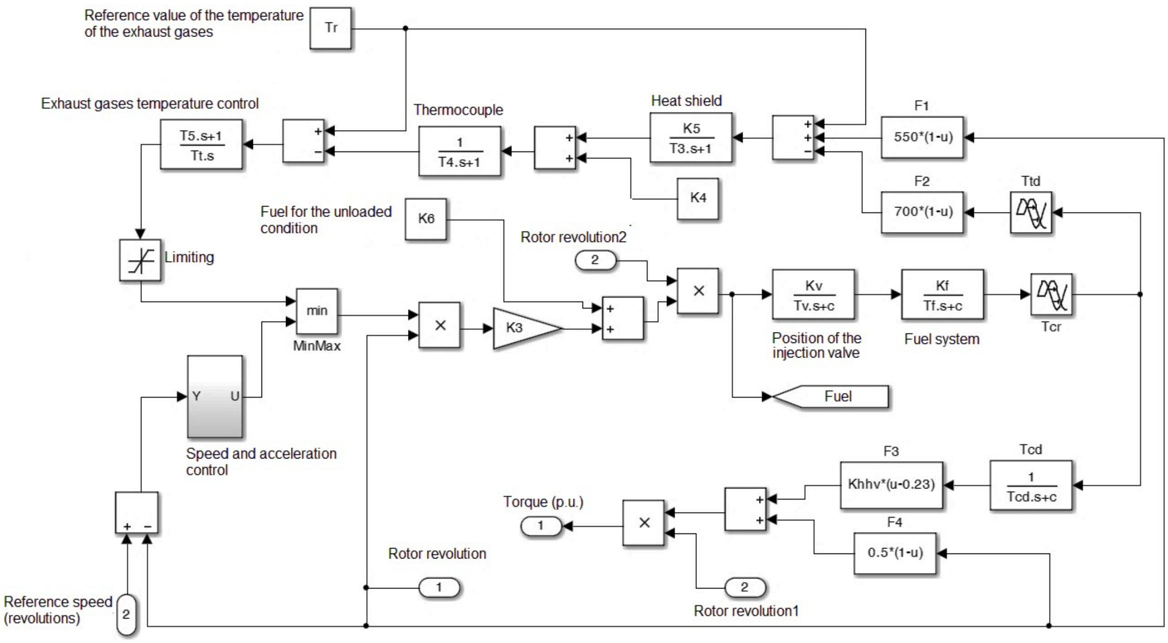

Fig. 5 Numerical model of the microturbine in MATLAB/Simulink environment

dependence on the amount of fuel that grows from zero output value at 23 % of maximum fuel flow rate up to the maximum fuel flow at full power.

5.3 DC synchronous machine model

DC model of the synchronous machine with permanent magnets can be derived from the model of a synchronous machine with excitation winding so that we introduce with simplifying parts and assumptions:

- removal of drive winding rotor,
- power supply is harmonious progress,
- stator winding parameters R and L are the same and constant for all windings,
- conduct of the magnetic induction B in the air gap constant,
- neglected iron losses,
- linear magnetic circuit of the stator,
- induced voltage Ui is harmonious shape.

Equation of the mechanical torque output of the synchronous machine model (Fig. 6) is:

$$T_M = T_E - J.\frac{d\omega_m}{dt} \qquad (6)$$

Where: T_M - mechanical torque machine, T_E – electromagnetic torque, J - the moment of inertia of the machine and ω_m - the mechanical angular velocity of the rotor

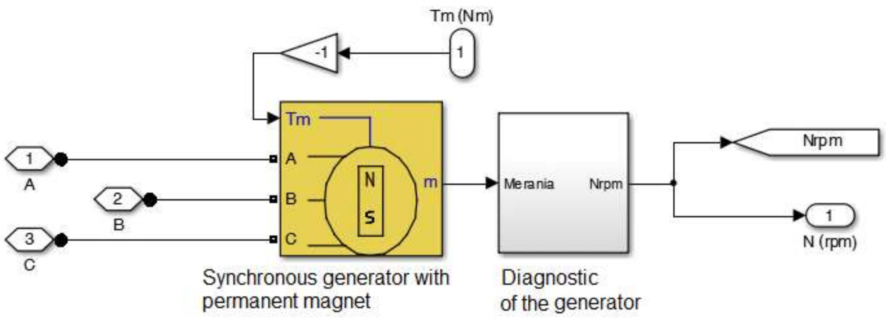

Fig. 6 Mathematical model of the permanent magnet synchronous generator in MATLAB/Simulink environment

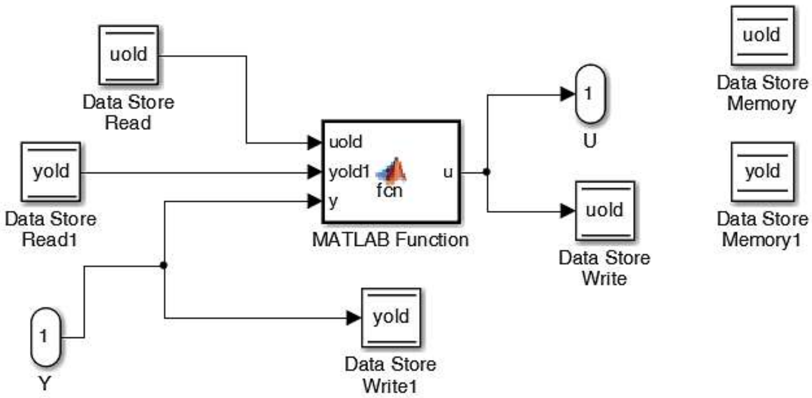

Fig. 7 Management structure of speed and acceleration control

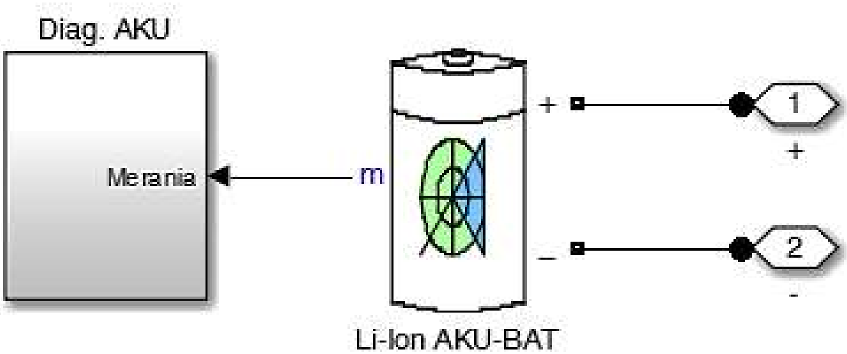

Fig. 8 Model of the battery system with connection for t
the charging current from electric generator

The actuator has one output and three inputs. Its output is a requirement for the amount of fuel entering the fuel requirements of the previous cycle, unlike the reference and measured speed and gap reference and measured speed of the previous cycle. (Fig. 9, Fig. 10, Fig. 11) The requirement for the amount of fuel and the difference of reference and measured speed is stored in memory blocks.

6 CASE STUDY AND SIMULATION RESULTS

At the beginning of the simulation is checked demand for the fuel in the previous cycle, and not to exceed the maximum value. If this value is exceeded, is reduced back to the maximum value and proceed further. If the maximum value of the fuel is not exceeded, calculate the amount of fuel increment by the size difference of reference and measured speed. The lower value of this difference, the smaller the increment of fuel. If the speed difference is negative, nominal speed value fuel requirements are reduced. When the speed difference within the system, the requirement on the amount of fuel does not change.

Length of simulation is 50s at discrete sampling step $\tau s = 0.02s$ define is.

Process of the simulation is as follows: at the beginning of the simulation with a microturbine generator is turned off, the reference speed have the value 0 at $\tau = 2s$, the value of the reference speed changes to 1, the value of nominal speed 90,000 rpm. at $\tau = 25$ seconds, the reference speed changes back to 0, fuel supply to the turbine is stopped and the rotational speed decrease until the turbine to the generator to a complete stop. (Fig.9)

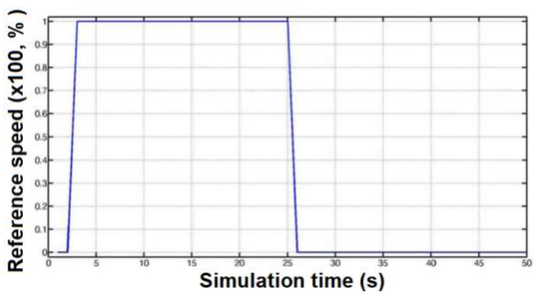

Fig. 9 Reference speed during simulation

Fig.10 shows the course of the measured speed of the generator rotor. At the time of two seconds the turbine starts about 5 seconds reaches nominal speed (with control deviation approx. 50 rpm), which subsequently maintained until the time of 25 seconds, when the turbine is shut down. In the quantity of fuel injected (in p.u.) in Fig. 11 is very similar to the speed. At the time of 25 seconds, when the speed reference is changed to 0, the fuelsupply off, then no turbine and the generator only rotate due to the inertia, until the time of 50 seconds to a complete stop.

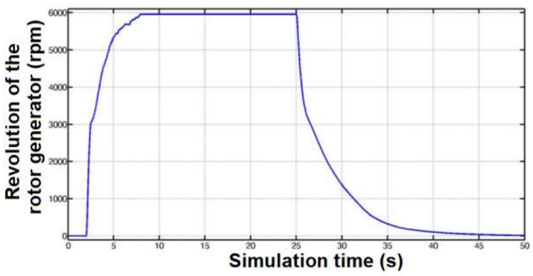

Fig. 10 Time response of the rotor speed of the electric generator

Battery voltage is set to a constant value 400V. When microturbine start working, the charging voltage of the battery system will increase. After switching off the microturbine to the battery voltage begins to stabilize. After switching of the load will battery system start discharging and the voltage decreases.

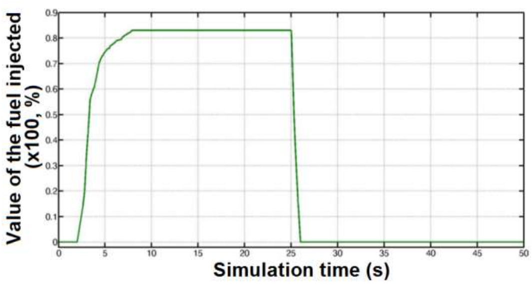

Fig. 11 Time response of the fuel injection during simulation

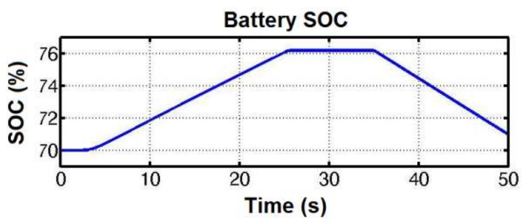

Fig. 12 Time response of the battery system SOC

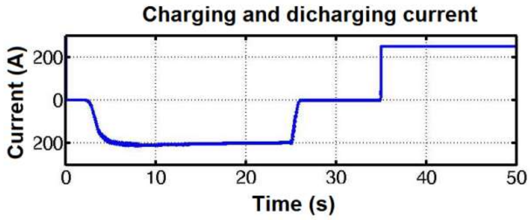

Fig. 13 Time response of the battery system current

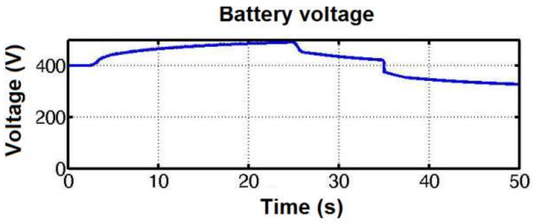

Fig. 14 Time response of the battery system voltage

7 CONCLUSION

Modelling and simulations in this paper was performed on cooperation of microturbine with electric generator, which were explained most widely used methods of coupling with microturbine with electric generator. Advantages and disadvantages of these design solutions described are.

The main part of this paper represents the simulation model of management and control system of power through the combustion microturbine with electric generator in MATLAB / Simulink. It was created mathematical model microturbines, which was after applying the characteristics of the turbine and it is connected to the model synchronous machine with permanent magnets. The generator produces three-phase AC voltage, which is connected to the battery system. (Fig. 8) Designed model simulates a system extension range, charging the battery for hybrid electric vehicle. The result of the simulated system is applied on battery system with 300 kW power output.

Not only traction and energy systems of the UGV, but also the system chassis and platform as a suspension system will be further improved throughout for the following vehicles. When in UGV is applied adaptive suspension, this system will require a power supply. [13]

Therefore, in a further embodiment, the energy requirements need to be specified for active suspension of the UGV. [13]

Based on the calculations and simulation results are given time UGV operating in different types of loading and operational parameters.

Energy system implemented with a serial hybrid system proposed UGV is a mobile power station that provides electricity, which provides energy for example two mobile operating (surgery) rooms with power 60kWh for 5 hours. With this energy potential UGV exploratory version can be operate in required area and forward information for 24 hours.

Acknowledgement

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ANALYSIS OF BLAST LOADED STRUCTURES

Lucia FIGULI, Vladimír KAVICKÝ, Kamil BOC, Dagmar VIDRIKOVÁ, Štefan JANGL

Abstract: The paper deals with the analysis of structures subjected to blast load. Firstly are mentioned the sources of blast loading. It requires to know parameters of blast pressure wave, its effect on structure and to know the tools for the solution of dynamic analysis. There is described standards and codes background used for such loaded structures.

Keywords: Blast resistant. Blast wave. Blast load on buildings. Critical infrastructure. Dynamic analysis.

1 INTRODUCTION

It would seem that the world is in a quiet period, because in the beginning of the century it was not a direct threat of global armed conflict. But it is not a true! The threat of terrorism resulting from religious and economic results treats the world. The terrorism is one of the gravest problems of nowadays and it is a real treat of states and people safety. The incidents, which happened not only at world battlefields of Iraq and Afghanistan but also in centers of developed countries. The assassinations of Madrid, Moscow, London, Oslo or recently of Boston brought innocent victims. Soldiers are not threatened, but they are ordinary people coming home from the work or going for culture or to do sport. This type of attacks can not let passive anyone from democratic world.

The fight against all form of terrorism is very long process in which the terrorists get a start. This fight could not be successful if some forms of terrorism are overlooked. The terrorism has a lot of goals, method, forms, sources and means. Every successful terroristic attack encourages terrorists and persons, directly supporting the terrorism, to another activity and at the same time it provokes the distrust of citizens in their democratic governments. The most danger and insidious method of terroristic fight is to abuse explosives and ammunition.

With this type of terroristic attacks the great number of the loss are innocent human lives and damage to property. We want to dedicate our article to the protection of persons and properties in the normal – peaceful life. Especially we want to concentrate on the objects resistance.

Buildings or structures subjected to bomb attack by terrorist organization or offenders are considered as one of critical infrastructure elements. There is creating a model / system for evaluation of the effectiveness of security measures to protect typed objects in terms of used security elements, breakthrough resistance, technical capabilities and effectiveness in detecting and slowing the movement of offenders or potential intruder to overcome them in relation of the active intervention time in our Faculty of Special Engineering [7]. This type of extreme loading is not commonly considerate. Required input data for such model is the resistance of blast loaded structures.

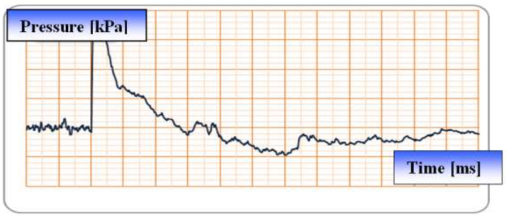


Fig. 1 Real pressure time – history [1]

2 BLAST LOADING AND BLAST EFFECTS ON STRUCTURES

2.1 Blast pressure wave

Introductorily, it is necessary to notice; each explosion of real improvised explosive device is different in real situation. And they do not exist two exactly same causes. Every one takes place in different place, in different climatic condition. It can be initiated in different ways or used explosive can have diverse properties. The theory concerning with the exact mathematical modelling of an explosion not is available. And the precise modelling of explosion effect on surrounding area does not exist. It is not possible to model real situations. For example, accidental entrance of armoured supply vehicle to the space of explosion will change the shape of blast wave and its effect will be different. Existing mathematical models modelling an explosion are used for the prevention of major industrial accidents and for the determination of object safe distances from explosion potential place in military area only (i.e. from ammunition stores, fighting vehicles parking etc.

Theory of mentioned calculation, used in developed countries, is based on the same principle – on Hopkins's scaling law:

$$Z = R / \sqrt[3]{W} \qquad (1)$$

Where Z is reduced distance, R is the actual effective distance from the explosion, W is charge weight. The scaling law says, if two charges of the same type of explosive and the same geometry, but of the different weights detonate in the same atmosphere, they produce closely similar blast waves in the same scaled distances. We express the scaled distance as a multiple of real distance from the detonation centre and cube root of charge weight [12].

This principle is very simplified and corresponds to the level of knowledge in the period of origin. Correctly we would consider as a reduced variable quantity not charge weight but energy released by a detonation. In all countries, there is a customary assumption, the energy released by a detonation is proportional to its weight. Based on reality, each charge has different energy value, it is necessary to introduce a correction coefficient to a reference explosive type. As a reference explosive type is considered TNT (Trinitrotoilene). The corrective coefficient is set on the base of the ratio of detonating heat of TNT and selected explosive. When the blast wave propagated, the pressure decrease rapidly (cube root is in the dependence to overcame distance), because geometric diversion and energy loss is caused with the heating of the surrounding air. Simultaneously the pressure decreases exponentially and interval of his effect is very short, only some seconds or milliseconds. Explosion can be compared to "bubble" trying the high pressure increase and heat to level out with the surrounding air characteristics. Detonation create the blast wave, which can be characterised with instantaneous increase of ambient atmospheric pressure with peak characteristic. When the initial part of blast wave reaches its maximum value, it drops to the level of the ambient pressure and it is followed by negative phase, which has longer duration as a precedent phase.

The detonation generates hot gases, which expands forcing out the volume it occupies. As a consequence, a layer of compressed air called a blast wave forms in front of this gas volume containing most of the energy released by the explosion. The effect of the blast wave depends mainly on the sort of detonation a stand off distance. The blast wave rapidly increases to a value of pressure above the ambient atmospheric pressure (positive phase). After a short time, the pressure may drop below the ambient pressure. This phase is called a negative phase. During it a partial vacuum is generated and air is sucked in. This is also accompanied by high suction winds that carry the debris for long distance away from the explosion source [3]. The positive phase has a shorter duration and higher intensity than the negative duration. As the stand-off distance increases, the duration of the positive phase blast wave increases resulting in lower amplitude, longer duration shock impulse. The stand-off distance is defined as a distance between the blast source and the target (structures). A typical reflected pressure time – history is shown in Fig.1 [1].

Using this real time history of the blast wave is very complicated. The negative phase has longer duration and lower intensity (it has relatively low amplitude) than the positive phase. The latter phase is commonly neglected in design of structures. This is either because of the difficulty associated with measuring or computing the characteristics of the negative phase, or because most researchers consider it relatively unimportant compared to the positive phase.

In the past some researchers suggested certain relationships to represent the pressure time-history *P(t)* of the ideal blast wave, generally emphasizing only the positive phase. The simplest form assumes a linear decay (see Fig. 2) given as

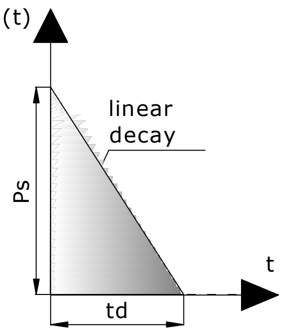


Fig. 2 Linear decay time profile

$$P(t) = P_0 + P_s(1 - \frac{t}{t_d}) \qquad (2)$$

where

t is the time after the pressure wave arrival,
P_s is the peak pressure,
P_0 is the ambient pressure,
t_d is the duration time.

More complex is form assumes a exponential decay (see Fig. 3) given as

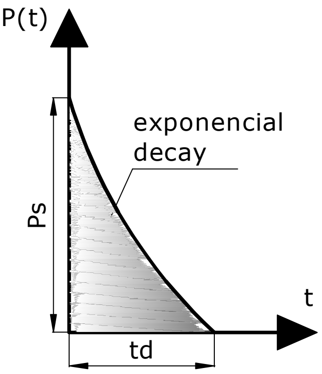


Fig. 3 Exponential decay time profile

$$P(t) = P_0 + P_s(1 - \frac{t}{t_d})e^{-\beta \cdot \frac{t}{t_d}} \qquad (3)$$

where
t is the time after the pressure wave arrival,
P_s is the peak pressure,
P_0 is the ambient pressure,
β is the decay parameter coefficient,
t_d is the duration time.

A somewhat more complex model has been proposed as

$$P(t) = P_0 + P_s(1 - \frac{t}{t_d})a.e^{-\beta \cdot \frac{t}{t_d}} + (1-a)e^{c \cdot \frac{t}{t_d}} \qquad (4)$$

a, b, c are constants obtained from experimental data.

If we consider the negative phase (see Fig. 4) pressure the form would be expressed as follows [2]

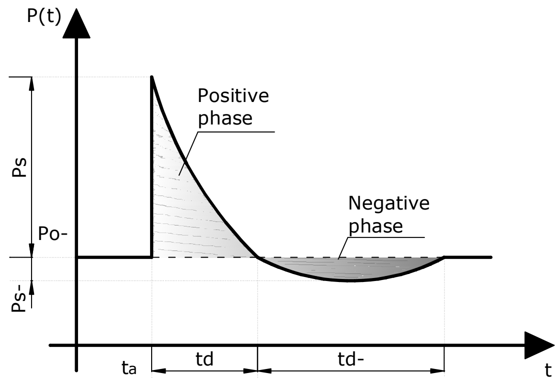


Fig. 4 Time profile considering negative phase

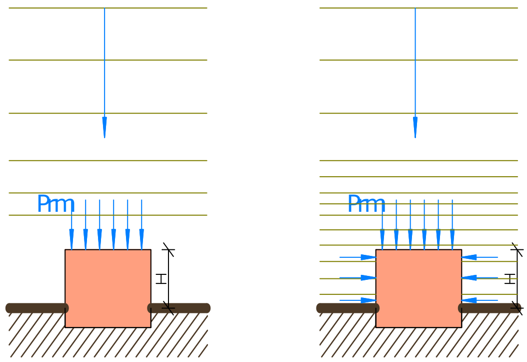
$$P(t) = P_o - P_S^{-}\left(\frac{t}{t_d^{-}}\right)\left(1 - \frac{t}{t_d^{-}}\right)e^{-4\frac{t}{t_d^{-}}} \qquad (5)$$

where
t is the time after the pressure wave arrival,
P_s is the peak pressure,
P_0 is the ambient pressure,
β is the decay parameter coefficient,
t_d is the duration time,
t_{d^-} is the duration time in negative phase.

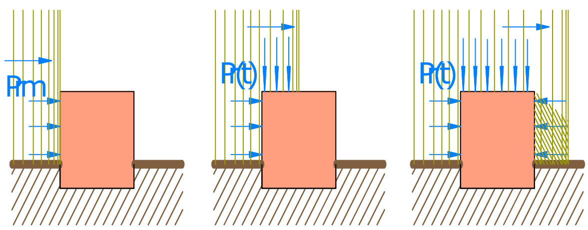
2.2 Effect of blast wave

The effect of blast wave on structures depends on stand-off distance, sort of explosion and bomb size. In a nuclear explosion, the structure is firstly loaded by reflection overpressure from above. After the drop of blast wave on the earth surface, all structures are immersed in the layer of press air and are loaded of all-sided pressure in the same time.

Loading of building by over ground explosion has a different character. Firstly, the side facing to the epicentre is loaded of overpressure reflection. Then the overpressure continues to the lateral sides, the roof and the back side. After the blast wave attack on the front side wrapping occurs. Overpressure drops rapidly down as it is shown Fig. 5 [4], where Prm is overpressure and Pr(t) is reflection overpressure.



a) Distribution process of nuclear detonation



b) Distribution process of over ground detection

Fig. 5 Influence of blast wave on buildings

3 DYNAMIC ANALYSIS

After specifying the load on structure it is necessary to do the analysis of structural response. The main role is to do a dynamic analysis of structural response on blast load.

A blast or explosion is a typical source of impulsive non periodic load.

3.1 A single degree of freedom system

The analysis of dynamic response of blast-loaded structures is very complex. To simplify the analysis, the structure is idealized as a single degree of freedom (SDOF) system. The real structure can be replaced by an equivalent system of one concentrated mass and one spring representing the resistance of the structure against deformation. Therefore, so called single degree of freedom system is a springmass-damper system where the mass is allowed to move in only one direction.

For a description of behaviour this system we use an undamped SDOF structure because maximum response usually occurs during the first vibration cycle when damping has minimum contribution to the dynamic response. For structures under the

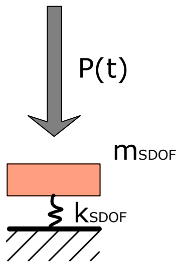


Fig. 6 One-degree System

impulsive loads (blast loads) dumping has much less importance because the maximum response will be reached in a very short time, before the damping forces can absorb much energy from the structure. The effects of damping are hardly ever considered in blast design because of the following reasons:

(1) Damping has very little effect on the first peak of response, which is usually the only cycle of response that is of interest.
(2) The energy dissipated through plastic deformation is much greater than that dissipated by normal structural damping.
(3) Ignoring damping is a conservative approach [6].

3.2 Solution of Equation of Motion

The mass of SDOF system can move in vertical direction only and all mass in the system deflects by the same amount (the spring is assumed massless). The equation of motion of un-damped SDOF system a time ranging from 0 to the positive phase duration t_d is given by [9]

$$M\ddot{v} + kv = P_s\left(1 - \frac{t}{t_d}\right) \quad (6)$$

where M is the mass of the system, $\ddot{v}$ is acceleration, k is the spring constant and v is vertical displacement of system.

The particular solution of this differential equation is divided in two parts. The loading during first phase (forced vibration phase) when $0 \le t \le t_d$ and the second, free vibration, phase when the displacement

$$v(t) = \left(\frac{p_0}{k}\right)\left[\begin{array}{l} 1 - \left(\frac{t}{t_d}\right) - \cos\omega_n t + \\ + \left(\frac{1}{\omega_n t_d}\right)\sin\omega_n t \end{array}\right] \quad (7)$$

and for the time $t_d \le 0$ in the second phase of the loading is [10]

$$v(t) = \left(\frac{p_0}{k}\right)\left[\left(\frac{1}{\omega_n t_d}\right)\left[\begin{array}{l} \sin\omega_n t(1-\cos\omega_n t_d) \\ -\cos\omega_n t(\omega_n t_d - \sin\omega_n t_d) \end{array}\right]\right] \quad (8)$$

Since the natural circular frequency of vibration is

$$\omega = \frac{2\pi}{T}, \quad (9)$$

where T is the natural period of vibration.

It is very important for the design of such loaded structure to find the maximum response. The maximum response is defined by the maximum dynamic deflection, which occurs at time t_m. It can be evaluated by setting the velocity of the mass (the first derivation of displacement) equal to zero, i.e. when the structural velocity is zero. Solving this problem we may plot response spectra R_{max} to given input versus some system parameters [6].

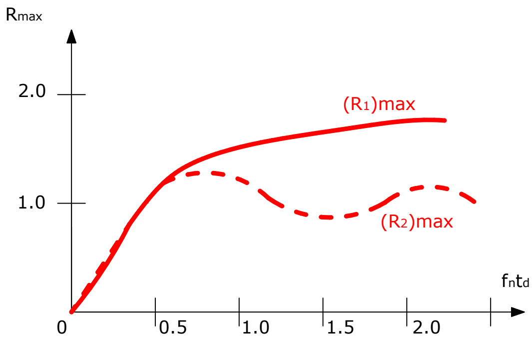


Fig. 7 Response Spectrum for a Triangular Pulse Load

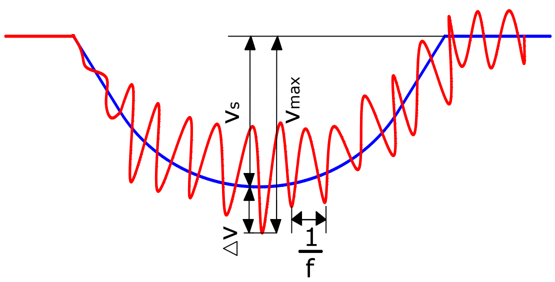


Fig. 8 Dynamic Load Factor

3.3 Dynamic Load Factor

The dynamic load factor (or dynamic magnification factor DMF) is defined as ratio of the dynamic deflection at any time to the deflection, which would have resulted from the static application of the load, which is used in specifying the load – time history, DLF is defined

$$DLF = v(t)/v_{st}(t).$$

3.4 SDOF factors

For to obtain the response of structure to blast load, the real structure is transformed to equivalent system by equating the total energy of the SDOF system at any time to the total energy of the beam assuming a predetermined displacement shape. The lumped mass of the SDOF system is made equivalent to the distributed mass of the beam by assuming that both have the same kinetic energy.

Real mass of the beam we have to transform to equivalent mass

$$M_E = \int_0^L m(x)\phi^2(x)dx \tag{10}$$

where ϕ is the shape function and it is a ratio of the deflection function and maximum deflection. It may be calculated for elastic and plastic range.

In the next step it is necessary to determine equivalent force- total load applied on the structural element is multiplied to obtain the equivalent concentrated load for the equivalent SDOF system. The concentrated force on SDOF system can be made equivalent to the distributed force on the beam, by assuming that the works done by the two forces are equal

$$F_E = \int_0^L m(x)\phi(x)dx \tag{11}$$

We have to know the spring constant for computing the first natural frequency of the system. The spring constant k is defined as the force at midspan necessary to cause unit deflection at the same point. To simplify the calculation of equivalent mass, force and resistance SDOF factors were set [9].

Transforming the real structure to SDOF system, the dynamic analysis can be solved by integration of equation of motion described above.

3.5 Approximate Analysis of Impulsive-Load Response

For short duration load, for example $\frac{t_1}{T}\langle\frac{1}{4}$ the maximum displacement amplitude v_{max} depends principally upon the magnitude of the applied impulse $I=\int_0^{t_1} p(t)dt$ and is not strongly influenced by the form of the loading impulse. Thus the area beneath the pressure time history represents the impulse. A convenient approximate procedure for evaluating the maximum response to a short-duration impulsive load, which represents a mathematical expression, may be derived as follow.

The impulse-momentum relationship for the mass m may be written

$$m\Delta\dot{v} = \int_0^{t_1} [p(t) - kv(t)]dt \tag{12}$$

where $m\Delta\dot{v}$ represents the change of velocity produced by the loading. In this expression it may be observed that for small values of t_1 the displacement developed during the loading $v(t_1)$ is of the order of $v(t_1)^2$ while the velocity change $m\Delta\dot{v}$ is of the order of t_1. Thus since the impulse is also of the order of t_1 approaches zero is negligibly small for short-duration loadings. On this basis, the approximate relationship may be used: [11]

$$m\Delta\dot{v} = \int_0^{t_1} p(t)dt \tag{13}$$

The response after termination of loading is the free vibration

$$v(\bar{t}) = \frac{\dot{v}(t_1)}{m\omega}\sin\omega\bar{t} + v(t_1)\cos\omega\bar{t} \tag{14}$$

in which $\bar{t} = t - t_1$. But since displacement term $v(t_1)$ is negligibly small and the velocity $\dot{v}(t_1) = \Delta\dot{v}$, the following approximate relationship may be used

$$v(\bar{t}) \cong \frac{1}{m\omega}\left(\int_0^{t_1} p(t)dt\right)\sin\omega\bar{t} \tag{15}$$

3.6 Other methods of dynamic analysis

Dynamic analysis can be solved by direct integration of motion equation, using charts or numerical SDOF software.

Commercial software can be used for analysis of more complex structural model. The numerical method to the simulation of the blast problem is typically based upon a finite element, finite difference and finite volume method utilizing explicit time integration (for example AUTODYN, ANSYS and SCIA ENGINEER).

3.7 Mechanical properties of structure

For determine the resistance of structure subjected to blast loads are very important mechanical properties. The mechanical properties, especially yield stress, of steel under dynamic loading condition are quite different from that under static loading. The stresses that are sustained under dynamic conditions gain values that are remarkably higher than the static compressive strength. This enhancement is described in terms of the dynamic increase factor (DIF), which can be evaluated for different steel grades. Details of dynamic increase factor *c* are written in [8].

4 BACKGROUND OF CODES AND STANDARDS

The standard Eurocode 1 (EN 1991-1-7) is valid for countries of European Union. In the system of Eurocodes the blast load is considered as accidental actions. EN 1991-1-7 provides rules for safeguarding buildings and other civil engineering works against accidental actions. In this context specific rules are given for accidental actions caused by impact and internal explosions but does not specifically deal with accidental actions caused by external explosions, warfare and terrorist activities, or the residual stability of buildings or other civil engineering works damaged by seismic action or fire etc. We don't have any national codes or standards, which deal with this problem of blast design structures. Existing military standard STANAG 4440 deals about the security stand off distances only.

For United States of America are valid Unified facilities criteria UFC 3-340-02 Structures to Resist the Effects of Accidental Explosions. This UFC 3-340-02 presents methods of design for protective construction used in facilities for development, testing, production, storage, maintenance, modification, inspection, demilitarization, and disposal of explosive materials. In so doing, it establishes design procedures and construction techniques whereby propagation of explosion (from one structure or part of a structure to another) or mass detonation can be prevented and personnel and valuable equipment can be protected.

5 CONCLUSIONS

Nowdays, it is preparing an experiment of steel beams subjected to blast loads generated by the detonation. The experimental results will be analyzed using an equivalent Single Degree of Freedom model of the beam and more complex structural model based on finite elements method.

Acknowledgement

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MODEL OF UNMANNED GROUND VEHICLE SUSPENSION COMPONENT FOR DYNAMIC LOAD

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Abstract: The paper is focused on creating computationally effective dynamic model of suspension system damper mounting of unmanned ground vehicle, which contain all elastic properties corresponding to the real component. The first part deals with experimental measurements of damper mounting, which is excited by different frequencies. Modified Bouc-Wen model is used to modeling force-displacement characteristics. Mathematical models of the damper mounting are created according to the measured experimental data in Matlab/Simulink. In the conclusion the models characteristics are verified and evaluated by the measured data.

Keywords: Damper mounting. Silentblock. Bouc-Wen. Spencer.

1 INTRODUCTION

The development of defense technology is also addressed with the possibility of rapid response to change in the requirements of the final product through the use of virtual simulation and application of CAE tools. Thus, it is possible for the engineer to re-examine the impact of individual parameters on the properties of the final product. Repeated virtual simulation reduces the costs of testing products, because the accuracy of the solution can be verified prior to actual production. The great advantage of simulation is that it gives the designer the opportunity to test a number of very rapid variations of parameters and drive development in the right direction. [1]

The paper deals with the modeling of rubber mounting of chassis of UGV unmanned ground vehicle. By strong vibration or shocks may occur electronic control unit fault, which may result in removal from vehicle operation.

2 EXPERIMENTAL MEASUREMENT OF DAMPER MOUNTING

The measurement was carried out on damper mounting, Fig. 1, Fig. 2. Damper mounting absorb vibrations and shock from irregularities from terrain. Characteristics are obtained by test rig EDYZ 4, Fig. 3. Test rig is controlled by the computer according to the scheme Fig. 4 and powered by a hydraulic pump. Damper mounting was excited with sinusoidal signal at frequency 1Hz, 5Hz and 10Hz and displacement amplitude at 3 mm.

Fig. 1 Damper mounting on test rig

Fig. 2 Damper mounting

Fig. 3 Test rig

To obtain the characteristics of damper mounting was used the measuring instruments as potentiometric position sensor (Gefran PZ67-S with a measuring range of 150 mm) and force transducer (Hottinger U2B ± 5 kN and U2B ± 20 kN). Data from the sensors were acquired in a National Instrument LabVIEW Signal Express by acquisition cards NI 9237 and NI 9215, subsequently processed in Matlab.

Characteristics were obtained from the acquired force response to an excitation signal.

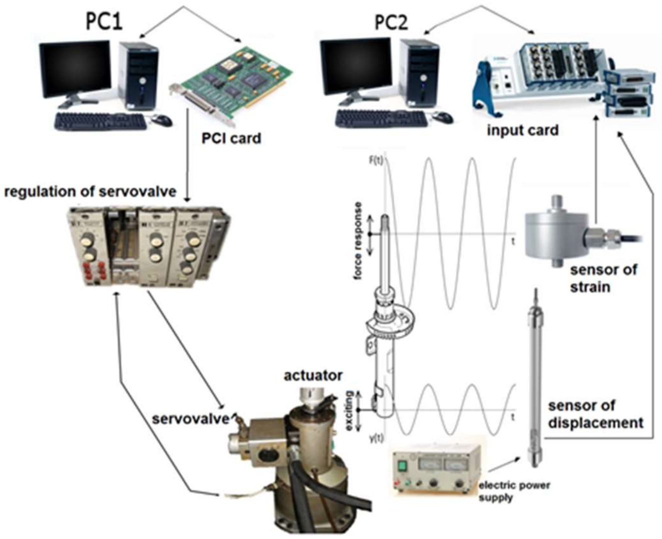

Fig. 4 Test rig with data acquisition system

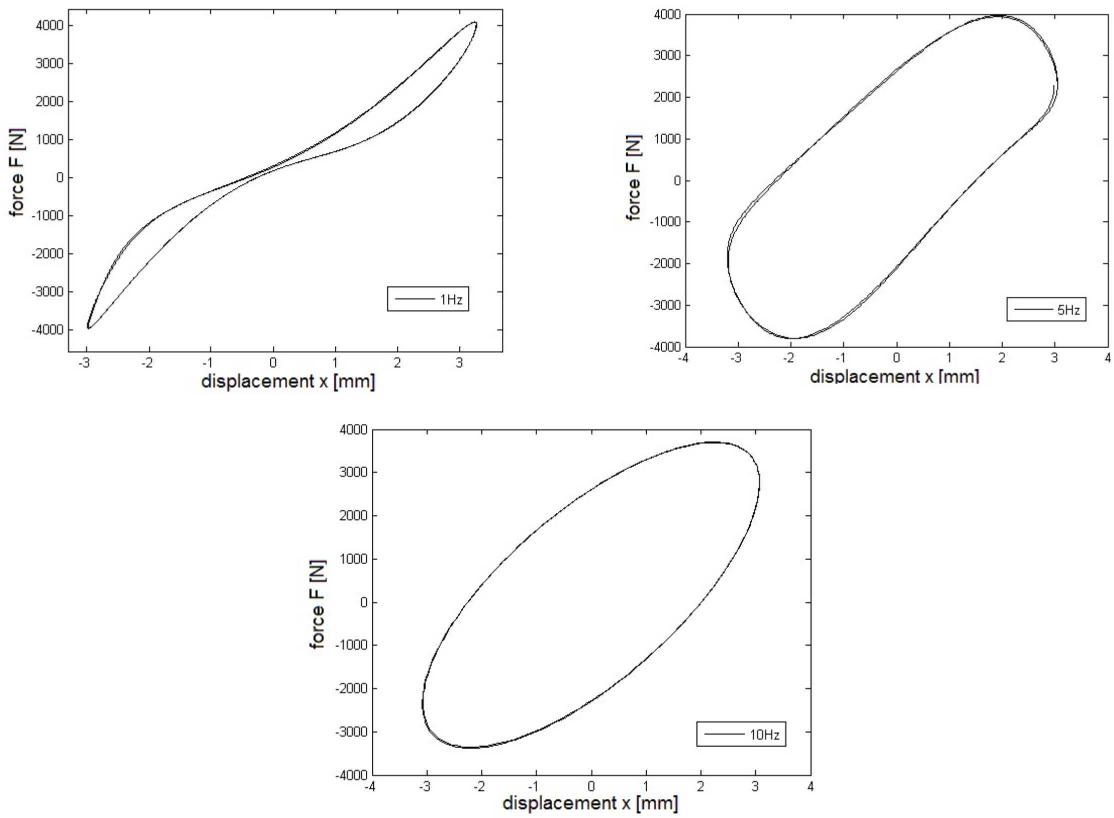

Fig. 5 Force-displacement characteristics of damper mounting

3 MATHEMATICAL MODEL OF DAMPER MOUNTING

The term model we can imagine a system that tries to imitate another, the aim of modeling is to create a process model that responds to input certain clearly specified way. From the measured characteristics of damper mounting can see that it is a component with strongly non-linear properties. For an accurate description of the model the nonlinear properties into account, therefore was chosen the Bouc-Wen's model and the modified Bouc-Wen's model by Spencer.

Bouc-Wen's model involves an inherent simplicity, it recognizes the general community of engineers [2]. Various types of nonlinear properties, such as hysteresis rubber can be represented using just Bouc-Wen's model. The model is based on a simple differential equation, which includes hysteresis variable "z" [3].

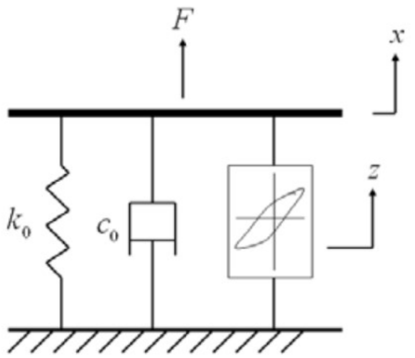

Fig. 6 Bouc-Wen model

Bouc-Wen model is defined by the equation hysteresis variable [4]:

$$\dot{z} = -\beta|\dot{x}(t)|z(t)|z(t)|^{n-1} - \gamma\dot{x}(t)|z(t)|^{n} + A\dot{x}(t) \qquad (1)$$

where *z* is a variable hysteresis and dot over denotes the time derivative, k_0 is a spring constant of model element, c_0 is a damper coefficient of model element, *x(t)* is the imposed displacement of the device (or the material deformation) [4].

The power produced by the hysteresis element that represents the Bouc-Wen model, is expressed as follows:

$$F_{BW}(t) = \alpha\frac{F_y}{x_y}x(t) + (1-\alpha)F_y z(t) \qquad (2)$$

The quantities β, γ, n, A are dimensionless parameters that defined shape and amplitude of force response.

Parameters α, x_y, F_y described material properties of rubber. The resulting force response of the model is:

$$F = c_0\dot{x} + k_0 x + F_{BW} \qquad (3)$$

More precisely characteristics of damper mounting were modeled using the modified Bouc-Wen's model by Spencer, which is shown in Fig. 7, but it is a model which has a larger number of parameters. This means that for data identification was needed more computation time.

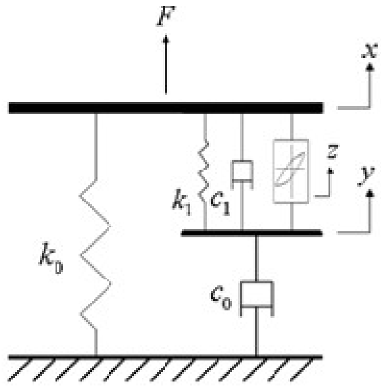

Fig. 7 Spencer model

The equations defining the model:

$$\dot{z} = -\beta|\dot{x}(t)|z(t)|z(t)|^{n-1} - \gamma\dot{x}(t)|z(t)|^{n} + A\dot{x}(t) \tag{4}$$

$$\dot{y} = \frac{1}{(c_1 + c_0)}\{\alpha z + c_1\dot{x} + k_1(x - y)\} \tag{5}$$

where *z*, *x* are the same as in the Bouc-Wen model. Constants k_1, c_1 are equal to k_0, c_0 in the Bouc-Wen model. The quantities *β, γ, n, A* are identical to dimensionless parameters in the Bouc-Wen model.

Parameter *α* described material properties of rubber also. The resulting force response is:

$$F = c_0\dot{y} + k_0(x - x_0) \tag{6}$$

Constants k_0, c_0 in the Spencer model are additional spring and damper elements.

Model parameters are searched through optimization toolbox for parameter identification Control and Estimation Tools Manager in Simulink. First, is loaded into the toolbox course of power response, which was obtained from the experimental measurements and it is in the shape (Nx1) for values of power and also for time values. Due to the resulting process was argued parameters of differential equation of model. Identification process is shown on Fig. 8.

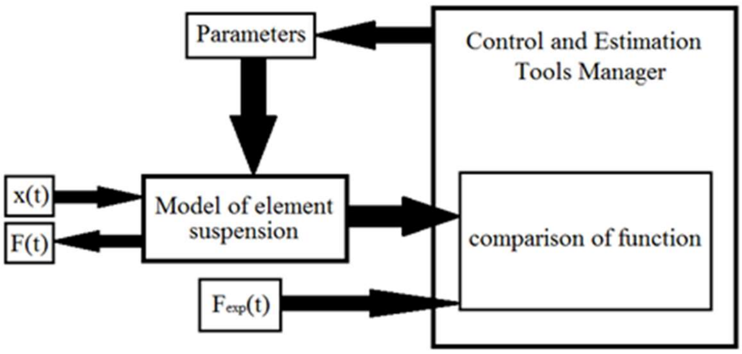

Fig. 8 Model parameters identification

After identifying the model parameters were made the characteristics of damper mounting.

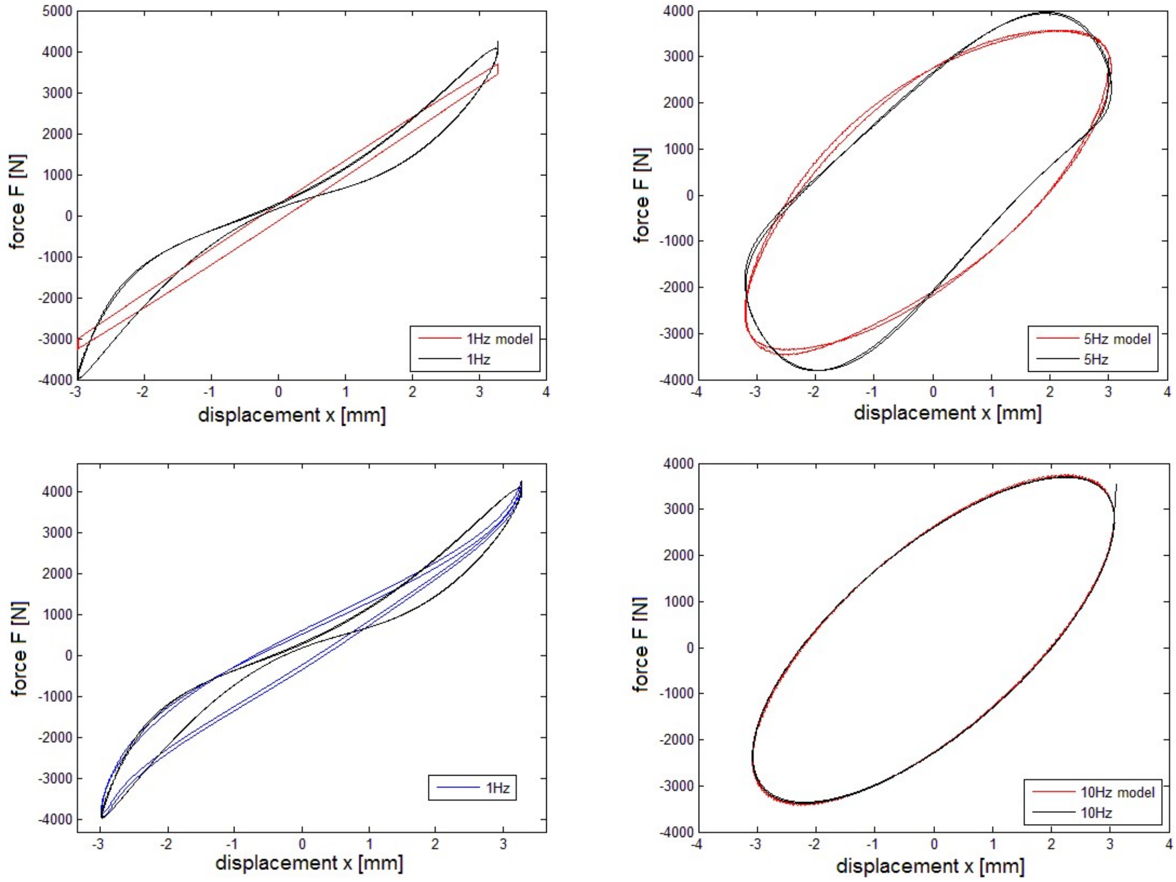

Fig. 9 Modeled and measured characteristics

Characteristics were modeled for various amplitudes displacements from 0.5 to 4 mm and different frequency of excitation signal from 1 to 50 Hz. Model parameters, coefficients and cocnstants were obtained from parameter identification process described above. On the next Figure 9 are presented characteristics of modeled and measured data. Error of model ε is determined by comparing force response of the experimental measurement and force response of the model according to equation (7) [5],

$$\varepsilon = \sum_{i=1}^{n} \frac{\left|F_{e_i} - F_{BW_i}\right|}{n} \tag{7}$$

where *n* is the number of lines during the matrix, F_{e_i} is the i-th value of the experimental measured force and F_{mi} is the i-th value of measured force from model. Calculating the percentage deviation of the conformity σ of the model and experiment is performed according to our proper equation (8).

$$\sigma = \frac{\varepsilon}{\frac{\sum_{i=1}^{n}\left|F_{e_i}\right|}{n}} * 100 \tag{8}$$

Table 1 Errors of modeled and measured forces

	f [Hz]	ε [N]	σ [%]
Damper mounting	1	231	10.7
	5	320.9	14.3
	10	40.8	1.8

4 CONCLUSION

This article deals with experimental measurements and modeling of rubber damper mounting of unmanned ground vehicles. The model has been taken into account nonlinear characteristics of rubber, which causes as well as hysteresis rubber. Currently used simulation models parts of the suspension without taking into account nonlinear properties of the system components. This introduces uncertainty into the simulation. This article has shown how it can be easily modeled nonlinear response and thus increase the accuracy of the simulation model. With this feature we cancontinue to work in simulation environments such as ADAMS and Matlab / Simulink.

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INSURGENCY AND COUNTERINSURGENCY

Martin NIČ, Peter SPILÝ

Abstract: This paper analyzes a possibility of sending military forces of crisis management to the crisis territories on which activities of the insurgents take place. In addition, it analyzes insurgents' skills and tactics. This paper also deals with counterinsurgency principles and required skills of coalition troops to be sent to these territories. Moreover, the authors of the paper also analyze possible consequences of the operation for the Armed Forces of the Slovak Republic.

Keywords: Insurgency. Counterinsurgency. Security. Crisis management. Globalization.

1 INTRODUCTION

The invasion of Western Civilization countries in the Muslim part of the world represents an open confrontation between these countries and the beginning of the fight for the last crude oil deposits, especially after the September 11, 2011 events. This period is sometimes referred to as "clash of civilizations" predicted by Samuel Huntigton as early as in the late 1990's. Despite the fact that high political representatives of the Western powers argue that it is not a war either against Islam or against the inhabitants of the Islamic countries, a motif of "clash of civilizations" and this idea appears in the minds of both civilian population and the members of international armed forces, especially when the conflict brings death. The experience from real territories confirm the fact that the victims in the conflict are caused partly by a misunderstanding of culture and its specifies in the countries in which armed forces try to introduce stability and build peace.

Another possible indirect reason for the life and property loss during the operation of international armed forces in crisis territories of the world are rising anti-Muslim feelings. Considering any Islamic borders, it can be said that the Muslims have a considerable difficulties with peaceful living with their neighbours. But the question arises if the conflict between Muslims and non-Muslims really expresses a philosophy of relations between different civilization groups in the global context. The answer is negative because Muslims represent only one fifth of the world population despite the fact that, especially in the 1990's, they were much more involved in the violence betweeen different groups than other civilizations. "In the 1980's, the military coeficient, that is a number of military personnel per 1,000 inhabitants as well as military index, that is a coefficient related to the countries' wealth, was considerably higher in Muslim countries as compared with other countries. On the other hand, this index was considerably lower in Christian countries. Average military coeficients and indexes of the Muslim countries compared with Christian countries were approximately doubly much higher. It is quite evident then that there is a certain connection between Islam and militarism"[1].

For example, between 1993-1994 the Muslims were involved in twenty six out of fifty ethnic and political conflicts. It would be wrong to argue that the Muslims prefer violent way of life to life in peace, although the Muslim propensity to military conflicts is expressed, in a degree of militarization of the Muslim societies.

2 THE USAGE OF INTERNATIONAL CRISIS MANAGEMENT FORCES

In addition to the activities of the Western powers in the Middle East area, the Alliance groups led by the United States of America were also involved in three military conflicts in the Persian Gulf area. At present, the coalition forces of the member states of the NATO and its allies are involved in the ISAF operation in Afghanistan. Also in this case, the United States is a leading state in this operation. On the one hand, partial success of the allies cannot be denied, especially because of technological dominance and prevailing amount of military forces as well as because a long experience of the American soldiers from the fights in problematic territories of the world. On the other hand, it would be wrong to argue that all goals of the Afghanistan mission have been achieved and that the Afghan nation has received permanent alternatives for its future existence. The Taliban movement is still considerably supported by local communities and many soldiers and mujahideens are flowing through basically unguardable borders with Pakistan. In addition, most of the population is existentially dependent on growing and production of opiates and the success of the development programmes offering the Afghan people other ways to secure living is highly questionable. A strong dominance of the United States of America in Afghanistan evokes doubts about legimitization of the presence of foreign troops on the Afghanistan territory and causes resistance especially from influential Taliban leaders who lead the insurgency against the coalition military forces: "International power (global hegemony), despite being led by one state, requires a social legitimacy in both economic and political spheres. This legitimacy is required not only by the rulers, but also by the ruled. It provides the rulers with a self-confidence, a sense of a certain mission and necessary moral conviction about their aims and interests. Governed by this legitimacy, they excuse their obedience, they make their situation easier and keep humility" [2].

What is specific for Afghanistan is that even the main Afghan government does not have a necessary legitimacy, respect and influence on many distant regions which is, in connection with insurgency activities, paradoxical because insurgency in rural areas (where Afghani (that is pro-American) government does not have enough support from the local population) causes less problems than these activities in big Afghani cities with built-in areas. This paradox is an evidence of a strong influence of respected local leaders (warlords) on all spheres of public life of the Afghans. It also confirms a necessity of cooperation between the commanders and leaders of foreign organizations and the representatives of local social structures.

3 ATTITUDES OF THE LOCAL POPULATION

Operation environment consists of the elements which have considerable influence on the conditions and circumstances under which the operation takes place. In addition to physical, political, economic, security and information environment, the environment of the military operation consists especially of human environment which includes society (local people) living in a particular state, its social groups and individuals. Their perception of the occupation troops can be different but it should be realized that it constantly develops in both positive and negative ways depending on the coalition troops' steps in different areas of responsibility within all their activities. "The attitudes of the local population thus can be divided into four groups:

- *positive* – this group generally includes local government if it is legitimate and if it cooperates with coalition forces. Here can belong individual members of this government and governmental institutions including courts, police, military force and other local security units. These institutions, however, have a propensity to be infiltrated by enemy groups,
- *neutral* – this group includes these individuals who are willing to stop their anti-governmental activities immediately, these who are passively obedient as well as these whose support of the government is limited by their objections against it. Neutral representatives consider conflict to be a risk because it can bring both success and failure. Social groups included in this category usually play an important role during military operation, especially if their represent a considerable part of the population. History shows that gaining a passive support of „neutrals" is very important for a possible success of the insurgency. This group does not usually support local government but the government must gain this group's support,
- *negative* – this category of people expresses a disagreement with the government's legitimacy, but its everyday behaviour is not accompanied by violence. Their negative attitude can have many reasons stemming from a historical feeling of injustice, ideology, religion, nationalism and negative personal experience. These people try to achieve political agreement to fulfill their aims. They represent this part of population which is approached by the insurgents to be recruited as potential insurgents' members, although „the neutrals" are not always willing to support the insurgents immediately. Recruiting these people as future generation of insurgents does not depend as much on a behaviour of the uprisers as of the allies on the operation territory,
- *enemious*- this group of individuals resists both the local government and coalition forces actively and violently. They consider violence to be a legitimate tool to achieve their aims. From the point of view of radicalness, the members of this category can be divided into unreconciliable and unreconciliable. In some cases, the enemy groups can use political agreement as another means used to achieve their aims"[3].

4 INSURGENCY, SKILLS AND TACTICS OF THE INSURGENTS

Insurgency is obviously defined as an organized movement the main aim of which is to overthrow legally elected government through the use of subvertive activities and armed conflict. Its aims can be different, from the overtaking of power through revolution through a creation of separated autonomous states based on ethnic or religious principles up to rather limited aims to achieve political advantages which would be impossible to achieve without violence. Generally, the insurgents try to achieve political change through propaganda, subversive activities and violence the main aim of which is to frighten and convince broad masses of people to support and accept the change. Although each insurgency is different, all insurgencies have some common or, at least, similar features. Insurgency mostly occurs in the countries where considerable racial, religious, ethnic or ideological conflicts exist. These conflicts lead to a lack of national unity and to a production of the weak, ineffective, unstable or unpopular governments. Other factors such as corruption, propaganda and outside support can speed up beginning of an insurgency. In a real world, the insurgents use tactics and methods which are in keeping with their specific needs. Successful insurgency is usually based on a unified command and organization giving most of the people, or at least, the elites able to keep further development, a vision of attractive future. Only the insurgency which is able to attract broad masses of people (at least during its crucial phases) represents a real threat for the authority of the state. Other factors which can contribute to a successful insurgency are the outside support (sources, training, shelters), the ability to control a certain territory, the ability to create regular military forces or to cooperate with the military units of the allies'organizations. Many insurgents use terror and spread fear to eliminate support for the legitimate government.

5 THE COIN PRINICIPLES

If the main aim of all international military operations is to stabilize the situation in a particular state and to offer sustainable alternatives, these military forces must gain a confidence and support of the population (mind and heart). When the insurgency begins, the armed operation is only one of several ways to be used to achieve success. Since the insurgents are aware of their minimal chances for success in a direct fight, they use a civilian population to achieve their aims. They are successful especially in the cities and villages. They are less vulnerable by technologically advanced weapons of the allies in this environment than in an open space. The fight to win a favour of the local population must be a characteristic feature of counterinsurgency activities, that is not a fight against it since, basically, what can be generalized is the fact that a fight against the insurgents cannot be won without a support of the local population. In other words, as long as the insurgents are supported by the local communities, they are basically unbeatable. This is basically an unsolvable problem concerning the operations on the territory of Afghanistan. It is estimated that as much as 70% of GNP of Afghanistan is created by the assets from the production and marketing of opium by local indebted farmers. Burning out opium fields by ally helicopters and expectation of a local support for counterinsurgency activities can be called an ambiguous thinking since it includes two contradictory and ambivalent ideas and believing in both of them at the same time. It is no secret for a local population that there is an increasing number of pilotless airplane attacks of the allies on the territories of Pakistan and Afghanistan. It is clear that local population mostly disagrees with them, but local governments covertly support them. Luckily for the allies, the attitudes of the governing elites play a decisive role. Not only in this, but also in other cases the absence of democratic mechanisms in geopolitical space or in the sphere of interest does not play a significant role for the allies since the current situation is in keeping with their interests. What is a necessity during the operation against the insurgents, especially in residential areas, is to gain and keep support of local communities because „in principle it seems that in 2020 two thirds of the world population will live in urban areas, mostly in megacities which will have more than 10 million inhabitants. This implies a depopulation of large rural areas. Social and political violence will be urban in its nature, probably terroristic since this strategy is more suitable for cities while the conventional or guerilla war requires vast areas. Current demographic explosion brings an increase in number of a young population aged between 15-20. This age category has the strongest propensity to be influenced, especially their views and attitudes, especially because this group of people concentrates in the third world countries. For example, in the Middle East, thousands of young people are graduating but only half of them can get a job, and even less a satisfactory job. These young people meet at the cafés, drink coffee, smoke water pipes and, of course, lead discussions on political problems and the possibilities of their (radical) solutions. These are especially the places where the terrorists recruit a large number of their sympathisers“ [4].

6 SKILLS OF INVADING MILITARY FORCES

Counterinsurgency fight doctrine defines the fight against the insurgents as an activity aiming at neutralization of organization which uses armed violence in the form of guerilla war or terrorist attacks. This kind of activity tries to reduce enemy's manoeuvers and to gradually diminish its operational space. The quantity of invading forces and a degree of the use of both lethal and non-lethal means depends on existing political and international opinion, on the quantity of the enemy's forces as well as on the attitudes of the local population. International forces will not act against the people's movement, but they will be securing security of population against violent actions of the insurgents. Since the insurgents try to gain control over and a support from the local population, they create managerial and supporting social structures parallel with a civilian self-government. In practise, these include especially various religious and social funds gradually and intentionally creating a dependence of the receivers of the funds on their providers through the process of which the providers can influence activities of the dependent fund receivers in keeping with their aims. For example, they are such organizations as The Muslim Brotherhood in Egypt, Hizballah in Lebanon or Boko Haram Organization in Africa. The aim of the armed actions of the insurgents is to gain the civilian population and the civilian self-government, especially in areas where this government is least effective. To be successful, the insurgency must be centrally managed which makes it vulnerable. Activities against the insurgents are meant to defeat the insurgency by means of military, semi-military, police, political, economic, psychological and governmental actions. The government which has to face the insurgency on its own territory is directly endangered which implies that it will be willing to accept a higher risk and losses than its foreign ally which supports this government and its efforts.

The key to a suppression of the insurgency is an analysis of factors which maintain it, that is an analysis of:

- the reasons for the origination and continuation of the insurgency,
- an extent of the insurgency including inner and outer supporters,
- tactics and armament of the insurgents,
- a degree of connection between the insurgents and the population,
- general operation environment,
- the ability of the host country to resist the insurgency [5].

To provide a local region with security is one of the most important tasks aiming to gain a support from the local communities which can also reduce operational space of the insurgents. The problem of the counterinsurgency is complex especially because there is a necessity to solve a lot of problems and, at the same time, to coordinate activities of many subjects at the operation space with the main aim to neutralize the insurgents. This neutralization requires a necessary both physical and psychological isolation of the insurgents from the population, especially through gradual elimination of the sources of dissatisfaction of people. Physical isolation can be secured through the use of the armed forces, and psychological isolation is usually secured through the use of PSYOPs, CIMIC means as well as through the development of the relations with the public. After insurgents' defeat, it is necessary to maintain the projects and the self-government in order to eliminate the possibility of the insurgents' return to a particular territory. If the local population is convinced that after coalition forces departure the insurgents' rule is re-established, their support for the operations will be minimal, especially because of unclear future and perspectives after coalition forces leave which also implies a threat of various forms of persecution.

7 IMPACT ON THE SLOVAK ARMED FORCES

The members of the Slovak Armed Forces work in organizations of international crisis management. In Afghanistan, they are the members of provincial reconstruction teams (PRT), the operational mentor and liason teams (OMLT). They are also fulfilling the tasks of the military exploration, they do sappers' works, provide medical care, protect and guard the aliation objects. During the education and training of the personnel engaged in the operations of international crisis management, the teams responsible for training draw especially on their experience from the operations, on a translation of field manuals of alliance army and the Common Military Doctrine SVD-30-44 (Counterinsurgency Doctrine-COIN). According to a former Head of the General Staff of the Slovak Armed Forces, "its content means a shift in military thinking of the Alliance which is based on the experience of other military operations and represents a concrete application of comprehensive approach at executing the power of the Alliance and its member countries called whole government approach in some countries. This means that not only the armed forces, but also other organs of the self-government participate in the preparation of the operation and its course"[6]. The problem of insurgency and counterinsurgency measures of the international community forces in the crisis areas must correspond with a dynamic development of the situation in the world. Globalization of the world does not bring only positive effects such as rapid and unlimited movement of people, technologies and material, but also glooming of the activities, spontaneity and a reduction of possibilities to control activities in different geopolitical spaces before and after the crisis. What is especially important is a constant need to follow recent trends in the personnel of international crisis management training. The main aim of this is to train the personnel to be able to apply an appropriate response to the expected circumstances and to educate the personnel to solve unexpected situations.

An increasing number of attacks of the insurgents, especially members of the terrorist organizations infiltrated in the Afghan National Army units, on the members of the coalition forces cooperating with the Afghan National Army is the evidence of the terrorist leaders' ability to bring new and more and more insidious ways of influencing moral status of the coalition forces and the local population. A considerable part of the insurgents'attacks is realized by the blackmailed people who do not basically have any chance to reject required terrorists' tasks since the terrorists threaten them to kill their family members in case they reject. Simply, to save a life of his/her child, a blackmailed parent is obviously willing to do anything what is required from the terrorists. In this way then, being in the hands of terrorists, the parents thus become a perfect tool for any terrorists' plans and aims. The main force of a blackmailed person is the elementary self-preservation instinct in his attempt to save the family. Thus, generally, there is no obstacle which he would not be willing to overcome to fulfill this aim. In addition to be in keeping with standard principles of the protection of the coalition forces against the attacks, another necessary task is a constant observation of the behaviour of the personnel consisting of the local inhabitants including these persons who seem to be loyal, even trustworthy for a long time because especially these people are often used by the enemies to increase devastation effects on the coalition forces and objects. A closer attention paid to these people can evoke the feelings of distrust which can offend the observed people, but this must become an inseparable part of a behavioral pattern of the coalition unit members operating in such an environment.

In the Armed Forces of the Slovak Republic personnel training process for Afghanistan it means to use the training aimed not only produce an effective reaction to the outer or visible enemy, but also to the enemy who is dressed in the ally uniform, who seemingly behaves as an ally, but in a decisive moment, or when he finds the moment where he can cause the biggest damage, he becomes and enemy. From the point of view of the management of the Armed Forces of the Slovak Republic, to influence the quality, quantity and the presence of the members of the Afghan National Army is very limited so far. What remains is only the observation and alerts related to the suspicious behaviour of the members of the local armed forces.

8 CONCLUSION

It can be said that the importance of perfect and topical a counterinsurgency doctrines increases in the 21st century. Strategic and political ideas inherited from the period of national decolonization, especially in Asia, are in keeping with a need to create a unified and complex strategy to isolate insurgency forces. These attempts are often criticised, especially from the military point of view since counterinsurgency measures presuppose that the host state is strong enough and has a necessary influence which is, especially in the case of Afghanistan, for example, disputable. An ongoing conflict in this country points out difficulties at the application of counterinsurgency doctrines in this country. The United States of America and its allies must thus make a difficult decision, that is either to abandon the country and leave the population of this geopolitical space to gradually empowering insurgency groups or to continue with the modernization and projects which must face emerging problems more and more.

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LEADERSHIP IN THE MILITARY ORGANIZATION: HOW TO CHANGE THE RELATIONSHIPS IN VALUABLE INTANGIBLE ASSET

Piotr MALINOWSKI

Abstract: Throughout centuries leadership in military organizations has been a decisive factor as far as outcomes of military actions are concerned. However, in the age of massive armies and wars waged at the beginning of the previous century its significance had been unfavorably reevaluated. Only the changes within military arrangement ending the previous century and expansion of relations with other armed forces of the democratic countries prompted the comeback of the old and proven values. It has been confirmed through attempts to transform the system of commanders selection, their education, development and perceiving leadership as intangible asset which significantly influences achieving goals set out for military organizations.

Keywords: Leadership. Tangible assets. Military organization.

1 INTRODUCTION

The issue of leadership in various organizations has been the subject of theoretical ruminations and practical trainings for many years. Since centuries it has also been a very popular, continuously analyzed – with variable intensity – and described concept in military organizations.

In the military sphere the issue of leadership, though not fully-identified, has been present from the moment people started forming communities of military character.

Nevertheless, general theoretical interpretation of *leadership* concept and commander's tasks had been changing as sociology, political sciences, social psychology, organization and management studies and other sciences progressed. These changes resulted from noticed inadequacies of previous descriptions and theories as well as transformations within their surroundings and redefining the challenges that organizations and their leaders have to face.

On the basis of long-standing studies, R. M. Stogdill stated that that number of leadership definitions corresponds to number of researchers and pragmatists who attempted to clarify this concept.[1]

Diversity in interpreting leadership caused the present multiplication of its classification systems and cognitional perspectives.

It is crucial to distinguish leadership and organization management as these are two different concepts; though, ideally, they should complement each other. As stated by J.P. Kotter, leadership is *a complement of management and not its substitute* [2] and each of these has its own functions within organization and is characterized by particular actions. The similar relationship applies to leadership and commandment.

2 LEADERSHIP AS A RELATIONSHIP

Viewing leadership as interpersonal relation between individuals in a group is one of the perspectives described by B. M. Bass[3] in his classification. The strength of this relation might vary but it is always based on voluntary character of commitment, not means of coercion. Simultaneously, in organizational context, leadership is understood as the ability to influence behavior of others in order to fulfill particular goals. What underlies this interpretation is the assumption that it is based primarily on figures of high esteem and derivative authority voluntarily accepted by other individuals. Leadership in these types of interpretation is associated with behavior and actions of a leader.

This is a basic approach when assessing military leadership. Great leaders such as Alexander The Great, Julius Caesar, George Washington or Horatio Nelson are usually viewed in this context. However, along with development of massive armies and reorganization of commandment methods, such manner of perceiving leadership started to apply more to the lowest ranks of commandment.

This tendency began to gradually change in the second half of 20th century. It was influenced by the idea stressing that specificity of organizations, especially noticeable in the case of armed forces, forms a characteristic context of leadership through environmental and social conditioning.[4] This context is largely responsible for the way a leader is perceived, as an organizer, a coordinator and an inspiration for others. That is why some commanders, whose job is often characterized by

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1 STOGDILL, R. M.: *Handbook of leadership: A survey of theory and research.* New York : Free Press, 1974. p.7.

2 Harvard Business Review on Leadership. Gliwice : Polish edition, Helion, 2005. p. 47.

3 BASS, B. M.: *Bass & Stogdill's Handbook of Leadership: Theory, Research & Managerial Applications.* 3 Sub edition. New York : Free Press, 1990. p. 11- 20.

4 AVERY, G. C.: *Understanding Leadership. Paradigms and Cases.* Warszawa : Polish edition, PWE, 2009. p. 28.

autocratic authority, face series of difficulties while implementing the notion of leadership.

Opinions of military scholars researching this issue have also been significantly shifting as they indicated that a model of commandment requires combining formal-legal competences and leadership authority (informal). It is also important to preserve harmony between the rule of joint decision-making process and sole responsibility of commander figure as well as subjectification of subordinates' position allowing for display of initiative, creativity and self-reliance[5]. Such an approach also indicated the unification of a heroic commander attitude with a leader responsible for whole organization that is operational not only during war.

3 LEADERSHIP AS A TANGIBLE ASSET

In the case of the Polish Armed Forces, the positive changes and revaluation of leadership idea[6] and its organizational effects intensified involvement of military levies in Iraq and Afghanistan as well as tightening of relations with other NATO allies. It also helped to view leadership as a certain multiplier and element of combat power[7] presented in Figure 1.

Fig. 1 The elements of combat power
Source: *Operations,* FM 3-0, C1, 2011, p. 4-1.

Though significantly better systematized, the presented idea was not new. It is very similar to traditional perceiving of commandment effectiveness as intangible element of combat capabilities.[8]

Both views are also convergent with the conception of intangible assets derived from organizational management. What formed the basis for optimizing sets of intangible assets were the results of long-standing studies conducted under the aegis of Center for Business Innovation of Cap Gemini Ernest & Young[9] since mid-70s. These assets were considered in three areas: human, relational and organizational. Leadership according to this approach is an intangible asset within the human area. Its required level is very significant as it shapes other intangible assets. Effective leadership in organization influences organizational culture, reputation, communication, flexibility and innovation. It also influences acquiring and proper use of human resources.

The words of P.F. Drucker might function as a confirmation of legitimacy of viewing leadership as one of organizational intangible assets: "*organization incapable of solidifying its existence tumbles down. That is why modern organization must think about people who can run it tomorrow".*[10]

As an intangible asset, leadership also influences the functioning of an organization and, according to R.G. Lord and K.J. Maher, this influence is direct and indirect[11]. First of them is reflected through influence exerted by a leader on members of an organization, the former consists in performing direct actions, such as creation of environment for better work efficiency.[12]

The studies on identification and optimization of intangible assets sets carried out in 2009 indicated that leadership was evaluated as the second significant asset after human resource.[13]

These studies indicated that leadership viewed as intangible asset is a tool for management support and influences efficient functioning of military organization. It is also a phenomenon influencing its functioning in a wider perspective as intelligent and enterprising leadership allows not only for achieving organizational goals but also generating new

5 *Przywództwo w dowodzeniu wojskami (Leadership in Military Command and Control)*, part I. Warszawa : National Defence University, 2001. p. 11.

6 In the studies of 2003 as much as 60 % of respondents indicated that there are very few true leaders among commanders – M. J. Śmiałek, *Przewodzenie w kierowaniu. Wyzwania i potrzeby (Leadership in Management. Needs and Challenges).* Poznań : The Stefan Czarniecki Military Academy, 2003. p. 68.

7 *Operations*, FM 3-0, C1, Headquarters Department of the Army, Washington DC, 2011. p. 4-1.

8 WOŁEJSZO, J.: *Sposoby obliczania potencjału bojowego pododdziału, oddziału i związku taktycznego (Means of Calculating Combat Power of Subunits, Units and Division).* Warszawa : National Defence University, 2000. p. 4-7.

9 LAW, J., COHEN, K. P.: *Invisible Advantage How intagibles are driving business performance*, Polish edition. Kraków : Oficyna Ekonomiczna, 2006. p. 42.

10 DRUCKER, P. F.: *The effective executive.* Warszawa : Polish edition, MT Biznes, 2004. p. 86.

11 LORD, R..G., MAHER, K. J.: *Leadership and Information Processing; Linking Perceptions and Performance*, "People in Organization", vol. 1. Boston: Unwin and Human, 1991.

12 AVERY, G. C.: op. cit., p. 32.

13 MALINOWSKI, P.: *Zasoby niematerialne stymulatorem rozwoju instytucji wojskowych* (*Intangible Assets as a Stimulant of Military Institutions' Development*). Warszawa : National Defence University, 2010. p. 54.

capabilities helping in achieving the goals of tomorrow.[14]

4 LEADERSHIP DEVELOPMENT IN MILITARY ORGANIZATION

In order to provide the presented solutions with more details, in 2010 the studies on series of actions that most significantly shape leadership viewed as intangible asset were carried out.[15] These actions concerned a leader figure, interpersonal relations, generating trust atmosphere in groups (teams) and realization of tasks, i.e. areas presented in figure below – stressed by J. Adair in his concept of leadership.[16]

Fig. 2 Areas of needs by J. Adair
Source: J. Adair, *Effective leadership masterclass*, p. 45.

In the optimized set in the area associated with individual requirements there are actions that concern influencing through behavior, attitudes, language register expressed by the presented and developing paragon of a leader (commander). These actions are supplemented by supporting personnel's ambitions of professional development and assigning professional successors. In military organization conditions, there exist actions that are most difficult to carry out; they are focused around problems pertaining to proper rewarding, appreciation, stabilization of employment, personal development and promotions.

Generating positive interpersonal relations between superiors and subordinates, creating the organizational atmosphere of trust and openness, allowing for variety of opinions and constructive polemics as well as inspiring and encouraging personnel to take up difficult challenges are among actions determined by the group requirements. Continuous appraisal of commitment, expressing immediate appreciation of personnel, teaching others and performing the function of mentor by the head figure (commander) are the factors distinguished as their supplementation.

In the task area, the delineated actions were not only focused on goal specification and problem solving, but also on creating credibility of a head figure (commander) through assigning different people with tasks of variable level of difficulty.

While evaluating the proposed set of ten actions collected within the three previously-described areas, the polled group of middle level commandment gave the highest marks to the action associated with creation of positive interpersonal relations between superiors and subordinates. The action consisting appraisal of commitment and expressing appreciation of personnel came in at the second position. The third most important task was generating the organizational atmosphere of trust and openness.[17]

Actions associated with assigning subordinates with responsibility for tasks generating commanders' credibility and allowing for variety of opinions and constructive polemics received lowest marks from the respondents.[18]

The success of tasks associated with creation of positive interpersonal relations between superiors and subordinates at the individual level is mostly dependent on a leader and his ability to generate positive relations and communicate with others.

In military conditions it implies the need for reflection, not only concerning the education methods regarding future commanders but also successful development of leadership abilities. It should be supplemented by the search of solutions allowing for application of individual-level tasks to develop intangible assets of an organization as a whole.

Establishing and development of proper relations should be based on free exchange of ideas, the supplementation of which consists in non-verbal communication, i.e. leader's body language and ability of active listening. Feedback is also an important complement of successful communication. It should assume acceptance ofsubordinate while constructively pointing out his weak sides which should be improved.

[14] BEHN, R.D. *What Right Do Public Managers Have to Lead?* "Public Administration Review", nr 58(8) 1998, p. 209 – 224.

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[18] Ibidem, p. 63.

The reality of commanders' environment requires efficiency of actions that is immensely hard to attain and which is not only achieved through the highest prowess of mind, know-how and hard personal work. Nowadays, maybe more than any time in the past, commanding efficiency is dependent on the ability to gain trust of subordinates and proper relations. For these reasons *leadership development* at the individual level is vital; not only required, but plainly indispensablein the structures of a military organization aiming at long-term success.

The studies carried on the notion of *leadership development* indicate that *only great leaders achieve great effects*[19] and that is why their planned and properly organization-tuned and evaluated development is so crucial also for military organizations. While carrying it out, the commander that is aware of basic leadership principles should simultaneously realize who he is, what does he know and what he can do – differently speaking, know his strengths and weaknesses, capabilities and limitations in order to control and discipline himself and effectively lead the others. It derives from the assumption that evaluating others usually turns out easier than oneself; however, the lack of objective self-evaluation negates successful leadership.

In addition to self-awareness, a leader should also develop exceptional awareness of organizational environment, which allows for easier detection of variable opportunities and threats. Efficient leader should be sensitive to environment where he lives and works and try to fully understand it. His developed sensitivity and empathy are required to understand the individuals whom he cooperates with.

Significance of empathy derives from the assumption that it aids the avoidance of misunderstandings and strengthens positive interpersonal relations; even in the age of unmanned vehicles, human factor of superiors and subordinates remains the most crucial element of military organization.

It becomes even more significant while observing the behavior of personnel within various organizations, including the military ones, which confirms that each of the parties wants to attain its own benefits and realize various needs. What is also influential in this matter is the responsibility for execution of tasks that in extreme conditions within military organization play a decisive role regarding its further existence and even the life of the parties involved. That is why leadership is still most important for combat activities.

Conducting studies on the Polish military facilities, B. Szulc stresses that leadership is an influence exerted on people, i.e. indirectly on human resources – through determining goals, their management, motivating to carry out assigned tasks and organization development.[20] He also distinguishes three aspects important from leadership perspective – *to be, to be able to and to have* – the reflection of which are values, traits, capabilities, knowledge and modi operandi of leaders at each level of commandment.[21]

Development of capabilities influencing the shaping of an individual as a leader is possible through distinguishing their proper sets and strengthening developmental self-awareness. The structure of a set of capabilities might be based on general capabilities such as e.g. communicative skills, decision-making skills and also capabilities adjusted to specificity of organization and organizational level at which the leader undergoing development is to function. The set of properly-selected capabilities to be developed should guarantee possibly best effects in the sphere of influencing members of a group and creation of relations assuring exercising authority with or without limiting the formal means of motivation. Such an approach is very accurately presented by C.B. Randall through the claim that *leader must know, know that he knows and convince others that he knows.*[22]

For the individuals aspiring to take up the leader role this means that not only striving to attain a high level of general skills and know-how but also following some guidelines regarding their application. Simultaneously, they do not exclude the factor of care exercised towards previously-expressed general issues.

According to many authors, these guidelines should be limited to distinguish, at each level crucial for efficient leadership as a whole, i.e. individual, interpersonal, management (commandment), one most important determinant and its constant monitoring.

S.R. Covey,[23] J.M. Kouzes and B.Z. Posner[24] consider *credibility* as the most important leader feature at individual level. It functions as a backbone of creating leadership from the inside, i.e. self-creation, directed outside. It is also associated with

[19] FULMER, R., BLEAK, J.: *The Leadership Advantage: How the Best Companies Are Developing Their Talent to Pave the Way for Future Success.* New York : AMACOM, 2007. p. 3.

[20] *Przywództwo w dowodzeniu wojskami lądowymi RP (Leadership in Command and Control the Land Forces of the Republic of Poland)*, part I, (ed.) B. Szulc. Warszawa : National Defense University, 2001. p. 33.

[21] Ibidem.

[22] RANDALL, C. B.: *The Folklore of Management.* San Francisco : John Wiley&Sons Inc., 1997.

[23] COVEY, S. R.: *Principle-Centered Leadership.*Polish edition. Poznań : Rebis, 2004.

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the need of objective assessment and continuous improvement by a leader candidate of his competences and character as these are the features that determine its degree. Attaining personal credibility requires constant professional and interpersonal development as well as careful selection with regards to making various promises, establishing performance standards and keeping up to them. In a military organization it also requires accepting responsibilities for own decisions and performing in line with applied guidelines and commandment standards.

Credibility as a foundation of leadership from behavioral perspective is performing the actions that were declared to be carried out.[25] It is equally important in military organizations and its attainment forms the basis for creating a determinant at the interpersonal level of *trust.*

Trust is possible to attain in a leader-and-his supporters system through shaping emotional connections and cooperation based on partner relationship. It is found on loyalty, honesty, consequence of actions and proper set of specialist competences, i.e. military.

At the same time, trust is not only crucial for leader's success, but also enables participation of other concerned individuals in the management process (commanding) within organization.

Legitimacy of the presented approach to determinants of individual and interpersonal levels is also confirmed by the Polish studies on army leadership. They indicate that within the transformation process – from formal commandment to performing leader roles – the most important factors are continuous gaining of trust and care for subordinates as well as providing an example worth following in each situation.[26]

At the level of management (commanding) *empowering* performs the role of such determinant – it means that each task should be assigned to the individual who will be accountable for it and its realization, giving him considerable freedom of action and feeling of responsibility for the achieved result. Such an approach is essentially specified by T. Roosevelt, who claimed that *the best leader is a person who is reasonable enough to choose the right people for doing the thing he cares about and composed enough not to interfere.*[27]

At the last of levels, i.e. organizational one, the role of a determinant is fulfilled by *adaptation*, which indicates flexible approach to work organization, i.e. selection, training, reward system, apt team creation and ability to solve organizational problems. It is associated with proper approach to designing and establishing strategies of organization activity. If, at the organizational level, adaptation is properly appreciated, the functioning of an organization will be compliant with assumed goals and resources available at a given moment as well as conditions prevailing in its surrounding, which will ensure the assumed level of efficiency.

The studies carried out on the Israeli army[28] additionally indicate that it is good to base army leadership on the principle: expect more – gain more. According to these studies Setting higher trust-based requirements for subordinates functions as a certain factor of motivation for effective performance.

5 CONCLUSION

Leadership in military institutions is a complex notion due to the socio-political context and a high number of management levels – that is why its connection with realization of organizational goals and performance effectiveness is underestimated. Military leaders are rather viewed through the context of heroic commanders and not managers who systematically carry out their tasks and use resources at hand, especially the human ones.

Nevertheless, leadership in military organizations is nowadays also significant for the surrounding that is being transformed from relative stability into changeability and uncertainty, which is especially noticeable at times of various crises and military actions. Those are the exact conditions in which a high level of leadership skills allows for creation of the atmosphere facilitating stable functioning and motivating personnel to carry out tasks that assure success. It also strengthens possibilities of functioning at the verge of civil and military environment. And after all, cooperation with civil communities of often different culture and commanding in such conditions are commonplace in modern military conflicts.

Viewed as an intangible asset, leadership is of crucial significance for generating personnel´s involvement and performance of tasks that are sometimes impossible, i.e. innovation implementation and introducing changes that form the basis of modern military organizations' functioning and intensify their development. Despite the fact that during the last couple of years the growth of civil sector interest in leadership became noticeable, military surrounding does not fully appreciate this intangible asset. And it is exactly the proper leadership that might help tackling the institutionalized hierarchy, power centralization and

[25] KOUZES, J. M., POSNER, B. Z.: *A Leader's Legacy.* Polish edition. Gliwice : Helion, 2007, p. 29.

[26] ŚMIAŁEK, M.: op. cit., p. 40.

[27] CROSBY, P.: *The Absolute of Leadership.* Polish edition. Warszawa : MEDIUM, 1999, p. 141.

[28] ROBBINS, S. P.: *Truth about Managing People…and nothing but the Truth.* Polish edition. Warszawa : PWE, 2003. p. 80.

hindered communication that complicate introduction of changes and development. That is why in static situations within military institutions the model of formal authority is prevalent – it derives from the position held and is not especially close to the notion of leadership. Whereas in conditions that are more applicable to army specificity and purpose, which is recently noticeable with regards to levies operating abroad, personnel starts to apply higher significance to informal authority which characterizes the leader figure.

The meaning of leadership at organizational level is priceless for military organizations. Yet, leadership does not always have to be evaluated in macro scale, through the perspective of highest-ranking commanders. Also at the lowest level of direct relations, it exerts considerable influence on the functioning of an organization as a whole.

Complexity of leadership is also show through the fact that it is not only limited to a leader figure. Therefore its significance becomes higher if being supplemented with organizational actions shaping the proper candidates for leaders, i.e. related to human resources management and improving variable capabilities useful in commanding at a position held in organizational hierarchy. Simultaneously, it is aimed at increasing the significance of leadership viewed as an asset or even intangible asset of an organization.

An accurate opinion by G.C. Avery seems to be a proper summary of considerations upon the significance of leadership in military organization – *leadership propels the system which allows organization to achieve proper results*[29] – a thing worth remembering also in military environment.

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[29] AVERY, G. C.: op. cit., p. 33.