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I wish all our readers a lot of new inspiration and the body of editors a great deal of success in preparation of future editions.

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OPTIMAL CONTROL STRATEGY OF TRACKED INFANTRY FIGHTING VEHICLE HYBRID POWERTRAIN

Ján DANKO,Vladimír STAŇÁK, Martin BUGÁR

Abstract: The paper deals with the development of optimal control strategy of tracked infantry fighting vehicles hybrid powertrain functional prototype (model).The conditions and requirements for development of hybrid powertrain (HP) to tracked infantry fighting vehicles (TIFV) are presented, which resulted in the requirements of control strategy. Next the concept, structure and optimization of the control system and control strategy for HP operating conditions of TIFV are presented, which are different from road vehicles. Opportunities for further development, optimization and utilization of the proposed control strategy are presented in the conclusion.

Keywords: Hybrid powertrain. Infantry fighting vehicle. Control strategy. Electronic control unit.

1 INTRODUCTION

Nowadays under the pressure of expensive fossil fuels and rising greenhouse gas production has increasingly solves the motor vehicles powertrain with improving the efficiency of internal combustion engines, using hybrid or pure electric powertain. As promoted in the world road vehicles with alternative powertrain, as well as hybrid, so the questions of alternative powetrain are solved national armed forces countries of the World. This leads them to do especially the increasing price of fuel, and the steadily increasing fuel consumption in these forces, what increases the demands on logistics in various armed conflicts. To compare the costs of the Ministry of Defence of the United States for the purchase of fuel are around 10 -15 billion dollars annually. Also, the general fuel consumption per one soldier in the Second war in Iraq, compared with World War II is a 16 time higher [1].

The question of emissions is less significant, whereas it is not subject to the legislation of the vehicles road vehicles, as well as their implementation would lead, according to [2], to growing demand for powertrain construction.

The use of hybrid vehicles has the following advantages:

- improved fuel economy,
- source of electricity for various purposes, falls off the need for electric generator, use in the future electrical/electromagnetic weapons,
- noise and thermal detectability reduction,
- "quiet drive", the possibility of pure electric drive,
- improved dynamic properties, a better course of electric motor torque,
- flexibility and integrity of the structure,
- reduce exhaust emissions, etc.

For all these advantages and reliability of the vehicle has a major impact control system of hybrid powertrain (HP), whether it's structure, but also control strategy of hybrid powertrain. Control strategy for HP tracked infantry fighting vehicle (TIFV) is different from the control strategies of road vehicles as the result of other operating conditions and requirements imposed on these vehicles.

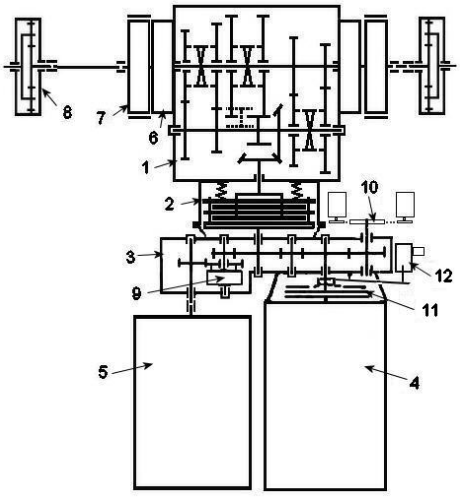
2 INFLUENCE OF HYBRID POWERTRAIN DESIGN ON CONTROL STRATEGY AND CONTROL SYSTEM

For the realization of building a functional model of the hybrid powertrain tracked infantry fighting vehicles were used vehicle OT-90 [3] (customer specification) that primarily comes from vehicle BMP-1. On the functional model of hybrid powertrain TIFV have been specified the basic requirements:

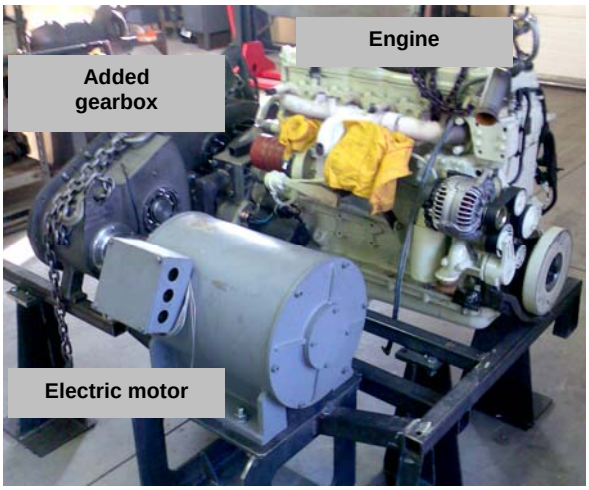
- maintain the basic concept of vehicle,
- maintain the dynamic properties and manoeuvrability of the vehicle,
- maintain basic vehicle powetrain with internal combustion engine,
- improve fuel efficiency and environmental impacts of vehicle operation,
- allow operation of a vehicle with minimized noise,
- increase the operating reliability of the vehicle powertrain,
- vehicle detectability reduction.

These requirements have been one of the entry conditions for the feasibility study and then for development of hybrid powertrain design and its control strategy. Also from the proposed control strategy is proposed control structure of the hybrid powertrain.

From the analysis results was chosen parallel HP, Fig.1 [3].



a) Concept of parallel HP



b) HP powerpack without equipments

Fig. 1 Paralell hybrid powetrain for OT-90
1 – OT-90 gearbox, 2 – OT-90 clutch, 3 – designed added gearbox , 4 – diesel engine, 5 – electric motor, 6 – planetary steering mechanism, 7 – braking system, 8 – final gear, 9 – electromagnetic clutch, 10 – alternator and compressor drive, 11 – diesel engine clutch, 12 – diesel engine clutch control system.

On the basis of further analysis were determined the basic driving modes for the parallel HP [4]. These driving modes are based on the requirements of the customer and from the conceptual possibility of a parallel HP. Basic driving modes are:

- **Normal mode** - in this mode central control unit (CCU) control all processes in conjunction with a driver. In this mode, you can choose from the following sub-modes:
  - ***Hybrid mode*** - the vehicle driven by a diesel engine (DE) and an electric motor (EM). The flow of energy from these power plants is controlled by CCU control strategy;
  - ***Mode diesel engine*** - the vehicle is driven only with DE;
  - ***Electric system*** - the vehicle driven with electric motor;
  - ***Charging system*** - the vehicle is not moving and DE working in area with a minimum specific fuel consumption in order to recharge the battery or like a electrical generator.
- **Safe mode -** this mode does not work CCU and the vehicle is moved by diesel engine.

This mode serves as an emergency transfer if should fail CCU and its other systems.

The function and operation modes and sub-modes provide a HP control system and proposed control strategy with CCU.

3 DESIGN OF OPTIMAL CONTROL STRATEGY

Design of optimal management strategies is based on established driving modes. In terms of hybrid vehicles is essential hybrid mode, in which the vehicle is driven with diesel engine or/and electric motor based on decision of control strategy. As mentioned above, HP control strategy is based on the construction of HP and also from requirements of the customer.

The selected control strategy is based on power split given power from DE and EM and from the necessary driving power. The strategy is based on minimizing fuel consumption, the diesel engine is maintained in the work area with a minimum specific fuel consumption, when the engine efficiency is maximal, Fig. 2.

Diesel engine work at different work areas in hybrid mode must diesel engine work in the area with minimum specific fuel consumption. In other work areas electric motor supply or replace the diesel engine. Based on the desired immediate driving power needed to move the vehicle control strategy distributes power come from DE and EM.

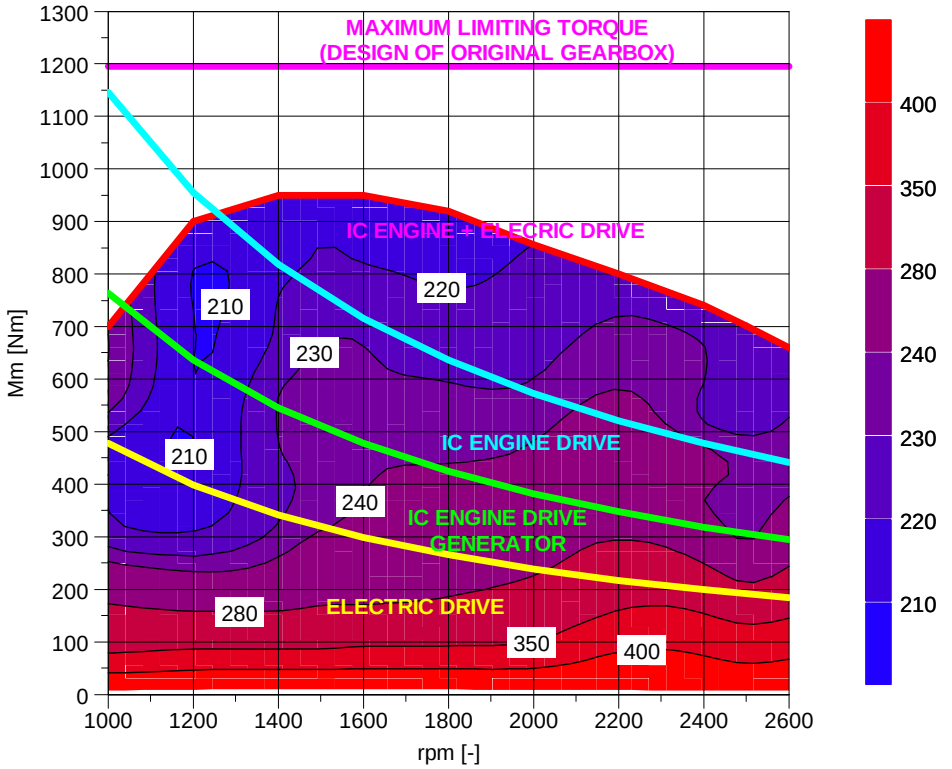


Fig. 2 Power split strategy

$$P_K = F_H.v = \frac{1}{2}\rho.v^3.S.c_x + m_v\left(g.f_r.\cos\alpha + g.\sin\alpha + \lambda.a\right)v \tag{1}$$

Vehicle driving power on driving wheels, P_K, can determine the equation of the driving force F_H and vehicle speed.

Where:

a – vehicle acceleration,
c_x – drag coefficient,
g – gravity acceleration,
α – slope,
m_v – vehicle weight,
f_r – rolling resistance coefficient,
S – vehicle frontal area,
v – vehicle speed (if wind speed zero),
λ – mass factor.

3.1 Working modes of hybrid mode

From power split are set working modes of hybrid mode, Fig. 2. The modes are bounded by torque curve, M_K, at a constant desired vehicle driving power:

$$M_K = \frac{P_K}{2.\pi.n} \tag{2}$$

where: n - speed of added gearbox output shaft.

Elecric drive - the acceleration and low power required vehicle is driven by the electric motor, because the diesel engine in this modes works with high specific fuel consumption.

$$P_{SM} = 0 \tag{3}$$

$$P_{EM} = P_K \tag{4}$$

Where:

P_{SM} - power on the drive wheels from the diesel engine,

P_{EM} - power on the drive wheels from the electric motor,
P_K - driving power on the driving wheels .

Diesel engine drive and generator – if increase the power required to drive it is appropriate to engage the diesel engine, which can load it with batteries charging and thereby keep the engine in work area with a lower specific fuel consumption (Diesel engine drive area).

$$P_{SM} = P_K + P_G \quad (5)$$
$$P_{EM} = 0 \quad (6)$$

Where:

P_G – generator power (EM in generator mode) to charge the batteries.

Diesel engine drive - at higher power it is suitable diesel engine load only the power required to overcome the driving resistance, DE works in the field with a minimum specific consumption.

$$P_{SM} = P_K \quad (7)$$
$$P_{EM} = 0 \quad (8)$$

Diesel engine and electric motor drive: - at high loads, where specific fuel consumption grows, electric motor assist with power, helping to reduce specific fuel consumption of internal combustion engine and the desired driving power is made from both of the machines. DE is kept in an area with a minimum specific fuel consumption (DE drive) and the rest of the power needed to driven the vehicle delivers an electric motor.

$$P_{SM} + P_{EM} = P_K \quad (9)$$

3.2 Work modes limitations of hybrid mode

Electric motor work is limited with capacity of batteries and their state of charge (SOC). The different modes of control strategy have certain limitations that are related to battery state of charge:

- The long-term driving at low power, in area with electric motor, after the batteries running down to the lower limit of SOC, DE driven vehicle and also simultaneously recharge the batteries.
- The long-term driving in the DE drive and generator after recharge the batteries at the upper limit of SOC the power from diesel engine is only used to driven the vehicle.
- Tthe long-term driving at high power, in area with DE and EM drive, the motor to assist with power while the batteries are discharged to the lower limit of SOC. Then the power required to drive vehicle gives only diesel engine.

3.3 Boost mode

The specification of the vehicle shows a need of good dynamic performance. In this respect, parallel HP provides the opportunity to drive the vehicle with DE and EM from the acceleration. This means that the modes EM drive, DE drive will be skipped. In terms of acceleration is important torque supplied to the driving wheels. The proposed design of HP had retained the original transmission from vehicle OT-90. Analysis of the various transmissions elements led to a reduction max. torque supplied to the transmission on the value shown in Fig. 2. Compared with the original drive the HP drive, as is seen, has better characteristics (DE + EM drive). Such characteristics provide better acceleration capabilities throughout the speed range drive machines, because HP provides throughout the speed range the maximum torque which is limited by the design of the original transmission.

4 STUCTURE AND OPTIMIZATION OF CONTROL SYSTEM

Based on the requirements of proposed control strategy and control capabilities of individual elements of HP was designed structure and control system of the HP. DE, EM and frequency converter with batteries have their own control systems with control units.

4.1 Design of control system structure

For the purposes of cooperation of EM and DE in each modes was created master control system with a central control unit. Structure of the HP control system is shown in Fig. 3.

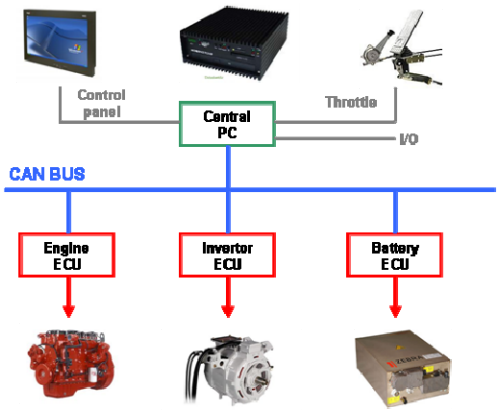


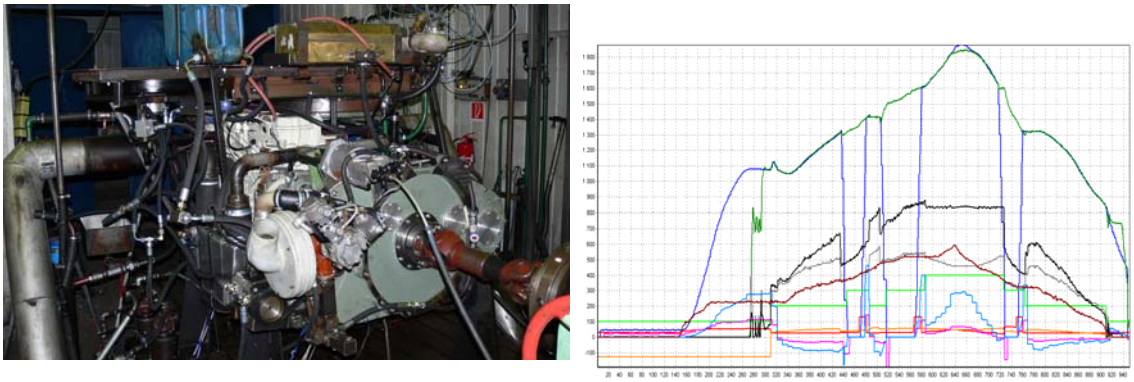
Fig. 3 Structure of the control system

The communication system CAN bus was chosen because the control units of individual elements using CAN bus. The control system is based on industrial PC [6]. The proposed control system uses the communications protocols SAE J1939 (DE) and CANopen (frequency converter and batteries).

4.2 Debugging and optimization of control system

From the proposed control strategy was developed the software of central control unit (CCU) in Delphi 7 environment [7]. Software system of control was implemented in the CCU. HP and control system with proposed software was debugged and optimalized on test rig, Fig. 4.

After the installation of HP to vehicle control system with software was re-debugged and optimized by driving tests. Software version from the test rig had to be adjusted slightly mainly due to dynamic changes by the vehicle drive. What was not possible to fully simulate with the test rig, which had its technical limitations. The process of debugging and optomization of software, Fig. 4 b), led to the final version. However, for financial reasons, the optimization process was stopped.



a) HHJ na test rig b) Mesaured data for optimization process

Fig. 4 Debugging and optimization process of CCU software

5 CONCLUSION

Design of optimal control strategy for HP of tracked infantry fighting vehicles is a long process, which resulted to a stable, reliable and robust control. Presented optimal control strategy is based on the conditions to minimize the specific fuel consumption but in terms of specification of the vehicle is necessary to ensure the maximum dynamic properties and other requirements that were commissioned of customer. During development, debugging and optimizing, there were many new

tasks, but in terms of lack of money and time have not been solved. These tasks are:

- distribution of the working modes under suitable working areas of the diesel engine and not just according to the drive torque curve of constant power (low consumption and emissions),
- the possibility of mode solution reflecting the greater emissions reduction for driving modes that do not require the maximum dynamic properties of the vehicle,
- optimization of the regenerative braking,
- optimization of transition states between different working modes.

Solving these tasks in addition to financial requirements require to ensure technology and staff on sufficient level.

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BATTLEFIELD MAINTENANCE REGULATIONS IN THE ALLIED COMBAT OPERATIONS

Tomasz SMAL

Abstract: The paper presents battlefield maintenance system during allied combat operations. The mentioned processes are described on the basis of allied policies, doctrines and regulations. A great importance of The Combat Service Support Working Group of NATO Standardization Agency was underlined as a board which contribute to the effectiveness of NATO forces through standardization in the combat service support field. There was a special emphasis on The Maintenance Panel described as well, which is established to develop standardization of maintenance organizations, operations and repair parts systems at the tactical and technical levels in order to improve the effectiveness of NATO forces.

Keywords: Logistics. Allied operations. Combat service support. Battlefield maintenance.

1 INTRODUCTION

To follow future combat operations requirements logistics units should aim at the same level of mobility and ability like supported by them fighting units [1]. An efficient and effective combat service support system of military units conducting any combat operations is the principal determinant of the success. This fact is confirmed by both the historical and conducted recently armed operations [2][3][4][5][6][7][8]. Ensuring for fighting units appropriate level of materials supply and logistics service is a crucial to effectively perform combat operations and requires to implement a number of coordinated with each other processes, which include: management, material supply, maintenance, medical support, movement&transportation and military infrastructure.

To face the mentioned challenges, there was an organizational solution introduced by NATO countries which is creation and implementation of common standards and regulations. One of them is The Military Committee Land Standardization Board (MCLSB), which established Combat Service Support Working Group (CSS WG). The CSS WG was found to contribute to the effectiveness of NATO forces through standardization in the combat service support field as it supports joint and combined operations on land. To improve NATO interoperability, the CSS WG advises the MCLSB and through the MCLSB the Military Committee on combat service support topics and issues. The WG primarily focuses on developing of Combat Service Support Doctrine and Procedures and to direct and co-ordinate the work of the subordinate Panels. The WG reviews and recommends combat service support concepts, and develops doctrine and tactics covering all of these areas from the tactical to the strategic levels, which are essential for current and future NATO operations [9].

2 THE MAINTENANCE PANEL

The Maintenance Panel (MP) is established by MC CSS WG upon the MC LSB approval to develop standardization of maintenance organizations, operations, and repair parts systems at the tactical and technical levels (division level and below) in order to improve the effectiveness of NATO forces.

The main task of MP is to initiate and develop standardization proposals and prepare STANAGs and Allied Procedures (APs) as forwarded by Panel members, that is [9]:

- maintenance doctrine for military equipment and weapon systems, to effect their repair as far forward as possible and to ensure their rapid return to combat;
- improvement casualty evacuation procedures to remove from the immediate battle area those equipment and weapon systems requiring more extensive repair, but which may be returned to combat effectiveness in a short period of time;
- maintenance organizations in order to enable and enhance mutual assistance of equipment maintenance in multinational forces;
- maintenance operations in order to maximize the potential for mutual assistance in multinational forces;
- requirements for common maintenance standards for generic equipment.

It is worth to add that each STANAG and AP is produced in one of the official NATO languages and must include an implementation paragraph, which clearly defines how and when the STANAG is implemented by the ratifying nations. All recommended draft of them must be ratified by the MC LSB, through the MC CSS WG. MP. MP is obliged to review the promulgated documents, which have been attributed to it, at least once every three years to determine their continued validity and recommend amendment (Fig. 1) [9]. Apart from, MP is responsible among other things for:

- provide input and support to the planning and conduct of interoperability and standardization exercises;
- evaluate lessons identified from recent operations and exercises with a view to

producing new or amended standardization proposals;
- exchange information and equipment with Panel participants;
- develop and review terminology related to the Panel and make recommendations as appropriate, through the MC CSS WG;
- consider the adoption of any suitable civilian standard;
- carry out, or co-ordinate, such tasks as may be directed by the MC CSS WG;
- foster joint research and test programs in order to achieve economies through the best use of resources;
- ensure, that standardization documents are consistent with the NATO Policy for Standardization and Military Committee Policy;
- review STANAGs and APs of other working groups/panels, which are of interest to the Panel and submit comments or proposals as necessary;
- initiate, develop and process proposals to establish common procedures for co-operation with multinational forces, including the declassification of NATO publications whenever possible;
- recommend to the MC LSB, through the MC CSS WG, projects that might be appropriately handled by another NATO body.

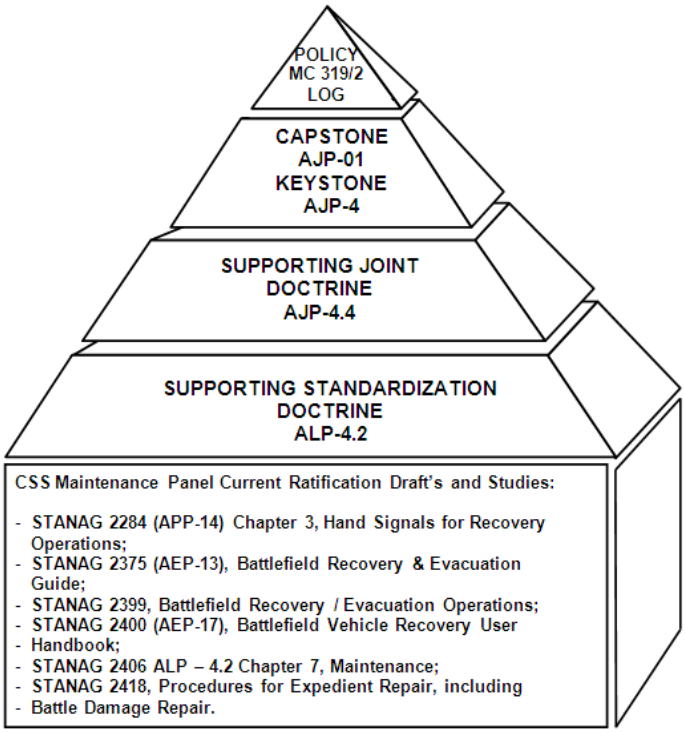

Fig. 1 Maintenance Panel Documents Hierarchy [personal preparation]

3 BATTLEFIELD MAINTENANCE OF WEAPON SYSTEMS

According to doctrinal documents, technical support means maintenance of weapon systems to keep them ready to use and recovery of their ability to use in case of damage as well as supply military units in military equipment, spare parts and technical materials, which are crucial to conduct service and repair [10]. Maintenance processes of weapon systems are presented on the Fig. 2.

An essence of technical support is maintenance of weapon systems at appropriate level of readiness to use. The mentioned processes are conducted within the confines of combat service support of military units during peace, crisis and wartime by logistics units. During peace maintenance includes numerous of tasks connected with keeping military equipment ready to use like servicing, repairing and maintaining during long-term storage. Apart from that, there are modernization, retrofit or purchasing of new weapon systems executed in connection to needs. However, combat operations are very dynamic process varying with time and space. The combat and tactics situation is changing rapidly on the battlespace instantly and random. Meanwhile all combat service support processes are determined and require precise planning, organization and supervising. That point of view considering, combat service support system slows down dynamic and pace of combat. Therefore, maintenance actions will be often limited to recovery of weapon systems, that

is: quick assessment of situation, evacuation, quick expedient repairs and sometimes cannibalization or destruction of equipment which cannot be evacuated or repaired [12]. It should be underlined that weapon systems belong to group of technical object using in random mode [13] and, like agricultural, city or rescue service equipment, they require specific maintenance system, which is determined to perform tasks just on time and place.

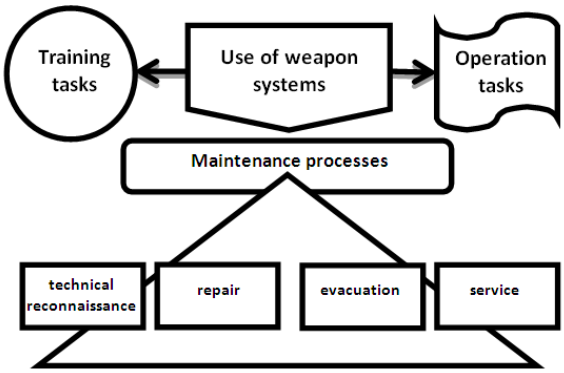

Fig. 2 Maintenance processes of weapon systems [11]

As the history and experiences of last wars show, modern and nonconventional means of fire will caused increasing losses in weapon systems [7][14][15]. That is way, the crucial processes of Battlefield Maintenance are evacuation and repair of weapon systems used to perform combat operations. Efficiency of that process will determine success on the current battlespace, which is connected with logistics forces and means supporting recovery tasks during operation [14][16][17].

An proper assessment of technical problem, which occurs during combat operation is very important as a the first step when a crew member recognizes battle damage. An assessment determines the extent of damage, the level (location) of repair to be conducted, and the risk involved and also estimates the personnel, time and materials required to perform recovery tasks. It should be executed by appropriately qualified specialists, who carries out fault diagnosis and damage analysis straight after the damage has occurred at or in the immediate vicinity of the location of breakdown. If an assessment not handled correctly, time, man-hours, parts and resources can be wasted and opportunities to get back in the fight will be missed. The correctly asset battle damage, crews and maintenance personnel should use right procedures, therefore some armies introduced them by special instructions (manual) [18].

According to STANAG 2399 „ Battle Field Recovery/Evacuation Operation", recovery and evacuation of weapon system should be executed very close to fighting units with use of the newest technology, which allow to quickly recover of damaged equipment and accomplish a task [19]. Recovery means the extrication of an equipment casualty and, if necessary, its removal to a place, where it can be repaired. It is usually the first step in returning disabled or damaged equipment to the battle. Although it is possible to repair damage object without recovery. In general, initial recovery is an owning unit responsibility. Based on a tactical situation, recovery operations may be limited to just moving equipment from the direct line of an enemy fire. Evacuation means the movement of equipment casualties within the logistics system to a place where repairs can be conducted. Evacuation should be executed only as far to the rear as is necessary for repair.

As far as weapon systems concerned, most of damaged parts can be recovered on the battlefield and reused. It is very often basic source of supplying military units during combat operations [11][20]. The Logistics Doctrine of NATO Land Forces is basic doctrinal document, which unambiguous regulate recovery of military equipment problems [10]. It describes conditions and criteria of providing logistic support during allied operations. According to mentioned doctrine, repair includes all activities in order to recovery weapon systems as soon as possible. The special role of repair, executed in the field conditions, is underlined which can be improvise, temporary and conduct without standard methods. At the same time, there is claimed in the document, that efficient field repair depends on systematic and flexible applying of following undertakings:

- determining of repair priorities and urgent repair needs;
- assessment of damage range and necessary repair means;
- specifying the level and place of repair;
- determining and obeying procedures of repair;
- providing supply of spare parts and repair materials;
- organizing of evacuation and repair process.

There is also stated in the mentioned doctrine that the expedient (temporary) repairs, conducted on the fighting area, are crucial tasks of battlefield maintenance system. It should be improvised and executed as close a broken equipment as possible in order to quickly restore damaged weapon systems. The expedient repair is taken if:

- there is not enough time or lack of spare parts to provide standard repairs;
- the operational situation forces to quickly restore damaged weapon systems;
- after expedient repair and accomplishing task restored object must be repaired using standard methods.

The latest NATO document that refers to battle damage repair of weapon systems is STANAG 2418, which introduce idea of expedient repair. This kind of activity was defined as repair, which can be temporary and executed with use of nonconventional (improvised) methods in barracks or in the field conditions. The expedient repair can be conducted only in accordance with the accepted procedures and instructions [21]. According to the quoted document, expedient repair includes also battle damage repair. It is also permissible to restore working order of object only partially with using of improvise and temporary methods and technologies.

All NATO regulations underlined that specialized recovery equipment and personnel are limited. Therefore, not only logistics personnel but also weapon systems operators, drivers and crews are to be properly trained in a way permitting them to accomplishing basic recovery (self-recovery) tasks.

Finally, it is worth to add that some armies of NATO are developing state-of-the-art technologies and solutions which could be used to support maintenance personnel in executing their tasks during combat operations. The developed expedient/battle damage repair systems and telemaintenance system belong to the most promising of them [22][23] (Fig. 3).

Fig. 3 The concept of telemaintenance system in German Land Forces to support maintenance personnel during combat operations [22]

4 CONCLUSIONS

The weapon systems belong to group of technical objects use in random mode and they require special maintenance system, which is determine to accomplish task on time in specific place regardless of circumstances. Efficiently operating maintenance system can determine success in combat operation if it is organized on the strength of mobile and well trained and equipped maintenance units. As the history of last conducted wars show, that the system can even create advantage over an enemy by quickly recovering and restoring all damaged objects with the exception of heavy combat failures. That is why, the new and diverse solutions should be searched for in order to support fighting units in capable weapon systems without necessity of evacuation to stationary workshops.

The crucial role of efficient and effective maintenance system in the field conditions is underlined in the allied doctrines and rules. The Maintenance Panel of Combat Service Support Working Group is a place where new regulations are being created and improved. To properly provide its task, Maintenance Panel must includes all NATO and partners participants. Only full cooperation and allied regulations implementation in separate NATO armies will lead to effective cooperation on the future allied combat operations.

The appropriate documents admit execution of battlefield maintenance in order to fast recover of damaged weapon systems to battle area. As far as the battlefield maintenance of weapon systems at the appropriate level of task efficiency concerned it is very profitable to the all military equipment and armament would characterized by high level of survivability, vulnerability and maintainability in case of any damage.

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SPECIFICITY OF DESIGN AND ACTION OF THE WEAPON'S JUMP AND RECOIL LABORATORY TEST STAND

Lukasz SZMIT, Ryszard WOZNIAK

Abstract: Paper presents the specificity of design and action of the weapon's jump and recoil laboratory test stand. This laboratory test stand is able to examine weapon's jump and recoil of the various small arms including technology demonstrators of the new Polish modular rifles (MSBS-5,56) built both in the classic layout and as a bull-pup. Modular rifles and the laboratory test stand ware designed and manufactured during a research and development project financially supported by the Polish Ministry of Science and Higher Education from the science founds in years 2007 – 2011.

Keywords: Armament. Firearms. Small arms. Laboratory test stand. Recoil. Weapon's jump.

1 INTRODUCTION

Military University of Technology from Warsaw in cooperation with the "Archer" - Radom Arms Factory LLC completed the research and development project No O R00 0010 04 (financially supported by the Polish Ministry of Science and Higher Education) in June 2011. The main aim of this project was to build, manufacture and test technology demonstrators of the modular rifles cal. 5,56 mm (MSBS-5,56) which may become an armament of Polish Armed Forces. One of the main tasks of this project was versatile studies of those rifles. A need of optimising rifle's recoil characteristics appeared during the work. However analysis showed that the ballistic pendulum - the equipment currently used to examine the recoil - doesn't meet the requirements. Therefore designing a new modern and original laboratory test stand became necessary.

2 REQUIREMENTS FOR LABORATORY TEST STAND

Laboratory test stand is used to measure parameters connected with the recoil of MSBS-5,56 modular rifles built both in the classical layout and as a bull-pup. The test stand may be also used to examine various types of firearms similar with size to the MSBS-5,56. Requirements for the test stand were made before the construction works started. Final shape of the test stand was determined by both the characteristics of examined weapons and the character of the measured parameters. Due to that, the theoretical description of the examined phenomenon was the first stage of the work.

Weapon's reaction to the shoot was divided on three components – recoil, weapon's jump and weapon's turn. A mathematical model and a simulation program of each phenomenon were created in the next step. Simulation results were presented in several articles [1, 3 - 5]. Those results showed that the test stand should be able to measure parameters of the recoil and the weapon's jump. Measuring the weapon's turn appeared to be unnecessary due to the insignificant values of this parameter. The test stand should be capable to test MSBS-5,56 modular rifles built both in the classical layout and as a bull-pup. The test stand should also allow to test other firearms similar with the dimensions to the MSBS-5,56. In particular the test stand should be able to measure:

- recoil distance – no less than 100 mm,
- weapon acceleration – in the range of ±3000*g*,
- recoil force – in the range of 3 kN,
- weapon jump angle – in the range of 35°.

3 PROJECT OF THE TEST STAND

Laboratory test stand was designed in accordance with accepted requirements. During the designing process CAD programs like the Solid Works were wieldy used. 3D models of the test stand's components and an assembly of the complete test stand were made during that process. 3D models of the examined weapon were also made and used.

Weapon mounted on the test stand is placed on its side. This makes operating the weapon easier. This also allows making the construction of the test stand less complicated. According to the design the test stand can be set in three configurations:

- for measuring recoil distance and accelerations of the weapon,
- for measuring weapon's angle and speed,
- for measuring recoil force.

The test stand consists of the base with the guides and changeable elements used to mount the examined weapon and the sensors. The test stand prepared for measuring the recoil distance and acceleration of the weapon is equipped with the butt holder, front and rear carts, the barrel holder and the position sensor base. Laboratory test stand set in this configuration is shown at Fig. 1.

The base is a massive steel plate with the guides and the force sensor base. The base can be fixed by the screws and special montage elements to the Prototypa STZA 13 gun mount. The base has several

sets of threaded holes. They are used to fix the position sensor base, the turn axis base and the table used to measure the weapon's jump parameters. A set of smooth holes is used to fix the test stand to the ground or STZA 13 gun mount.

Rear cart is equipped with two linear bearings which allow him to move along the guides. Bearings are fixed to the cart's body. The cart's body has sockets for the acceleration and force sensors. The spigot for fixing the butt holder is placed on the top of the cart's body.

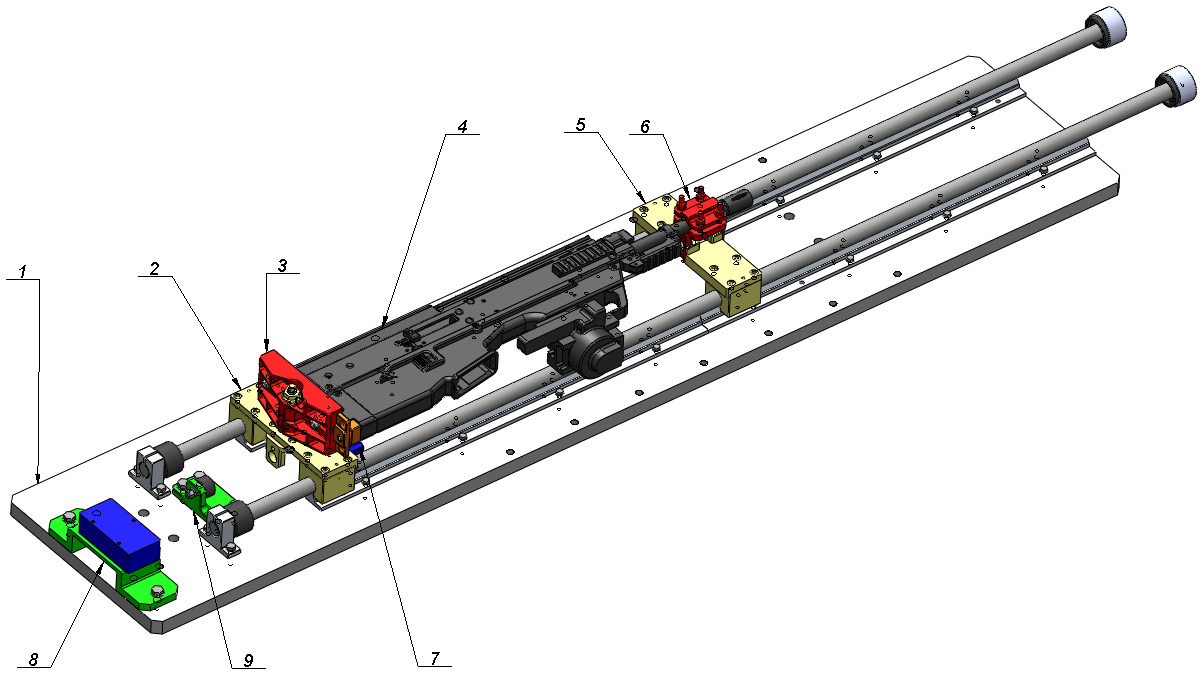

Fig. 1 Test stand set for measuring the recoil distance and the weapon's acceleration
1 – base, 2 – rear cart, 3 – butt holder, 4 – examined weapon, 5 – front cart, 6 – barrel holder,
7 – acceleration sensor, 8 – position sensor base with the sensor,
9 – force sensor base with the shock-absorber.

Butt holder is adjusted to hold the butt of MSBS-5,56 rifle built in classical layout. Butt holder is also able to hold (with the help of special montage element) the receiver of MSBS-5,56 bull-pup rifle. Hole used to fix the butt holder on the rear cart (or on the turn axis) is placed in the rear part of the butt holder. Butt holder placed on the rear cart is fixed with a nut, and a clamp.

Front cart is similar to the rear cart and it is adapted to fix the barrel holder. Fixing height of the barrel holder can be adjusted to the weapon's size and the barrel thickness.

Using proper fixing elements and adjustment capabilities of the test stand allows examining different models of firearms similar with size to the MSBS-5,56 rifles.

Position sensor is placed on the base fixed with screws to the test stand's base. Mirror for the laser beam of the position sensor is the rear surface of the rear cart.

Shoot is initiated by the electric trigger. The trigger is fixed to the examined weapon instead of the grip and presses weapon's trigger with a lever.

Weapon fixed to the test stand is able to move along the guides. Activation of the electric trigger causes a shoot. Recoil force generated during the shoot gives velocity to the examined weapon. The position and acceleration sensors are measuring recoil parameters (recoil distance and acceleration of the weapon) when weapon moves. Weapon is stopped by the shock absorbers on the end of the guides and the force sensor base.

Measuring the recoil force is possible with use of a force sensor. The force sensor is mounted on the force sensor base in the place of removed shock absorber. Fig. 2 shows the test stand set for measuring the recoil force. Examined weapon doesn't move when the recoil force is measured. The rear cart is fixed to the base by the force sensor.

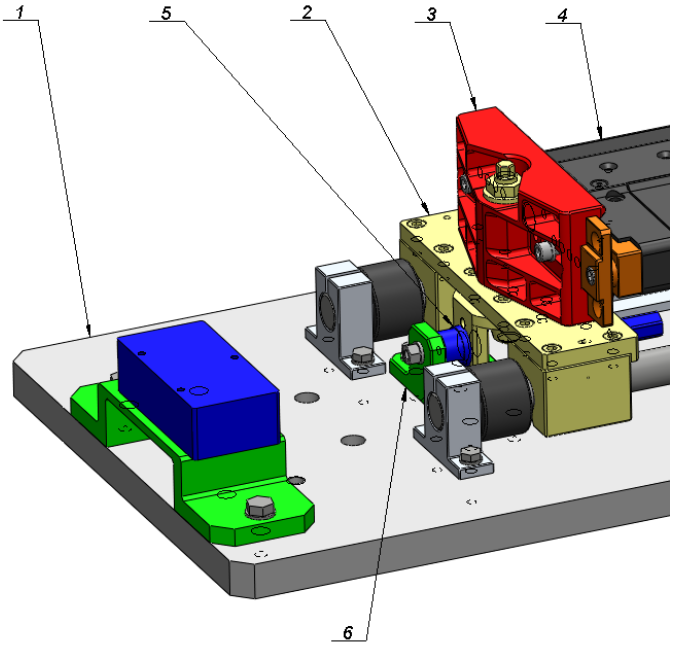

Fig. 2 Test stand set for measuring the recoil force
1 – base, 2 – rear cart, 3 – butt holder, 4 – examined weapon, 5 – force sensor, 6 – force sensor base.

A major modification of the test stand is needed to set the test stand for measuring the weapon's jump. The table supporting weapon's barrel during the weapon's jump must be fixed to the base of the test stand. The table is placed in position proper to the length of examined weapon. Test stand set for measuring weapon's jump parameters is shown on Fig. 3.

Barrel of the tested weapon is placed in the barrel holder and fixed to the transverse cart. Connection between the transverse cart and the barrel holder allows adjusting the stand to the different width of tested weapons. The transverse cart has two rolls rolling on the table.

The position sensor base must be removed to set the test stand for measuring weapon's jump parameters. The turn axis base with the encoder is mounted in its place. The turn axis base is equipped with an axis designed to support the butt holder. Encoder Connected with the turn axis is mounted inside the turn axis base.

Weapon placed on the test stand is able to turn around the turn axis. Possible weapon jump angle measurement range depends on weapon length. The test stand allows to measure the weapon jump angle in range of 36° for the MSBS-5,56 rifle built in the classical layout and in range of 48° for MSBS-5,56 bull-pup.

The electric trigger causes a shoot. Turning momentum (weapon's jump) occurs when the direction of reaction forces doesn't cross the turn axis. The encoder mounted in the turn axis base measures the weapon's jump angle. The butt holder allows adjusting the weapon's fulcrum. This makes possible to study and rate the influence of the fulcrum position on the weapon's jump.

4 TEST OF THE STAND

The laboratory test stand was made by the „Archer" - Radom Arms Factory LLC with usage of blueprints made by the Department of Special Design from Military University of Technology. Fitting of the main parts and mobility of carts and the turn axis was checked during the stand assembly.

Checked test stand was placed on the STZA 13 base. Then the sensors were mounted in their sockets. After that possibility of the movable components collision with the sensors was checked. Finally the test stand was set for measuring recoil distance and the weapon's acceleration.

Tested weapon was placed on the prepared test stand. The live fire tests started after assuring that the weapon is properly fixed to the test stand. Ready to fire test stand is shown on Fig. 4. Next stage of the tests was setting the test stand for measuring the recoil force and checking the test stand in this configuration. The test stand set for measuring the recoil force is shown on Fig. 5.

After finishing tests with a rifle built in the classical layout the test stand was checked and prepared to mount a rifle built as a bull-pup. Then the test procedure was repeated. The test stand action was recorded by a video camera and a fast camera.

Live firing test showed that the test stand works correctly and the sensors are recording proper parameters.

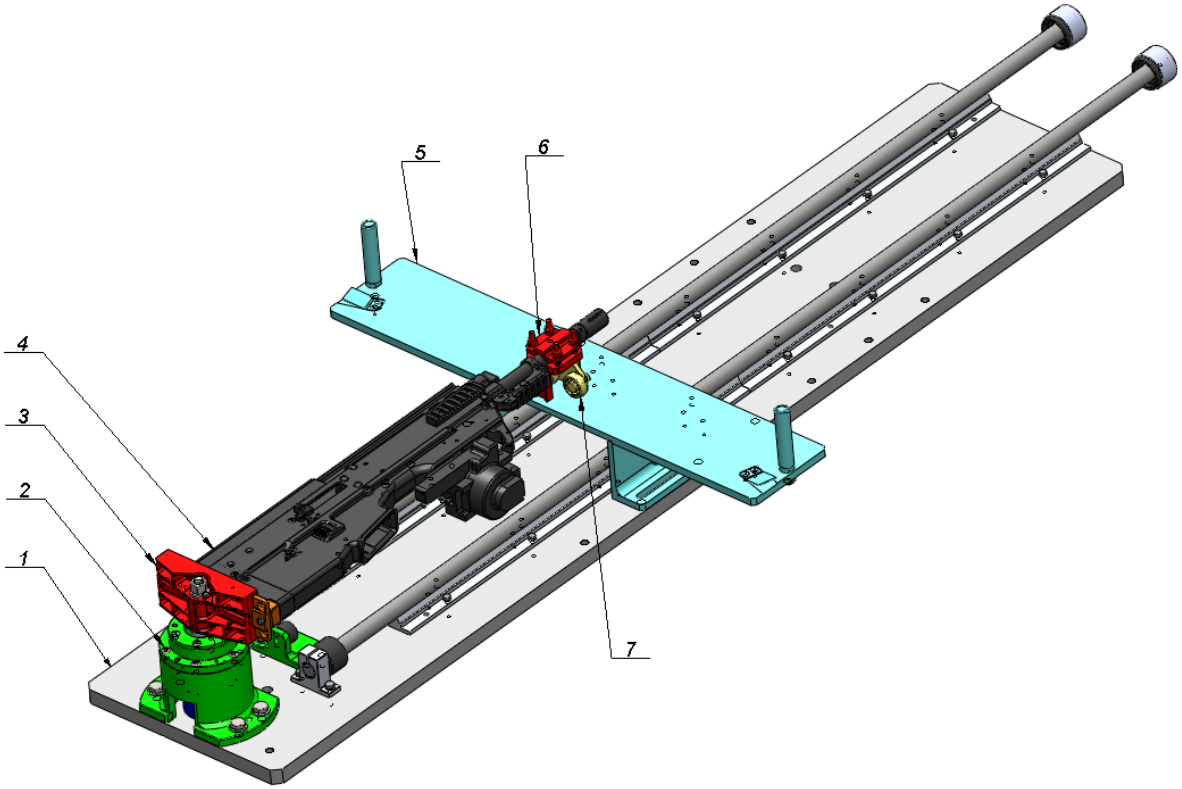

Fig. 3 Test stand set for measuring the weapon's jump angle
1 – base, 2 – turn axis base with the encoder, 3 – butt holder, 4 – tested weapon, 5 – table, 6 – barrel holder, 7 – transverse cart

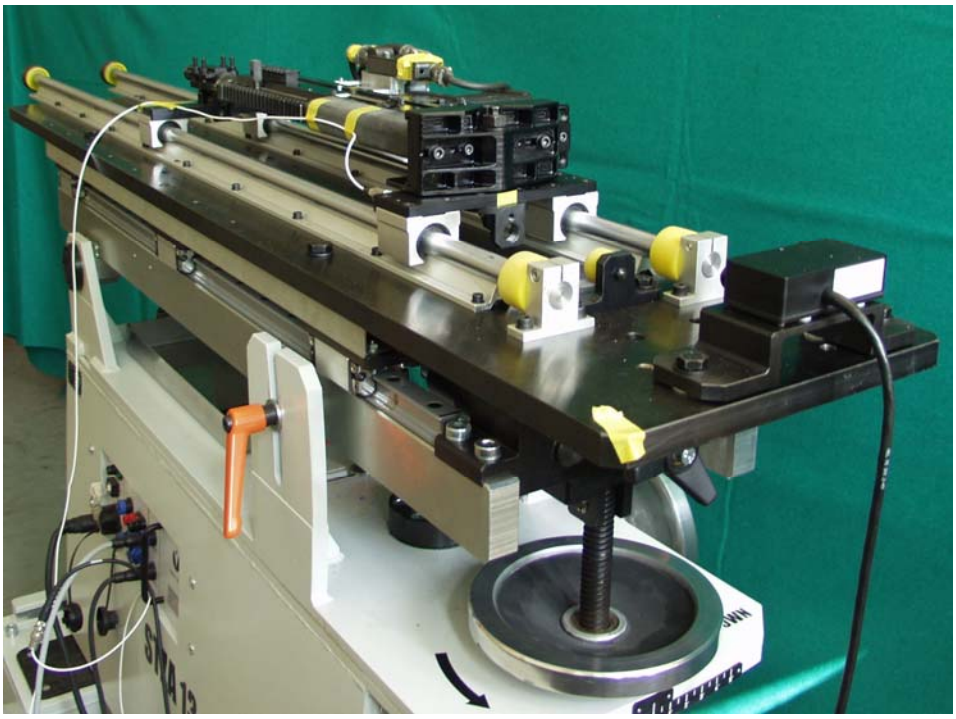

Fig. 4 Test stand placed on the STZA 13 gun mount and ready for measuring recoil distance and weapon's acceleration

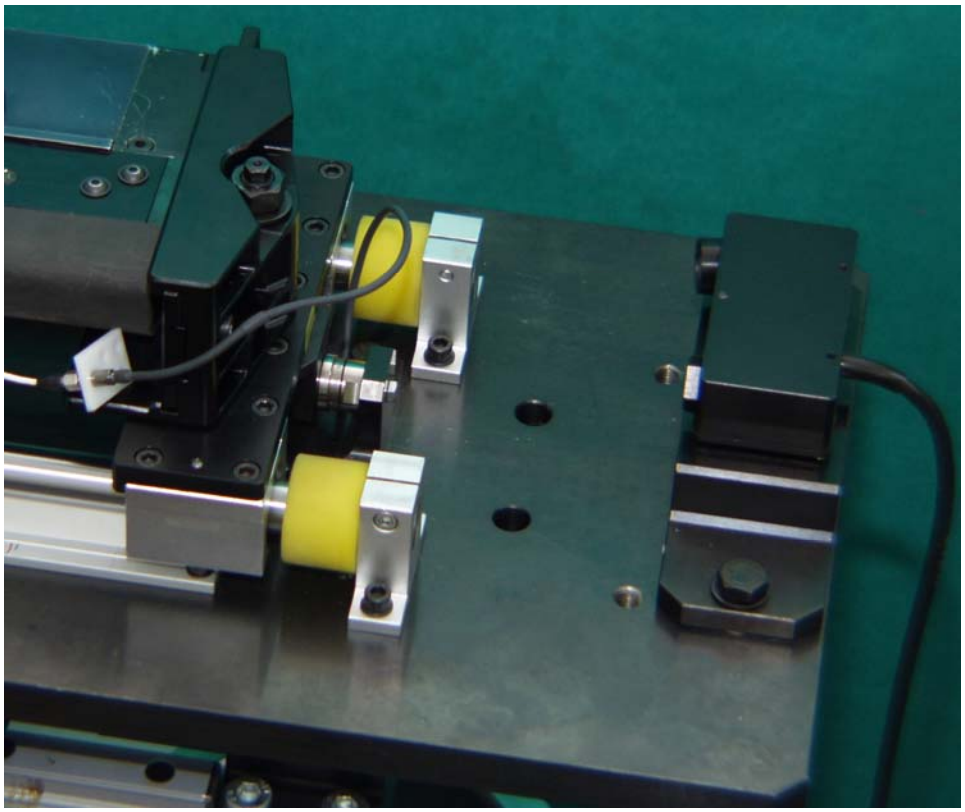

Fig. 5 Rear part of the test stand set for measuring the recoil force

After the tests of the stand set for measuring recoil parameters test stand was rebuild for measuring weapon's jump parameters. Test stand set for measuring weapon's jump parameters is shown on Fig. 6. Live firing test in this configuration included shooting in chosen positions of the weapon fulcrum. Life firing tests in this configuration ware made both with the rifles built in the classical layout ant with a bull-pup. This allowed examining the test stand in all conditions.

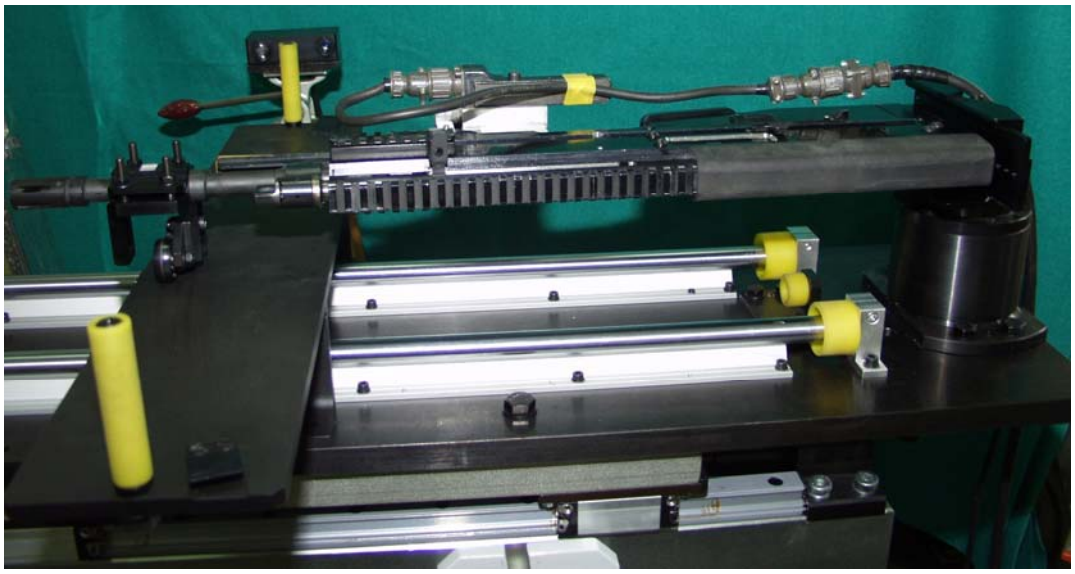

Fig. 6 Test stand placed on the STZA 13 gun mount and ready for measuring weapon's jump parameters

Data gained by the test stand sensors can be used to create weapon's jump and recoil characteristic. Fig. 7 presents example recoil characteristic created with data from the test stand sensors.

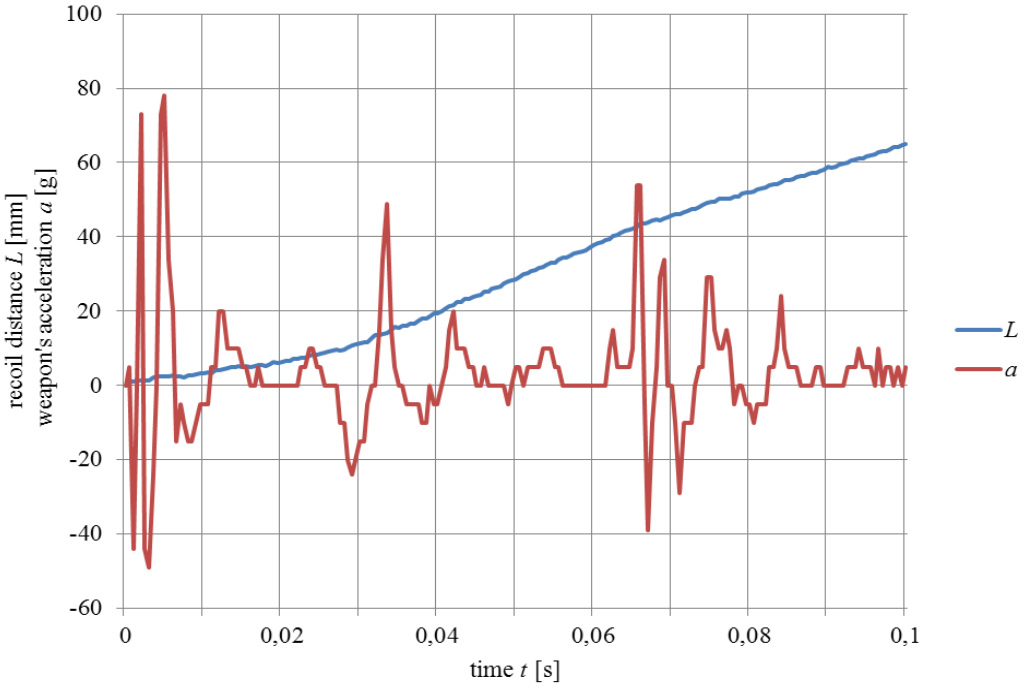

Fig. 7 Recoil distance L and weapon's acceleration a vs. time t

5 CONCLUSION

1. Able to measure parameters of recoil and weapon's jump laboratory test stand was made as a part of research and development program No O R00 0010 04. Preliminary test showed that the test stand meets the requirements and is able to examine the phenomenon connected with recoil.
2. Due to the unique design of the test stand patent procedures have been started in the Polish Patent Office.
3. Further works will concentrate at examining recoil and weapon jump parameters of different weapons and verifying mathematical models of the recoil and weapon's jump.

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NOISE LOADING OF CREW AND INDIVIDUALS

Peter LISÝ, Henrich KELEMEN, Emil HRIVŇÁK

Abstract: The aim of this work is to show the influence of noise loading on the crew (or individuals) of combat vehicles and military technics in the area of grand forces in comparison with noise loading of a personal car, and also of noise loading from automatic assault rifle. The measurements were focused on the detection of noise inside and outside of vehicles while they are at idling and during operation (without shooting). Moreover, measurements were done on self shooting with automatic assault rifles. The result values were then compared. The measurements of this work were made by using 1/3 octave frequency analysis and peak sound levels of noise were also measured through the using of hand-held analyzers of noise type 2250 from Brüel & Kjær firm. Until now was realized an arrangement on decrease noise effect on the operational crew of fighting vehicles (i.e. wearing protective special helmet inter alia as well as for needs of communications). However, the rest of the crew did not protected neither inside vehicles at long-term driving nor at self shooting from automatic assault rifles. Experiences and researches from US army show, that long-term run over threshold noise loading lead unto progressive loss of hearing or tinnitus. At present day as a result of fight in the urban area, let us say close combat fight, is put more emphasis in this area. For the rest of crew are show the advantage to application of the head sets. They are to be used on one side as a protection of hearing against severe influences of noise loading, and other side they can serve as communication facility that make easier communication between commander and individuals.

Keywords: Noise. Measurement. Fighting vehicle. Car. Assault rifle.

1 INTRODUCTION

Today's very technically-developed period which is always becoming more and more dependent on the work of machines, which create noise and thereby create the basis of harmful loading on the organism. The human body is able to defend against the noise but only in some measure and in its own way (Fig. 1). If the organism is in the presence of a bigger noise loading, then the middle ear is able to lower the sharpness of hearing which after finishing of the noise loading turns back to its normal state. The time when the ability of theear is again able to be in its natural state directly depends on the length of the noise loading influence. However, if the noise affects the human body for a long time then a so-called acoustic trauma phenomenon can occur [1] a [2]. This trauma is characterized by a permanent reduction in hearing acuity. In extreme cases, the total loss of hearing can occur.

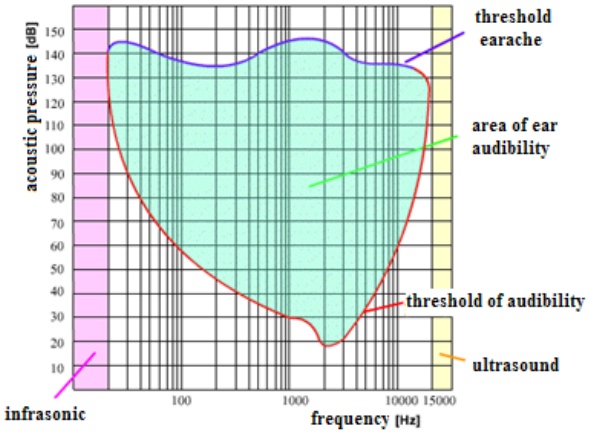

Fig. 1 Frequency dependence of threshold earache of human ear

Under term a noise we can understand an unfavourable sound in the frequency band from 20 Hz to 20 kHz. The noise is created by moving parts, because keystone sound is mechanical vibration elastic surroundings. The noise can be measured by contactless method. The time-weighted sound level $L_{x,y}(t)$ is defined as [3]:

$$L_{xy}(t) = 20.\log\left[\frac{\sqrt{\left(\frac{1}{\tau}\right).\int_{-\infty}^{t} p_x^2(\xi).e^{-\frac{(t-\xi)}{\tau}}d\xi}}{p_0}\right] \text{ [dB]} \quad (1)$$

where x is for A-, B-, C- or Z-weighted; y is for Fast-weighted (F = 125 ms) or Slow-weighted (S = 1s) ; τ is the exponential time constant for time weighting F or S; ξ is dummy variable of time integration from some time in the past, as indicated $-\infty$ for the lover limit of the integral, to the time of observation t; $p_x(\xi)$ is the x frequency-weighted instantaneous sound pressure; p_0 is the reference sound pressure, equal to 20 μPa.

The equivalent continuous sound level (also called time-average sound level) $L_{xeq}(T)$ is defined as [3]:

$$L_{xeq}(T) = 20.\log\left[\frac{\sqrt{\frac{1}{\Delta t}.\int_{T}^{T+\Delta t} p_x^2(\xi)d\xi}}{p_0}\right] \text{ [dB]} \quad (2)$$

where T is start time of the measurement; Δt is the average time interval.

The peak sound level $L_{xpeak}(T)$ is defined as twenty times the logarithm to base ten of the ratio of the greatest absolute instantaneous sound pressure $p_x(t)$, within a time interval, starting at $t = T$ and ending at $t = T + \Delta t$, to the reference sound pressure p_0.

The aim of this work is to give an idea of the problems of noise especially in the military area. In this area the individuals are in the presence of a large spectrum of noise sources which affects their unfavorably, whether for a short or long period of time. For example in Fig. 2 is shown of noise level at combined (highway and road) long-time journey in civilian car.

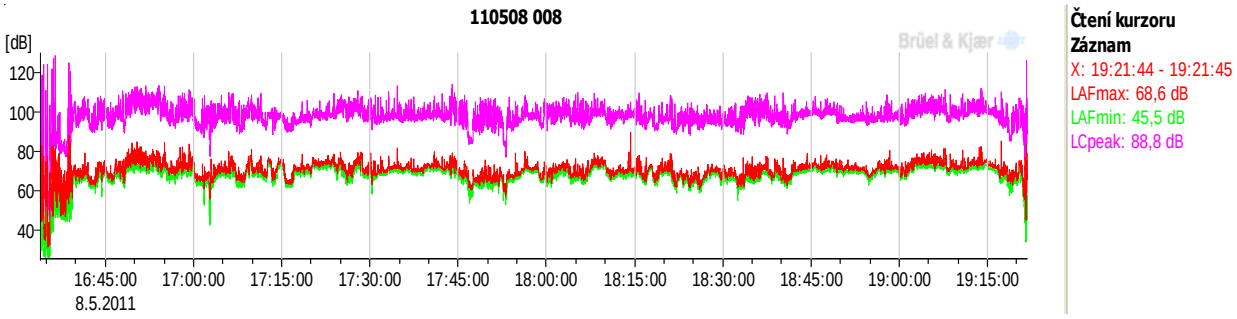

Fig. 2 Noise level at driver inside KIA Cee´d during combined long-time journey

We can suppose, that a noise loading which arises from the operation of military vehicles whether it is a track vehicle or a wheeled-vehicle at long-time journey, will be noise level more higher than at civilian car. It is difficult to imagine the combat operations without them. Then there also is the noise which is caused by their weapons. In many cases there can be a situation when these two sources of noise affect the individuals at the same time. In this case the individuals is affected by the presence of an enormous noise loading. This state can last up to a few hours, and can have permanent consequences on the health of the individuals. That is reason why is neccessary to try to protect the individual´s health by all possible means. The measurements of this work were made by using 1/3 octave frequency analysis and peak sound levels of noise were also measured through the using of hand-held analyzers of noise type 2250 from firm Brüel & Kjaer [3].

2 NOISE LOADING FROM VEHICLES

In the introduction was mentioned, that the source of the noise is the vehicle itself, which is used for carrying out the given tasks such as transport, support, combat and other tasks. The noise which arises, comes from the engine, from gear group, from the track movement or from the traction of the wheels on the surface. The noise which arises from the vehicle operation affects the vehicle crew but as well the individuals who are moving near this

vehicle. Therefore some measurements were taken on the driver´s side, on the co-driver´s side, and as well out side of vehicle. Also some measurements were taken in space of squad which serve as the transport place of the individuals in the combat technics. The measuring of the noise values of the vehicles were determined while the engine was operating (idling), but not doing any specific job, and as well during the operation when the engine of the vehicle was fully loaded. The measurements were taken both inside the vehicles and as well outside the vehicles. For a better idea of the noise loading difference, the courses of the personal vehicles were identified, and as well those of the combat vehicles and special techniques used in AF SR.

The measuremets were focused on the comparison of constituent noise loading affecting different places in the vehicle and as well outside of it. Furthermore the Table 1 and 2 and Fig. 3÷8 should have shown what kind of noise loading affects the area of the crew of the special technique in also the space of the squad. The individuals are not protected, in contrast with the driver, the vehicle commander and the gunner who are protected by a helmet system which has communication system and functions as head protection and helps as well with decreasing of the noise. In this work KIA Cee´d, Lada NIVA passenger cars were used and a bus Karosa, for illustration a lower noise loading affecting the crew, unlike the loading coming from the operation of the combat vehicles, APC-1 and APC-2 and of the special technique such as T-815 and AV-15 or power supply.

The measurements have shown us clearly, that the noise loading is bigger in the military technics (Table 1) than in civil vehicles (Table 2). One of the inceptive reasons for a bigger loading is a different construction of the vehicles, since the military technics are constructed to protect from shooting. And that it will be able to work with different superstructures what increases the weight of the vehicle and so it is necessary to use an engine which is able to put these huge vehicles into operation. The second reason is, that with civil vehicles the emphasis is put on the comfort of the crew and all the disruptive effects are eliminated by the producer during the construction of the prototypes. In military technology the emphasis was not put on the comfort of the crew but the main aim was to reach a proper operation of the vehicle in different terrains and to protect crew against shooting and splinters or blast.

In Fig. 3÷8 are shown column diagrams with 1/3 octave frequency analysis for individual representatives from both groups military technics and civil vehicles. These figure show the spectral distribution of the noise loading in range of hearing of human ear.

Table 1 Military technics

Type of measurement		Time [s]	LAeq [dB]	LCpeak [dB]
T - 815 outside engine, idling		18	83.5	102.3
AV - 15 driver, operation		20	78.4	115.1
APC - 2 individuals	idling	16	83.8	113.0
	operation	21	99.8	131.0
APC - 1 observer	idling	18	89.6	118.0
	operation	24	106.0	136.5
APC - 1 operation	commander	18.5	107.4	134.9
	between commander - observer	15	97.1	127.6
APC - 1 outside 7.5 m	idling	16	72.5	97.4
	through the road	14	89.8	113.6
Power supply	4 m	16	97.7	113.1
	muffler	14	103.8	119.8

Table 2 Civil vehicles

Type of measurement		Time [s]	LAeq [dB]	LCpeak [dB]
KIA Cee´d idling	driver	2	41.4	79.7
	passenger	8	39.8	71.5
KIA Cee´d 3000 rpm	driver	6	59.8	86.3
	passenger	6	56.8	83.4
KIA Cee´d through the road 7.5 m 40 kmph		2	62.3	86.9
KIA Cee´d muffler	idling	10	50.4	87.9
	3000 rpm	8	67.8	98.3
KIA Cee´d, combined long-time journey		3 h	74.4	129.9
Lada NIVA driver	idling	13	51.4	87.4
	3000 rpm	12	71.7	100.2
Lada NIVA through the road 7.5 m		15	63.3	87.8
Lada NIVA muffler	idling	14	63.2	91.7
	3000 rpm	15	76.6	100.2
Lada NIVA operation 40 kmph		177	74.0	115
Bus Karosa idling	driver	14 15	57.7 80.0	91.8 105.4

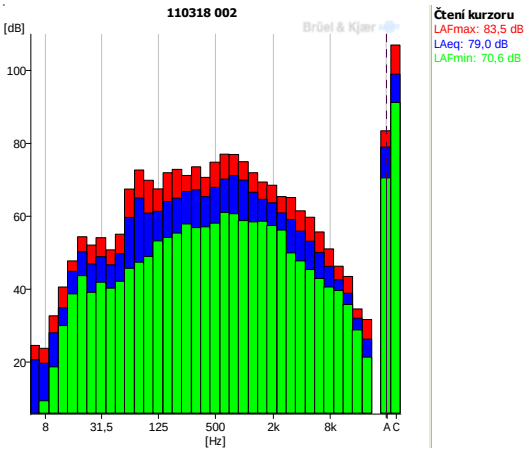

Fig. 3 1/3 octave frequency analysis at driver inside AV-15 during operation

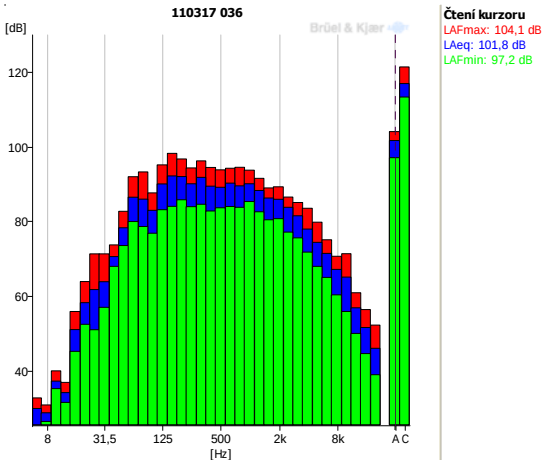

Fig. 4 1/3 octave frequency analysis at place for individuals inside APC-2 during operation

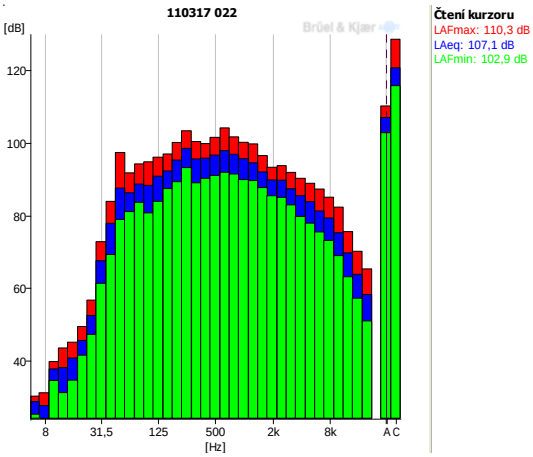

Fig. 5 1/3 octave frequency analysis at commander inside APC-1 during operation

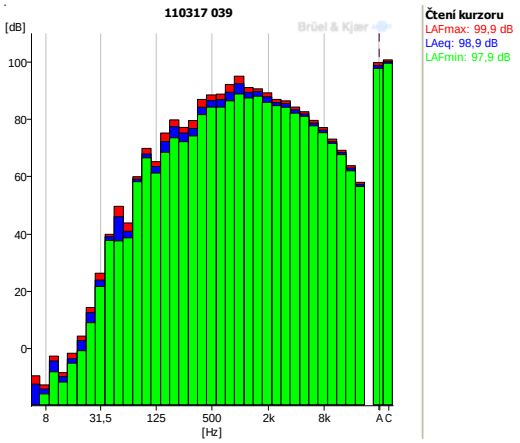

Fig. 6 1/3 octave frequency analysis at 4 m from Power supply during operation

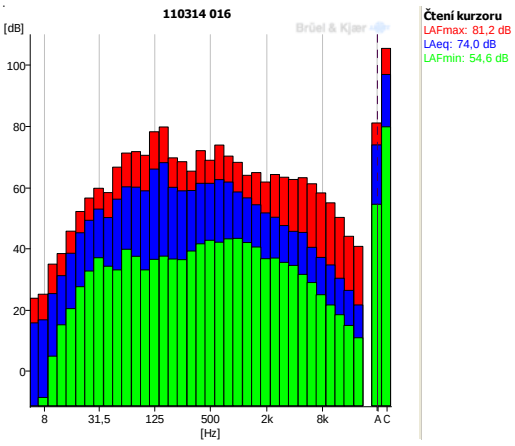

Fig. 7 1/3 octave frequency analysis on driver inside Lada NIVA during operation at 40 kmph

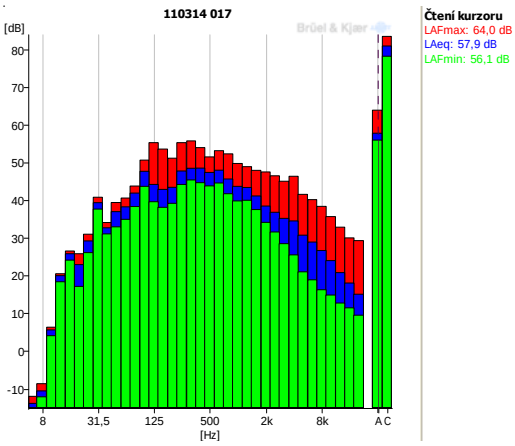

Fig. 8 1/3 octave frequency analysis on driver side Bus Karosa during idling

3 NOISE LOADING FROM SHOOTING WITH ASSAULT RIFLE

It is required to deal with the noise coming from the weapons of the individuals because without a weapons the individuals wouldn´t be able to fulfill the tasks in combat deployment and it is difficult not to think about the weapons as the most important part of the individual´s equipment and armament. The noise which comes from shooting is created by an progressive growing of pressure inside weapon after initiate cartridge cap which ignites gun powder. This causes the expansion of hot powder gases, they then sweep out the projectile from the gun barrel. Immediately when the projectile leaves the gun barrel the pressure leaks into the surrounding and the temperature drops rapidly. The consequence is a noisy sound. The next case which arises from supersonic speed shooting, where there is another attendant phenomenon the so-called acoustic boom, which arises in the moment when the projectile enters the atmosphere. During the measurements the automatic assault rifle Sa model 58 was used [4]. Blank and live ammunitions were used and the noise comming from these types of ammunition (ammo) was compared. Last but not least we have to take into consideration the noise which arises in combat deployment which affects inside the combat vehicle while shooting from gun**.** Measuring of this noise loading has not been carried out up to now.

The noise loading of the individuals was measured during single shots and as well during the burst of weapon fire. During the measuring the position of the measuring device was changed according to the weapon. The measured values and the conditions which were during the measuring are showed in Table 3 and Fig. 9÷12. In Fig. 9÷12 are shown column diagrams with 1/3 octave frequency analysis for shooting with both blank and live ammunitions. These figure show the spectral distribution of the noise loading in range of hearing of human ear.

Measurements of shooting noise with live ammunition were made in the distance 5 m perpendicularly to the muzzle barrel and at the same distance around half circle, i.e. from 0^o to 180^o.

Measurements of noise at the shooting with blank ammunition were made on the distance 2 m also perpendicularly to the muzzle barrel.

Table 3 Shooting from assault rifle 7.62 mm Sa model 58

Kind of measurement	**Time [s]**	**Angle from direction of fire [^{o}]**	**LAeq [dB]**	**LCpeak [dB]**
Single shot (live ammo)	6	0	104.9	149.1
	7	45	99.0	147.1
	8	90	99.4	147.1
	9	135	96.4	142.4
	14	180	97.9	132.8
Burst 10 (live ammo)	8	0	113.3	150.7
Single shot (blank ammo without extension)	7	0	108.9	152.9
Single shot (blank ammo)	4	0	112.3	155.5
Burst 10 (blank ammo)	8	0	116.8	154.0

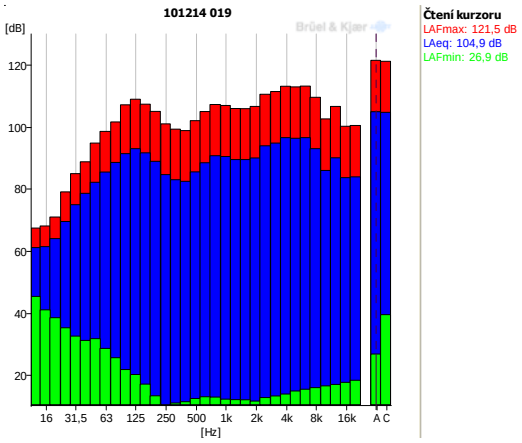

Fig. 9 1/3 octave frequency analysis at single shot with live ammo

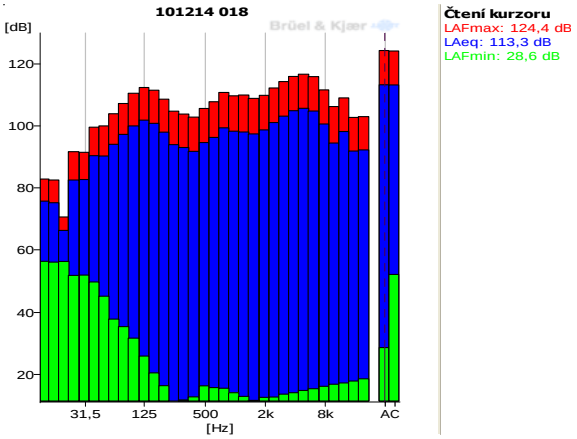

Fig. 10 1/3 octave frequency analysis at burst with 10 shots live ammo

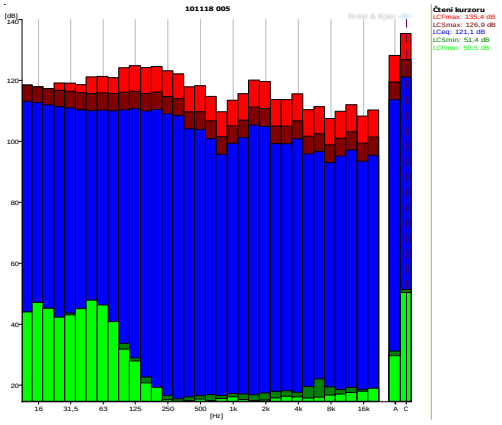

Fig. 11 1/3 octave frequency analysis at single shot with blank ammo without using attachment

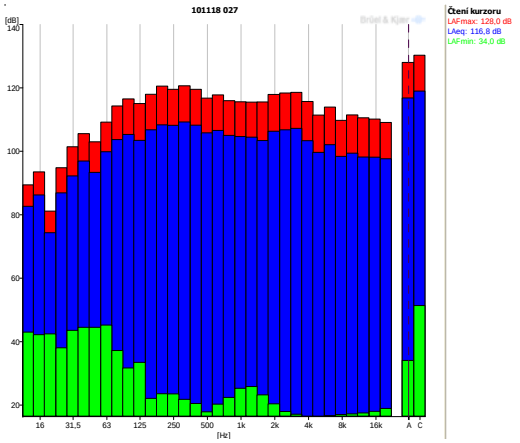

Fig. 12 1/3 octave frequency analysis at burst with 10 shots blank ammo

4 CONCLUSIONS

In armed forces it is also important to pay attention to the individual´s health. A certain capital is invested into their training. This capital would be just a waste when loosing the individuals or loosing their fighting capacity. That´s why it is neccessary to utilize the components protecting the health of the individuals and to lengthen their ability to stay in military service [5]. The measurements of the noise loading proved the harmfulness of the environment the individuals is put in. That is why it is neccessary to decrease the noise loading in this environment. It is difficult but mainly expensive to interfere in the construction of the vehicles and weapons. One of the possibilities is the application of the headsets from Nacre´s QuietPro+ company which can function for the ear protection as a communication device (Fig. 13 and 14).

PNR – Passive attenuation is effective at reducing medium to higher frequencies;

dANR –Electro-acoustically reduces the noise level within the ear canal. ANR is particularly effective for attenuating low frequency noise that is generally associated with mobility platforms.

Properties in-ear headset are: unrivalled hearing protection; enhanced „bionic“ hearing; full situational awareness; instantaneous high impulse noise protection; in-ear microphone; lightweight and low profile; binaural (split ear) and monaural option; whisper mode. This communication device, thanks to its digital system, is able to analyse the noise in the surrounding and to adjust the ear protection so it will be the most effective. Thanks to its small size and quality technology it is one of the best solutions in ear protection of the individuals.

Fig. 13 Cross-section of human ear setting the in-ear headset within the ear canal [6]

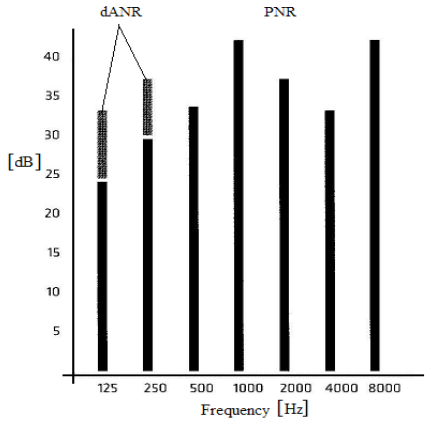

Fig. 14 Column diagram of attenuation and noise by in-ear headset [6]

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OPERATIONAL RELIABILITY DETECTION OF SELECTED MOBILE TECHNOLOGY

Mikuláš MONOŠI, Ladislav JÁNOŠÍK, Martin PIKA

Abstract: The paper explains evaluation method of operation and maintenance of firefighting equipment CAS (car fire-engine) on the chassis of the Mercedes-Benz Atego with fire trucks from the company THT Ltd. Policka in use at Fire Rescue Station in the Moravian-Silesian Region. Probability of failure and failure rate of the vehicle is estimated with using data from the operation and maintenance (failures). Recommendations for improving the data collection concerning the operation and maintenance of vehicles are expressed in the conclusion of the paper**.**

Keywords: Reliability in operation. Technique operation. Service of technique. Failure probability. Failure rate.

1 INTRODUCTION

The paper reassumes to forgoing evaluation of operation and maintenance of firefighting equipment constructed on the chassis Dennis Rapier [1], which are in use at Fire Rescue Service of Moravan Silesian region. Results of monitoring firefighting equipment CAS (car fire-engine) constructed on the chassis of the Mercedes-Benz Atego with fire trucks from the company THT, Ltd. Policka, which are in use at Fire Rescue Station in the Moravian-Silesian Region, are collected in the paper. The Moravian-Silesian Region is divided into 6 Regional departments. Firefighting equipment constructed on the chassis of the Mercedes-Benz Atego is deployed only at 3 of them. There are 22 Fire Rescue Stations in the Moravian-Silesian Region. Monitored equipment is located at 9 of them.

2 MONITORED MOBILE FIREFIGTING EQUIPMENT

Six firefighting vehicles constructed on the chassis of the Mercedes-Benz Atego were chosen for the operation and maintenance monitoring. The list of chosen cars is noted in the Table 1. Five cars produced after the 2007 were not included into the processing, because they are lighter type 1426 AF.

3 RATE OF VEHICLE EXITS

For the emphasizing of vehicle occupancy there are quantity of vehicle exits at Fire Stations of Moravian Silesian Region during years from 2006 to 2010 listed in the Table 2 [2].

First part of monitoring refers to the distance in kilometers and number of running hours at chosen vehicles. Results of monitoring are summarized in Table 3 and Table 4. We met a different level of data saving and processing in drive records and reports of firefighting vehicles work at various fire stations. Data are estimated ex post instead of exact logging. This causes to the biased average fuel consumption. The way how to fill in records for each firefighting vehicle at Czech Fire Rescue Service is described in Attachment 9 in accordance with [7]. Driving record and vehicle report are the main part of basic documentation. These reports can be replaced by other reports with comparable content or adequate software. It was WINBASE from January 2006, which was substituted with new software ISV 5.0, IKIS [11] in October 2009.

Table 1 List of chosen car fire-engines

Station	Type	Licence number	Year of construction
Opava	M-B Atego 1528 F 4x2	2T2 5621	2004
Hlučín	M-B Atego 1528 F 4x2	2T2 6138	2006
Nový Jičín	M-B Atego 1528 F 4x2	2T2 5881	2005
Bílovec	M-B Atego 1528 F 4x4	1T3 7634	2003
Karviná	M-B Atego 1528 F 4x2	1T3 8098	2004
Havířov	M-B Atego 1528 F 4x2	1T3 8099	2004

Table 2 Number of vehicle exits at fire stations

Year	Opava	Hlučín	Nový Jičín	Bílovec	Karviná	Havířov
2006	905	227	406	198	766	843
2007	1 146	318	512	275	900	947
2008	1 194	305	510	263	794	868
2009	1 074	289	626	237	760	760
2010	840	239	723	326	841	763

Table 3 Mileage of mobile firefighting vehicles

Fire station	Opava	Hlučín	Nový Jičín	Bílovec	Karviná	Havířov
Year	[km]					
2005	8 376	0	8 765	8 620	6025	6 097
2006	7 130	1 820	7 566	7 632	4625	6 802
2007	8 517	3 523	8 683	8 559	5870	8 872
2008	7 568	3 785	7 742	7 747	4 418	7 765
2009	7 488	3 741	6 563	5 730	3 324	4 450
2010	4 231	3 801	7 529	7 898	3 716	6 746
In sum	43 487	16 630	46 848	46 186	27 978	40 732
Average per year	7 248	2 772	7 808	7 698	4 663	6 789

Table 4 Number of running hours of firefighting trucks

Fire station	Opava	Hlučín	Nový Jičín	Bílovec	Karviná	Havířov
Year	[Number of running hours]					
2005	75	0	0	0	195	202
2006	68	3	0	0	150	169
2007	66	29	0	0	191	199
2008	73	32	0	0	206	208
2009	58	37	0	0	115	117
2010	99	24	110	192	73	38
In sum	429	123	110	192	929	933
Average per year	72	20	18	32	155	156

4 FAILURE RATE

Data collection was the object of monitoring repairs of chosen firefighting vehicles after failure. The aim was to evaluate particular vehicle rate of failure. Fig. 1 describes trends of repair numbers. Recognized final numbers of failure are more interestingly projected into operation costs of chosen vehicles. Annual costs of repairs after failure are described in the Table 5. Costs of repairs after traffic accidents are shown separately. Final calculated average annual costs are purged from these extreme expenditures. The highest numbers of failures are achieved at fire stations Opava (2T2 56-21) and Hlucin (2T2 61-38). The highest costs of repairs are detected at vehicles from fire stations Bilovec (1T3 76-34) and Havirov (1T3 80-99). High costs are caused by repair after traffic accidents. Annual costs purged from these extreme spendings are described in the Fig. 2, where can be seen an anomaly connected with the oldest fire vehicle from the fire station Bilovec.

As the original collected files of data are very huge, it is impossible to show detailed data processing. Substantial part of them is published in [3].

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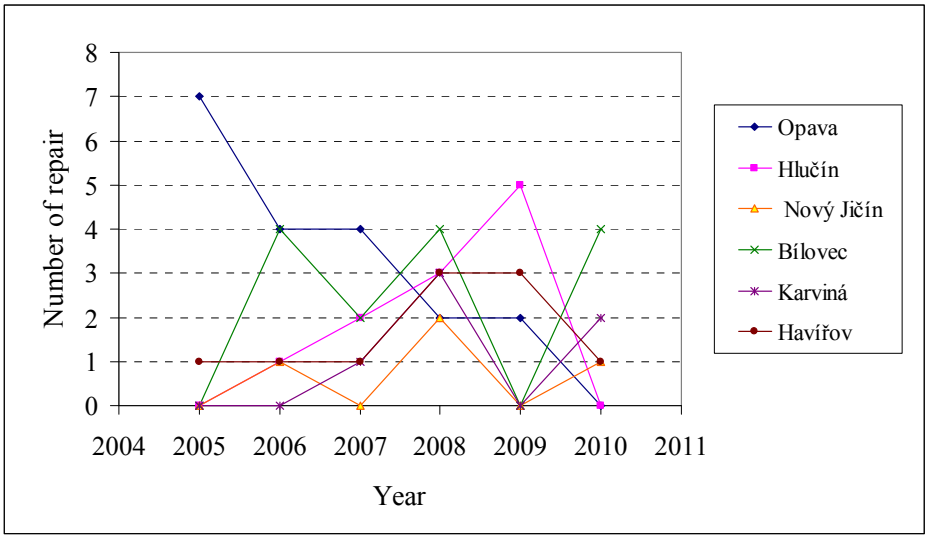

Fig. 1 Trends of repair numbers at selected firefighting vehicles

Table 5 Repair costs of chosen fire trucks

Fire station	Opava	Hlučín	Nový Jičín	Bílovec	Karviná	Havířov
Year	[CZK]					
2005	2 550	0	0	0	0	1 004
2006	1 742	2 500	2 486	72 000	0	450
2007	665	1 660	0	75 567	1 707	35
2008	1 616	2 600	25 000	60 000	9 390	11 671
2009	18 850	21 850	0	0	0	94 427
2010	0	0	500	7 500	1 200	6 000
total	25 423	28 610	27 986	215 067	12 297	113 587
- of this traffic accidents	0	0	0	99 250	0	92 000
Average per year:	4 237	4 768	4 664	19 303	2 050	3 598

5 RELIABILITY

Service reliability of fire vehicles is generally characterized as an ability of the vehicle to fulfill required functions [4]. This general concept can be quantified with such indicators as reliability, maintainability, and ability to assure the repair. Reliability is the ability to perform required functions permanently for the given period and under given conditions.

5.1 Probability of failure

The probability of failure occurrence in next 10 years was calculated from acquired data failures for selected vehicle. Data were elaborated at the Statgraphics software [5].

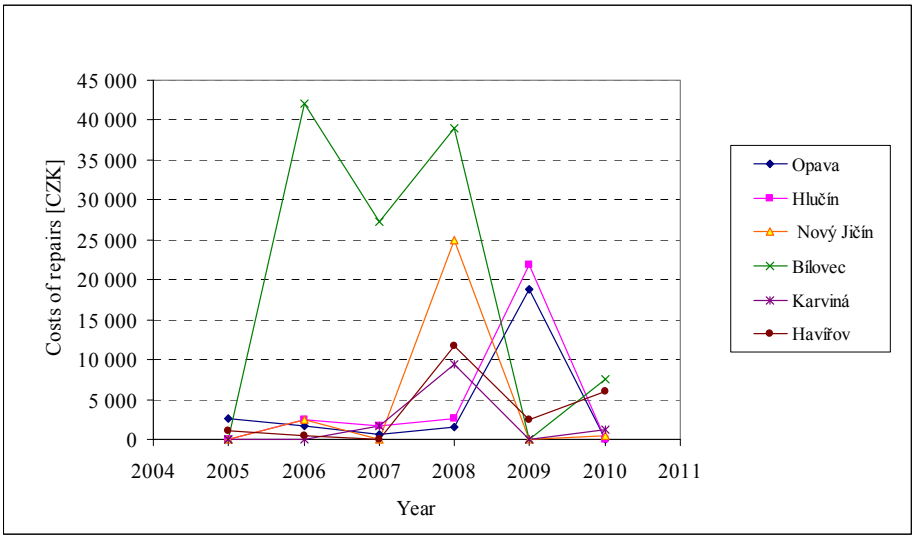

Fig. 2 Costs of repairs after failure

Processing of enter data about fire vehicles located at fire stations Opava (2T2 56-21), Hlucin (2T2 61-38) a Havirov (1T3 80-99) resulted to the finding, that the time to failure X is described with two-parametric Weibull distribution [6]. This hypothesis was tested by Chi-square conformity test

This test was set into the software at the data entering. Next there were values of shape parameter β (characterizes conditions of vehicles using) and scale parameter η (characterizes lifetime of the vehicle) calculated. Results of calculations are shown in the Table 6.

Table 6 Calculated values of Weibull distribution parametres

Fire station	Opava	Hlučín	Havířov
β – shape parameter	3,67643	3,1993	1,69919
η – scale parameter	5,99376	3,63592	2,26187

Density of probability $f(t)$ in the time t according to Weibull distribution is defined with the equation (1). If the random variable X (which presents reliability) has Weibull distribution, than $X \rightarrow W(\eta, \beta)$. Under given conditions $t > 0, \beta > 0, \eta > 0$ the distribution function of the failure probability in time t is calculated according equation (2). Probability values for chosen vehicles are shown in Fig. 3 (in percent).

5.2 Failure intensity

Instantaneous failure rate $\lambda(t)$ in two-parametric Weibull distribution is described with equation (3):

$$f(t) = \beta \frac{t^{\beta-1}}{\eta^{\beta}} \cdot e^{-\left(\frac{t}{\eta}\right)^{\beta}} \tag{1}$$

$$F(t) = 1 - e^{-\left(\frac{t}{\eta}\right)^{\beta}} \tag{2}$$

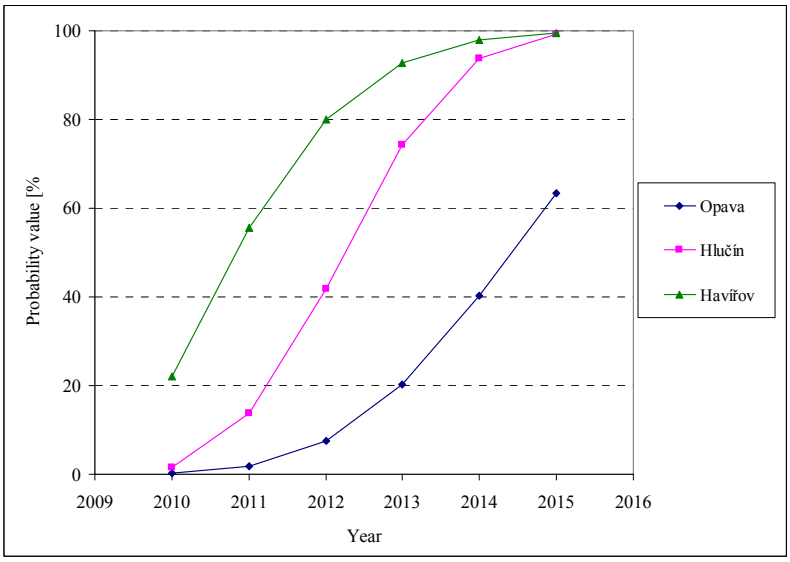

Fig. 3 Values of failure probability for chosen vehicles

$$f(t) = \beta \frac{t^{\beta-1}}{\eta^{\beta}} \cdot e^{-\left(\frac{t}{\eta}\right)^{\beta}} \tag{3}$$

where t is time in which failures are monitored and parameters β and η are taken from previous calculations. Calculated values of failure rate λ for the time t are shown in the Fig. 4. Results can be applied to the recently bought rescue fire truck CAS (car fire-engine) constructed on the chassis of the Mercedes-Benz Atego with fire trucks from the company THT, Ltd. Policka.

6 CONCLUSION

During data collection for the purpose of this paper we realized the similar fact as at monitoring data of fire vehicles firefighting equipment constructed on the chassis Dennis Rapier failure in use at Regional department Ostrava which were published in [9] and [10]. Drive records and reports of firefighting vehicles work at various fire stations do not contain complete data, sometimes data are estimated ex post. This fact can have a negative influence for monitoring and processing data concerned failures of fire trucks. Incomplete failure records come from the fact that some small repairs (replacing of damaged windscreen wiper, broken direction indicator light, cracked light bulb etc.) are solved in the regular controls according [7] right in the fire station. These small repairs are not recorded in the record list or into the particular software. Results of calculations from previous chapters are collected in the Fig. 4. The raise of failure rate can be seen for the 6 year-long operating time of newly bought fire vehicles according to [7]. Since the shape parameter $\beta > 2$, then failure rate $\lambda(t)$ for two of three monitored vehicles is a convex function, therefore the number of failures in time will raise likewise.

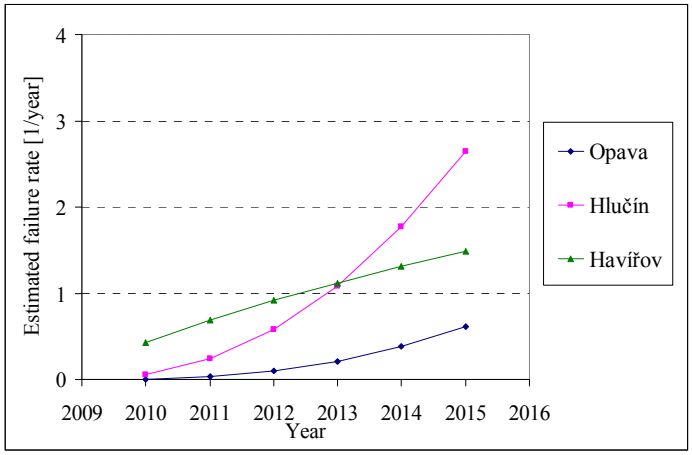

Fig. 4 Estimated failure rate trends of chosen vehicles

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RELIABILITY OF FINDING THE MOST BENEFICIAL ROUTE

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Abstract: When using spatial data and information in decision making is a complex knowledge of the characteristics essential for evaluating the reliability and accuracy of decisions. Using the method of value analysis and mathematical modelling is possible to create a comprehensive system for evaluation of spatial data usability. Based on the input characteristics of the used spatial data and databases, quality characteristics and their changes can be calculated with the help of analytical methods. A comparison of the quality improvement or modification of databases is possible to optimize both the overall usability, and costs incurred on its security.

Keywords: Reliability. Decision making process. Mathematical modelling. Spatial data. GIS. Quality assessment. Utility value.

1 INTRODUCTION

Rather extensive databases of area-localized data utilized in a number of fields are created in the Czech Republic. Data model geographic objects and phenomena of both natural and social character (water courses, settlement structure, atmospheric pressure, etc.). The created and utilized data always encompass a position element, which localizes objects and phenomena in a given reference coordinate system, and a thematic element, which describes qualities of the given objects and phenomena (e.g. the speed of a water course, number of inhabitants in a city). The actual data may then be of both geographic and non-geographic character. The following text therefore uses predominantly the general term "spatial data".

Basic localization database for command and control is created by the Geographic Service of the Army of the Czech Republic. Spatial data, provided by this database, are used not only for basic orientation in space but also as data for solving tasks connected with actual decisions, e.g. geographic impact on combat and non-combat army activities in given environments, in cases of military threats to the state, etc. In a number of tasks the source data are combined and based on mathematically or procedurally described processes, new data are created.

2 QUALITY AND RELIABILITY OF SPATIAL DATA CONCEPT

The produced data are intended for consumption, which means they are to be used in concrete spatial analyses, planning and management. From the user's perspective, systems for data evaluation are also highly important, particularly for their feature of utility value assessment [3]. Technical functionality can be assessed generally without knowing the particular task, methodology or spatial information use. Other quality components, particularly reliability, must be assessed with relation to the given implementation in a given process. The paper [5] lists a definition of characteristics and quality parameters with regard to information on cross-country communication network which draws on ISO 19113 but is adapted to given purposes. According to [3], it is possible to assess the quality of spatial data and information according to the following criteria (see Table 1):

3 FUNCTIONALITY OF DATABASE OF SPATIAL DATA

With regard to the application of value analysis theory, we may assess the utility value as a degree of digital spatial data database functionality ($^\circ F$) which can be expressed by the following aggregate function:

$$^\circ F = p_1 k_1 + p_2 k_2 \tag{1}$$

where variable k_i expresses the main quality criteria and p_i represents the weights of individual criteria. As a rule, the main criteria are expressed as a set of partial criteria which also have their own weights (for more see [3]).

When assessing the utility of used part of a database, the ideal level of quality must be defined at first. This ideal level then works as a comparative etalon for expressing the level of meeting the individual criteria in the given assessed part of spatial database. Upon implementing the comparative etalon, the level of compliance the individual criteria may be assessed and consequently also the total utility value or the degree of user function F. The level of meeting individual criteria can be generally expressed by the following formula:

$$u_s = k_s / k_s^*, \ldots \tag{2}$$

k_s represents the value of compliance the s'th partial criterion, k_s^* is the degree of compliance the s'th partial criterion or criteria of its sub-group under the comparative etalon. The total individual used value of database is given by aggregate function:

$$U^x = {}^\circ F^x = p_1 u_1^x + p_2 u_2^x . \tag{3}$$

Table 1 Criteria of spatial data and information quality

Main criteria	Sub-criteria characteristics	Definition	Quality parameter
Data model content – k_1	Complexity of conceptual landscape model	Concord of conceptual model and user requirements.	Percentage of incomplete information - k_{11}
	Compliance of required resolution of geometric and thematic data – k_{12}	Concord of required geometric and thematic resolution.	Percentage of objects without required level of geometric resolution – k_{121}
			Percentage of objects without required level of thematic resolution–k_{122}
Technical functionality – k_2	Transparency of data sources and methods for secondary data derivation - k_{21}	Transparency of source materials on primary data collection	Level of availability of information about used sources - k_{211}
		Transparency of used methods and model for secondary data derivation	Level of availability of information about used methods – k_{212}
	Position accuracy – k_{22}	Compliance with declared horizontal accuracy	Percentage of objects with unsatisfied conditions of declared horizontal accuracy – k_{221}
		Compliance with declared vertical accuracy	Percentage of objects with unsatisfied conditions of declared vertical accuracy – k_{222}
	Thematical accuracy – k_{23}	Compliance with declared accuracy of thematical data	Percentage of objects with unsatisfied conditions of declared thematical accuracy – k_{23}
	Logical consistency – k_{24}	Degree of adherence of geographic data to the models and schemas (conceptual model, conceptual schema, application schema and data model)	Percentage of objects with topological inconsistence – k_{241}
			Percentage of objects with thematical inconsistence – k_{242}
			with thematical inconsistence – k_{243}
	Data completeness – k_{25}	Degree of adherence of the entirety of geographic data (features, their attributes and relationships) to the entirety of the modelled part of landscape	Percentage of missing objects or objects there are surplus – k_{251}
			Percentage of incomplete thematical properties of objects – k_{252}

3.1 Change in Functionality of Spatial Database

Owing to the fact that spatial databases can never be ideal, it is recommendable to assess the impact of the aggregate function's individual components on changes in the database. In this case we may use derivatives of the U^x *(°F)* function according to individual variables which express the levels of meeting the given criteria. Generally, the impact of changes in compliance the main i^{th} criterion can be expressed in the following way:

$$d^{\circ}F = dU/du_i . \tag{4}$$

However, the degrees of compliance the main criteria are represented by functions of more variables. In order to express the value du_i, it is possible to employ two methods depending on the required information structure. If the *impact of individual variables* on the total individual utility value should be assessed upon an assumption that all other variables are constant, derivations of function U must be expressed in the following way:

$$d^{\circ}F = \frac{dU}{du_i}\frac{du_i}{dx} \tag{5}$$

where x is one of the given variables.

In practice, a situation may arise that a number of factors may be changed at a time, e.g. the technical quality of database is changed in all its parameters – used methods of secondary data inference are improved, localization and attribute accuracy and data complexity are enhanced and simultaneously data are placed in a geo-database accessible to authorized users where all topological, thematic and temporal relations are well treated. In this case it is recommended to express the value of du_i as the total differential of all the variables.

Through mathematical modelling it is then possible to solve tasks of the following types:

- how a change in a given partial parameter or several parameters of a database is reflected in its total usability;
- which parameters need to be changed to achieve the required product functionality;

- which parameters may be "degraded" owing to the fact that the product's functionality is unnecessarily high.

4 MODEL SITUATION - EXAMPLE

Above described procedure was used in the task "Finding the most beneficial route". The main aim of this task was to judge several possible calculated paths for the military vehicle Tatra 815, for more details see [4]. These paths were calculated in the „cost map (CM)" based on the patency parameters for this type of vehicle. In the experiment two versions of cost map were used. Map versions were created based on usable property changes of the database. Particularly, in this case we mean changes in topographic database, soil type database and digital elevation model. In our case the CM was created based on the parameters which evaluated influence of geographical factors for the cross-country movement of vehicles, published in [2]. Values of final pixels in CM were given by aggregate function for calculation of deceleration coefficients (formula 3.2 in [2]). As mentioned before two versions of database were used – before and after update. The option before the update has only a limited number of filled thematic attribute concerning reliability. Only 5 percent of data were known. After update the thematic attribute were filled in 99 %. In the first case the functionality of database was 0,8830, in second case 0,9132.

The ideal state of functional level is 1,0068 (i.e. performance standard). The positive change of database functionality cause higher costs necessary to ensure the data, e.g. the cost and time necessary to fill in the declared attributes. In the decision making process it raise an important question: *Were the resources spent efficiently with respect to the increase reliability of the suggested path?*

Three routes were calculated in the environs of Brno with area of 400 km2. Only the impact of terrain steps like embankments, excavations etc. was evaluated for simplification. The rest of other objects and phenomena were constant. No impact of terrain steps was evaluated in the first case. This route was 30.295 km long and its duration was 24 minutes. In the second case, when only passable steps were considered, the suggested route was 29.414 km, but the duration was 26 minutes. The third route was calculated after database up-dating. Its length was 31.339 km and duration was 25 minutes. Also in this case only passable steps were considered (See Fig. 1).

Theoretically, all routes can be used. If the first case is used, the route is more risky, so the commander assumes the risk that the vehicle cannot be able to overcome the obstacle on the selected road. In the second and third cases the probability of correct decision is high, so the vehicle should not get into trouble with overtaking of obstacles.

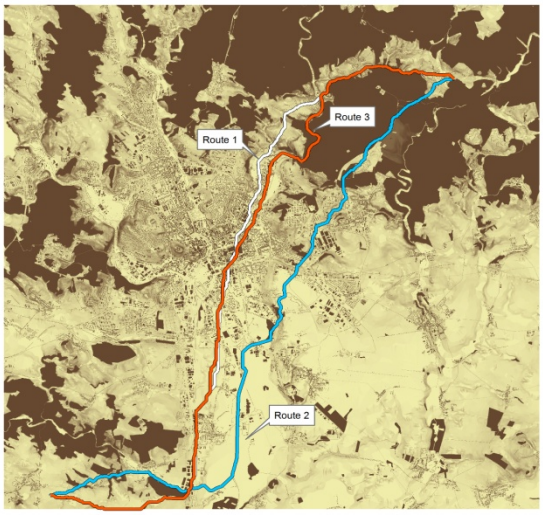

Fig. 1 Search results the most suitable route for the vehicle

This simple example was chosen only for comparing how the database functionally and reliability of decision making process matched together. In the complex evaluation is necessary to evaluate the impact of all terrain features in the area on cross country mobility.

5 CONCLUSION

The proposed solution aims to streamline the activities associated with the use of inhomogeneous data and information systems, command and control so that operational components should be available not only its own database, as well as relevant documentation about the quality and reliability of data used. Based on this information they can in their decisions to work with those documents and where appropriate their decisions correct.

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HOLISTIC ANALYSIS OF THE MILITARY DISTRICT UNITS DISASTER RELIEF EFFORTS

František BARTKO

Abstract: The author of the article focuses attention on preparation process, logistic support and real performance of tasks concerning disaster relief [1]. The article is based on the experience of the 2010 flood relief efforts and it focuses on the tasks performed by the Zvolen military district units. It discusses particularly the issues of crisis communication between local, communal and regional crisis response teams and the military district commander.

Keywords: Emergency. Floods. Readiness. Crisis response team.

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1 INTRODUCTION

This article is aimed at drawing the attention of officers in charge of the military districts and the representatives of the Slovak Armed Forces in local crisis response teams at problems related to handling emergencies and crises in cooperation with local government.

Providing assistance and aid in natural disasters which threaten lives and property of citizens is one of the main tasks of the Slovak Republic Armed Forces embodied in law. The armed forces have recently proved that they are paying sufficient attention to this task and their contribution is highly appreciated by experts as well as by the general public to which help and emergency relief are provided. This positive view is reflected in high credibility the armed forces have. Nevertheless, it will be necessary to analyse practical experience of troops deployment objectively and critically as this will ensure even more effective and adequate utilization of forces and equipment.

Experience shows that deployment of troops aimed at disaster relief or crisis management is becoming a common part of military life. It brings the need for close cooperation between individual military districts and local government bodies as well as all units of the Integrated Emergency System [2]. This communication must be based on the mutual understanding of possibilities and rules regarding deployment of forces and equipment, which follow from laws and individual internal restrictions of a particular unit of the Integrated Emergency System. Making the cooperation between these units more effective is very demanding and the experience from the 2010 flood relief revealed the risks which may have a negative impact not only on successful deployment of troops , but also on the whole crisis solution process. These risks concern mainly the human factor (insufficient readiness of citizens and local government officers in charge), the exchange of information (ability of involved parties to use information systems and convey crisis communication), technical and logistic risks (availability and readiness of necessary technical equipment) as well as competence risks (decision-making problems) [3]. The subsequent analysis of the activities performed by the Zvolen military district units and the assessment of the armed forces deployment performed by the General Staff [4] confirm the existence of these risks.

Higher levels of readiness for individual units of a military district are ordered by a superior level of command or by the commander of a military district; their purpose is to prevent emergencies or provide disaster relief [3].

When individual units work at a certain level of readiness, the military district commander issues an order, which includes also a precise roster containing names of personnel assigned to perform emergency tasks. Most commanders usually organize preparation of personnel and material for potential performance of emergency tasks in advance without an official order issued by a superior officer. These commanders use their own analysis (based on available information on water level, assumption of development for the coming days as well as their own experience of cooperation with local government bodies or units of the Integrated Emergency System in a particular region).

This advance preparation can guarantee readiness of troops for deployment because the experience proves that an official order is nearly always issued at the last moment (when speaking also about Warning order). In such a case, performance of the task in required time and extent would be impossible without previous preparation organized on the commanders' initiative.

Activation of forces and equipment based on the decision made by the commander of a military district is a tool which is rarely used. In this case the commander takes full responsibility for effective engagement of forces and equipment in accordance to laws in force. In this case, he is only bound to notify the higher level of command [3]. Thus, requirements made by mayors as representatives of local governments may be addressed directly to the commander of a military district or through a particular crisis response team (district, county). The way local governments ask a particular military district for help or relief may vary, but it must be clear to all members of crisis response teams. What is more, the representatives of the Armed Forces in these teams should clearly

define how ready a particular military district is to provide relief (personnel, equipment, material, reaction times, and so on). However, the experience shows that there are major problems related to readiness and preparation of local government officers in charge. Mayors generally do not know the possibilities of a military district on the territory of which their villages are situated. Equally, provision and sustaining of communication are at a very low level. Besides this, a lot of towns and villages do not have a direct contact to particular officers in charge who are authorized to provide adequate help.

Despite having a possibility to set a higher level of readiness in a particular unit independently, commanders usually wait for an official order issued by a superior officer (they only do preparation for execution of tasks while waiting for this official order). There might be several reasons for this – for example, insufficient communication between local governments and crisis response teams, unfamiliarity with or unwillingness to use a particular tool, and so on. It practically results in the fact that military units are engaged late and/or in places where they are not used efficiently due to lack of technical equipment.

Low effectiveness of the procedure used on a regular basis can be best seen on the last real deployment of Zvolen military district units to areas struck by floods (in this case the area to the north of the town of Fiľakovo).

The crisis response team which was operating in this area officially asked the Armed Forces for help only when it was clear that the local (non-military) forces and equipment were not sufficient and able to handle the situation. After sending this official request, it took more than three hours for the first unit to come to the area (in this case it was the shortest possible time). What is more, deployment of this unit in response to the floods in the area with such a delay was more or less formal. At that time the houses had already been flooded and the swollen river did not actually make any effective actions possible. Besides this, raising of the embankment was no longer effective. Nevertheless, the soldiers worked more than 180 working hours (3 hours, 30 personnel, two shifts). When it got dark, the embankment reinforcement works were stopped for safety reasons – at that time only a certain part of the embankment had been raised; as a result, water continued flooding the residential area. Since the works had not been finished, the artificial embankment collapsed at night and a new embankment had to be built again the next day. The situation was even more complicated due to the fact that the remains of the first embankment hindered laying of new sandbags. Moreover, the river's waters had started to recede, so another works were, in fact, useless.

This particular case points to ineffective deployment of personnel and equipment. What is more, this deployment in the flooded area blocked almost all available personnel and equipment of the military district. Due to legal limits (maximum duration of working time, compulsory rest period and so on [6]), the troops could be deployed again only the next day. Until then, the whole military district had only one deployable shift available in case of deployment in another area.

When the level of readiness is raised due to emergency, certain preliminary measures are taken in every military district. This means that commanders prepare personnel, material and equipment for potential deployment. What is more, the time standard is specified (it may differ according to a particular emergency, but usually it is 60 minutes after the order is issued). This means that outside normal working hours the personnel must be ready at their working place. However, it is not possible to keep the personnel at this state of readiness for a long time (legal limits, higher financial expenses and so on).

After the order that the unit should deploy to a particular area is issued, commanders control and manage activities of the unit under the command of the operation commander [3]. The experience shows that this activity is complicated by shortcomings following from the crisis communication – commanders do not have full information about the place they are to deploy or the tasks they should perform. This information "gets lost" as it passes through different levels of command. In fact, commanders are rarely directly in contact with the bodies which asked for disaster relief (mayors and so on). They get familiar with their tasks and duties only after they come to a disaster area.

This lack of information often results in situations when units do not have necessary equipment or have equipment they are not able to use. Besides this, it often happens that the number of personnel do not meet real needs – either this number if insufficient or redundant.

Only after another unit is deployed, the information is passed sufficiently in advance by means of reports; as a result, the commanders and units can be adequately prepared.

As mentioned before, deployment of the armed forces aimed at assisting relief efforts has recently become quite common. Individual military districts have emergency stores of material and equipment and every unit has precise lists of personnel and equipment which can be used to perform particular tasks – numbers of available personnel and resources may vary [3]. Nonetheless, every engagement of a unit means nonstandard load. It means that higher financial and material costs expended on response to emergencies have an impact on everyday peace life (training is usually limited afterwards and so on).

This is also due to the fact that units (MoD in general) cannot make any financial reserve budget for a particular year which could directly cover higher costs expended on disaster relief and response to emergencies. These are particularly costs of personnel (overtime, food, etc) and POL. Since these costs are not planned beforehand (and this happens every year), commanders are forced to use the sources not included in the plan (for example, the unit almost runs out of POL for some vehicles and equipment in the middle of the year). Thus, commanders take a risk that some budget items may be critically low and that they will not be able to perform other tasks. It may happen that a unit runs out of its financial resources for one deployment and it will not be able to deploy any personnel or equipment for another engagement, for example, one month later). Such situations are resolved by extraordinary measures resulting in the rise of the consumption standard; however, it is not certain to what extent financial limits will be increased and whether they will be increased at all. In this aspect, every deployment of units aimed at handling emergencies is hardly foreseeable in terms of money and equipment.

2 CONCLUSION

Following the above-mentioned practical experience of units concerning disaster relief efforts it can be said that the risks mentioned in the introduction are real and that it is necessary to eliminate them. This, however, requires higher effectiveness and directness as far as engagement of personnel and equipment of the Armed Forces is concerned as well as better communication between military units and particular regional government bodies. The representative of the Armed Forces in the regional crisis response team should be responsible for this task. He or she should ensure sufficient communication between all relevant subjects, including the local government bodies. This can help deploy units on time (the best alternative is deployment in advance). What is more, this would help prevent damage and not just eliminate disaster consequences – for example, it would be much better to raise embankments or evacuate people from disaster zones before the emergency situation culminates. All this is possible only under condition that commanders are informed in time and that they are able and willing to take certain measures independently and through their own initiative.

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CRISIS SITUATIONS THE MUNICIPAL TEAM MANAGEMENT APPROACH CRISIS – OVERVIEW OF THE PROBLEM

Antoni KRAUZ, Antoni OLAK

Abstract: It the short profile of problems of threat present world in put article was executed was in formulation of critical situation called out with the man's activity and the working the strengths of nature. It the different forms of threats were exchanged was on what present can be subject man. Management was have self - characterized critical according to different authors in this in legal formulation. It the principle was introduced was and the requirements of present of critical management. It the structure, task was has talked over was as well as the functioning the Communal Centre and the Team of Critical Management. It the form was described was and the character of work of team to critical matters on rung the populaces.

Keywords: Critical situation. Critical management. Communal centre critical management. Team critical management.

1 INTRODUCTION

The important factor of present time of development informative society, the impulsive defeats the social revolutions are growing. The government and the society with regard on more and more larger threats the flood, cataclysms, catastrophes the critical situations, reacting, be forced to building the specialist structures, links to planning and the removing in legal formulation the results of impulsive defeats. The problems of prevention the of the crisis, his limitation as well as it becomes the counteraction the contemporarily more and more important link in life of societies in global scale. From here important in become the preparation of society to counteraction and the limitation of results of impulsive defeats. Created in frames of administration of government structure the and link to management in time of room, the critical situations and the wars assure the functioning during threats the public administration, they assure functioning and the possibility of reproducing the infrastructure or restoration of her primitive character; they husband with strengths rationally and centres in critical situations. The men of conditions of survival in critical situations be prepared to assurance, across the working out the procedures of conduct in case the threats; preparing the *Plans of critical reacting*.

2 CATASTROPHE, BREAKDOWNS, CRITICAL SITUATIONS CAUSED IMPULSIVE DEFEATS THE WORKING THE STRENGTHS OF NATURE AND THE MAN'S ACTIVITY

The developing world, civilization of technique of, electronics, computer science, at present initiated nano of technique for man except guild positive, it brings in also sure threats, np. the cyber the terrorism. Next this caused the development of technique, robbery economy with the man's, negative activity supplies dirt of environment then the threat which cause it shaking the equilibrium in global system of nature, np. the change of climate. They in majority of threat rise the of element, violent, mass, unpredictable, character they are the cause of rise of catastrophes, breakdown - impulsive defeats. It was can divide on two groups of causes the rise of threats: caused the working the strengths of nature and the man's activity.

To connected with man's activity threats which they can cause can classify dangerous results:

1. Catastrophe:[1] communication (railway, road, air, sea); in mines (crump of, covering up, the explosion of gas the, fires, of flood); Water technical objects; in accumulating dangerous substances institutions; building.
2. Failures:[2] nuclear power plants, industrial plants, (machinery and equipment) in the network of municipal economy, in apartments, private houses.
3. The poisoning and the dirt of rivers and the land waters.
4. Duds, duds.
5. Spreading Protects Mass Dazzling (BMR).
6. Contamination Toxic Industrial Centres (TŚP), radioactive: the alive organisms of, food, of atmosphere, soil and the water.

[1] Natural catastrophe, seismic shocks, be understood, as connected from working the strengths of nature event, in peculiarity of static strong winds,, long-lasting intensive precipitations the occurrence the extreme temperatures, landslide of the ground, fires, droughts, reason, ice phenomena also on rivers and sea as well as lakes and water reservoirs, mass occurrence plants', diseases pests or animals or infectious men's diseases or working different element also.

[2] The technical Breakdown, she be defined as violent, unforeseen damage or the destruction the building object, technical device or the system of technical devices causing pause in their using or loss of their propriety, art. 3 law with day 18.04.2002 the r. *about state of impulsive defeat*. (Dz. U. No. 62 with day 22.05.2002 r. poz. 558, from after change.).

7. The Acts of terror: the terrorism, biological terrorism, on large scale terrorism, nano terrorism, different, np. of the men's kidnapping for ransom.
8. Cross border migrations, refugee and repatriates.
9. Different: illegal develop and the trade of drugs, international crime, trade the men - the slavery; conflicts and inflammable points on world; civilization diseases.

Forecasts impulsive defeats which can the working the strengths of nature be caused they are following:

1. The Quake of the ground: tectonically, dips, volcanic.
2. The Landslide of the ground.
3. Winds: stormy, hurricanes,, scolding hailstorm aerial horns.
4. Biological: mass occurrence pests.
5. Epidemics leave: plants' disease or infectious men's, disease animals np. bird's influenza.
6. Droughts.
7. Strong frosts with snow-storms.
8. Falls: rain, hail, snow, it will sweep.

3 CRITICAL MANAGEMENT THE REVIEW OF PROBLEMS

End XX and the beginning XXI age characterizes enlarged with intensification the critical situations caused with the man's activity and the strengths of nature. The growing phenomena generate the need of creation and the preparation of definite organs and the structures of human clever teams to working in critical situations with power of right. It requires then the study of definite procedures and the principles of control as well as the management in critical situations. By one should to understand the process of planning the, organization, of leadership and the controlling the work of members of organization as well as using the every accessible supplies of organization to achieving her aims[3]. *He control* marks the influence at organization from utilization of settled rules (the procedures) on her modules (the elements), also for achievement of intentional aim from this that it can accept it form:

- *managing* where right is the source of power to influence at organization, they are formal competences directing acquired together with with choice, delimitation or appointment to administrator's part,
- the *management*, when the right is the source of power to administering the supplies about special meaning for functioning the organization and fate of her elements,
- *leadership,* when moral authority is the source of managerial power and intellectual managerial organ.[4]

It to main principles and was one should number the requirements of present of critical management:

- the principle of primacy of territorial arrangement the horizontal competences - territorial, not perpendicular departmental,
- the principle of one-man management and the responsibility the one-man decisions, (not collective),
- the principle of generality the duties for all citizens together with packet of duty and the services,
- the principle of adequacy the reacting on the lowest level, in proportion to patent medicines and the kind of threat.

The management in critical situations, then systematic the and methodical undertaking aiming to prevention the or reduction of influence of crisis (the critical situation) on supplies and the social values for help of centres the control and the control as well as the coordination[5]. The relating hands of correct management in critical situations, realizing of definite procedures of critical reacting, team of undertakings - are following:

- crises are inevitable, it therefore was one should be always prepared on the worst, it
- was one should work out the plan of reacting and management in critical situations, you which should verify it in road monitoringu, trainings (practices) and practical costs,
- it was not one should was undergo panic, you in every situation to estimate on different ways situation should and variants,
- to prevent escalation always and spreading critical situation,
- was one should take over the initiative, not waiting on instructions from mountain, from respect of valid right,
- it in every critical situation establishes the rank of problems, it uses varied chances, it liquidates weakness,
- we look for allies, we exert oneself about social acceptance our decisions,
- we use every accessible strengths and centres we deal with only "crisis",
- we after capture of critical situation analyses her cause and we restore our working we, verify

[3] STONER, J. A. F.: *Management.* Warsaw : 1998. p. 20.

[4] KRZYŻANOWSKI, L.: *The basis of organizations and management.* Warsaw : PWN, 1994.p. 207.

[5] KONIECZNY, J.: *Management in the crisis situations, accidents and natural disasters.* Poznań, Warsaw : 2001.

- plans, normal state and we prevent the repetition the size of defeat (tragedy).[6]

4 STRUCTURE, TASK AND THE FUNCTIONING THE COMMUNAL TEAM OF CRITICAL MANAGEMENT

In situation of different threats of present unpredictable world the present *critical management* be understood as of organs of public administration being the element of control with national safety activity, which depends on prevention the critical situations, preparation to taking over them the control in road planned the workings the reacting in case of pronouncement of critical situations as well as on reproduction the infrastructure or restoration her primitive character. It in turn by *critical* situation*, was* one should understand the phenomenon being with after-effect of threat and leading in consequence to break or considerable infringement near simultaneous serious disturbance social fetters in functioning public institutions, however in such degree, that used indispensable centres to assurance or the restorations of safety do not motivate with extraordinary states introduction no about which speech in art. 228 mouths, 1 Constitution of Polish Republic.[7]

The village mayor is in matters the proper organ the critical management on terrain of commune, (the mayor, and president of city). Populaces relating at commune critical matters tasks be realized near help of organizational cell of office (city) proper in matters critical management. The village mayor's auxiliary organ, (the mayor, president of city) the Communal Team of Critical Management is in assurance executing the tasks of critical management (the GZZK) appointed by village mayor, (the mayor, president of city), which his composition defines the organization, seat as well as the mode of work, (rys. 1). Also in aim of realization of above mentioned tasks the village mayor, (the mayor, president of city) it can create Communal (Municipal) the Centre of Critical Management (the GCZK), (rys. 1).

In composition GZZK which directs with works the village mayor, (the mayor, and president of city), the persons come in qualified from among:

- workers' persons at office populaces, communal organizational individuals or auxiliary individuals,
- the workers of joint services, inspection and, directed by superiors to executing in this team the tasks on the village mayor's conclusion, guards of mayor, president of city,
- the representatives of social rescue organizations, different invited by village mayor persons in composition of communal team can come in, (the mayor, president of city).[8]

In composition of *Communal Team the Critical Management* (the GZZK) the following persons come in and five the working groups[9], (Fig.1):

- The boss of team (1), the deputy of boss of team (2),
- Two working groups about solid character:
  - the group of civil planning (3),
  - the group of monitoring, prognoses and the analyses (4).
- Three working groups about temporary character:
  - the group of operation and the organization of workings (5),
  - the group of logistic protection (6),
  - the group of wholesome care and the help the social- ital (7).

They two working groups about solid character make up the *Communal Centre of Critical Management* (GCZK), populaces are the organizational cell of office. Seat GCZK should be marked suitably, and his passed to public message in enabling way location informing all occupants' populaces.

The boss of communal team and the village mayor marks from among workers his deputy at office the populaces, communal organizational individuals or in auxiliary individuals, the possessing in range of life-saving the specialist education persons, the fire - fighting protection, engineering of civil safety or the critical management, graduates of higher military schools, and also from among officers of fire - fighting, appointed to executing beyond organizational individuals of State Fire Guard the tasks. Working solid groups and temporary it creates from among workers' persons at office populaces, communal organizational individuals or auxiliary individuals.

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[6] Based on the book „Generic Crisis Management Handbook (GCMH)" (w:) E. Jendraszczak, W. Kozłowski, *Management in the crisis situations,* based on the book „GCMH" published with The Council on Operation and Committee of NATO training (17.05.1997 r.) – on the rights of typescript, MON - DSO, Warsaw 1997., p. 9.

[7] Art. 2 The Act from 26th April, 2007 *about management in crises* (Journal of Acts. no 89 from 21st May, 2007, position 590 with further changes).

[8] Ibidem, art. 19 Act 6, 7.

[9] § 3 The Cabinet Disposition from 3rd December, 2002. *concerning creating the Municipal Council of Crisis Management, District and Provincial Council of Crisis Management, State Council of Crisis Management and their functioning.*(Journal of Acts. no 215, from 17th December, 2002, position 1818, with further changes). Art. 32 The Act from 26th April, 2007 *about management in crises* (Journal of Acts. no 89 from 21st May, 2007, position 590 with further changes).

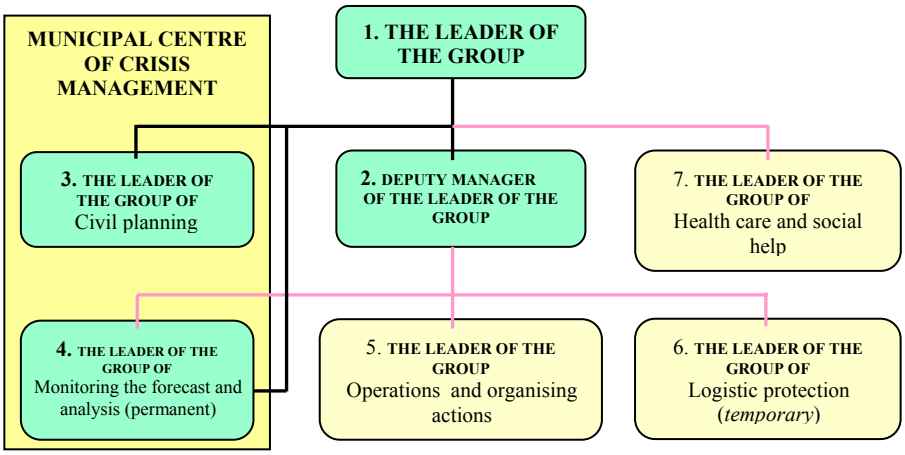

Fig. 1 Organizational Patern and functional the Communal Centre and the Team of Critical Management

The source: My own study: § 3 The Cabinet Disposition from 3rd December, 2002. *concerning creating the Municipal Council of Crisis Management, District and Provincial Council of Crisis Management, State Council of Crisis Management and their functioning.*(Journal of Acts. no 215, from 17th December, 2002, position 1818, with further changes). Art. 32 The Act from 26th April, 2007 *about management in crises* (Journal of Acts no 89 from 21st May, 2007 , position 590 with further changes).

The experts in composition of groups about temporary character can come in also the, experts, of person of social confidence, and also the representatives of organs of public administration or the social rescue organizations[10].

Commune team, it acts on basis of *Plan of work* confirmed by village mayor. The boss of team directs with works of team (rys. 1), to which one should in peculiarity:

- the preparation of year - old plan of work team,
- the study of regulations of current works team as well as the workings in situations of threats the natural catastrophe or the technical carrying the birth-marks of impulsive defeat breakdown,
- the establishing the object and deadline of sessions, notifying about deadlines of sessions,
- the chairmanship the sessions, initiating and the organization the works of team, it
- inviting on the persons' session not being the members of team.

His boss assembles on village mayor's recommendation the session of team, however more not seldom than once on quarter, and also in dependence from needs. In exacting the immediate analysis cases and the opinion of threats as well as the co-ordination of rescue workings, the boss can give dispositions the session of team in immediate mode. Boss directs with sessions of team, and **during** his absence boss' deputy. In case appearing making impossible circumstances holding by deputy duties, boss can mark from among members of team fulfilling the deputy's duties person.

Service - office assures team populaces (city). The working groups about solid character (rys. 1) work peaceably from the schedule of time of work valid at office at which be situated, with assurance of 24 hour duties. In time being in force the state of impulsive defeat the team works in composition of working groups about solid character and temporary, at office at which be situated, in continuous mode, with assurance of shift the persons' work entering in their composition. The documents of workings and they are the work of team:

- Communal plan critical reacting, which peaceably with law with day 26.04.2007 about management critical r. (Dz.U. No. 89 with day 21.05.2007 r. poz. 590 from with changes) it contains between different:
  - *main* including *plan*: the profile of threats, opinion of risk their the pronouncement of, map of risk of flood threat, the profile of strengths and the centres opinion of possibility of their utilization, variants of workings in critical situations,
  - the of *critical reacting* defining in case the team of undertakings the critical situations *procedures*, in time of extraordinary states and in time of war the, principle of co-operation,
  - *functional enclosures*: the main plan the defining standard operating procedures, organization of contact, system of monitoring the threats, warning and the alarming, ways of conduct in case the threats, organization of evacuation from menaced areas.

[10] Ibidem.

- Year - old the plans of work, plan of practices, current reports and periodical,
- Minutes of sessions of working groups about solid character and temporary,
- The card of events of, in case starting the working groups about temporary character, reports of reconstruction, different indispensable documents.[11]

The Duty of undertaking of workings in range critical management rests on this proper organ in matters management critical, which first received information about pronouncement threat. Organ this informs about event organs suitably higher and lower rung, representing simultaneously his opinion of situation immediately as well as information about intentional workings.

5 FORM AND THE CHARACTER OF WORK OF TEAM TO CRITICAL MATTERS ON RUNG THE POPULACES

In aim the to prevent the results of impulsive defeat, critical situation or their the removal the team to critical matters on rung of Office of Commune works in phaze the prevention of, preparation, of reacting and the reconstruction[12]:

1. In phase **prevention** team undertakes working, which they reduce or they eliminate the probability of pronouncement on terrain the populaces of impulsive defeat, situation critical or her results in considerable degree limit.
2. In phase of preparation the team undertakes the of planning relating the ways of reacting on time of pronouncement in populace of impulsive defeat working, the critical situation and also the having on aim working the increase the supplies of strengths and the indispensable centres to effective reacting.
3. In phase reacting the team undertakes the depending on delivering the help the injured, set - back of development working the stepping out threats as well as the limitation of losses and the destructions.
4. In phase of reconstruction the team undertakes the having on aim working the restoration on terrain the populaces of ability of reacting, reconstruction of stores of rescue services as well as reproducing key for functioning the you of telecommunication infrastructure, energetistic, fuel, forwarding the and delivery of water.

Working definite pkt. 1), 2) they are in populace realized by two working groups about solid character, however definite in pkt working. 3), 4) they be realized by team in full composition (rys. 1). Village mayor administers what in year practice realized by team in full composition, defining their aim, main tasks the least once and course. Technical conditions to work of team should assure following rooms:

- For on the duty service of team, for team to operating work and the practices,
- Social subsidiaries, sanitary and technical.

The standard equipment of team situated in/the it should be finished with day 17 rooms.12.2005 r. and to make up: [13]

- The position of work for village mayor,
- The flexible position as well as the auxiliary positions for on the duty service in indispensable number to realization of tasks peaceably with standard:
  - the operating standardmaps and the digital the as well as specialist software prognoses of planning, and also the records and the procedure suitably for populaces,
  - the device of line contact and wireless with considered in plan subjects critical reacting assuring their alarming, administering and the cooperation, and the also assuring passing on the information directing the workings in aim the to prevent the results of impulsive defeat, critical situation or their removal,
  - the specialist gear and the software of system the, assuring possibilities of multimedia introduction of data,
  - the system the compatible computer tele with functioning in every of remaining teams systems,
  - the system of starting of warning and the alarming the population,
  - the emergency plans of evacuation as well as the functioning in supplementary places the proper team the, emergency the power supply the final devices,
  - the system of registration of content radio conversations and telephone as well as their filing.

The technical Conditions and the standards of equipment of communal team, and in peculiarity the technical infrastructure and the equipment they, should make possible effective the filling the tasks of team, with behaviour of continuity the working and the exchange of information during work as well

[11] § 7, § 8, § 9, The Cabinet Disposition from 3rd December, 2002. *concerning creating the Municipal Council of Crisis Management, District and Provincial Council of Crisis Management, State Council of Crisis Management and their functioning.*(Journal of Acts. no 215, from 17th December, 2002, position 1818, with further changes).

[12] Ibidem, § 10.

[13] Ibidem § 13, § 18.

as the possibility of work in case of lack the external the power supply, pronouncement of breakdown or the damage of systems of contact.

6 CONCLUSION

Near present the threats what can call out the man or the nature very important the preparation of society becomes to counteraction the impulsive defeats across preparation of definite structures of teams to limitation of results of critical situations on every level of administration. The commune is on the lowest rung of administration the basic link in structures of administrative district. Started by village mayor with power of right in first phase formation of critical situation the Communal Centre of Critical Management fulfils near realization of critical tasks the requirement in populace. During impulsive defeat czy the growth of critical situation the village mayor of commune possesses the possibility and appoints the Communal Team of the Critical Management which realizes all critical tasks. The preparation of team the character and the form of work then the agreement on working in four phase in conditions of room, the crisis and the war.

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THE EVALUATION OF AIR QUALITY IN MILITARY VEHICLES

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Abstract: The optimization of environment inside of military vehicles, make it possible long- time activity in the comfortable climatic conditions. The mathematic model which was proposed, make it possible to observe the air contamination in the vehicle in consequence of carbon oxide increase, whose source is a respiration of persons.

Keywords: Microclimate of vehicle. Air contamination. Air quality simulation. Carbon dioxide.

1 INTRODUCTION

The microclimate inside of vehicle is determined by the humidity/temperature conditions and the air quality (purity). The majority of modern vehicles are equipped with powerful air-conditioning system, which ensures ventilation, heating and cooling. Generally, we can claim that problems of the humidity/temperature conditions within the modern vehicles are resolved and the current research work is focused on the optimization of the air-conditioning systems.

The air in the vehicle (Fig. 1) may be contaminated by pollutants that come from the surroundings (e.g. exhalations from burning fossil fuels), but also as components generated within the vehicle by the crew (e.g. respiration, machine-gun fire, gunnery, field firing) or as pollutants which may be released from the cabin interior material (e.g. phthalates, formaldehyde, etc.) [1].

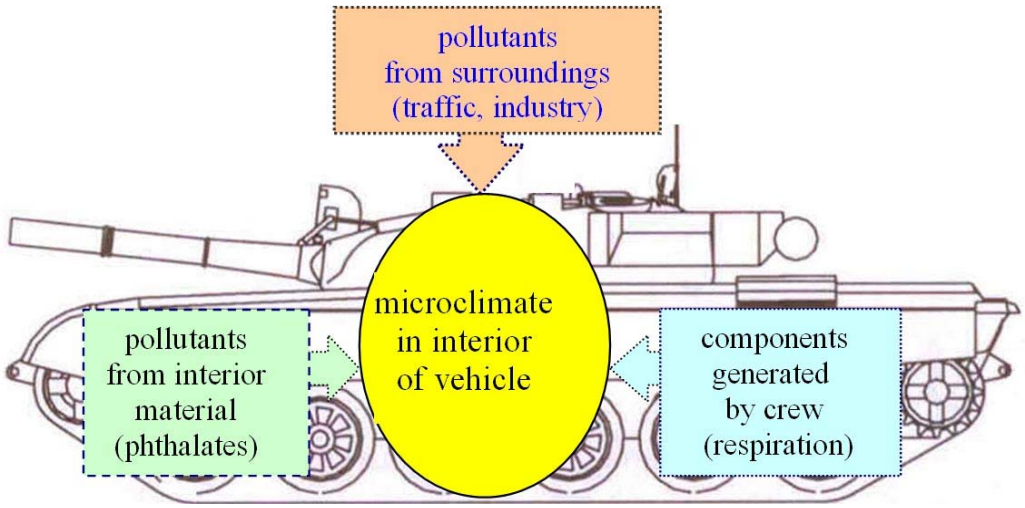

Fig. 1 Schematic of external and internal contaminations of cabin air

The quality of microclimate in the vehicle interior may be significantly affected by pollutants released from the cabin interior material (e.g. phthalates, formaldehyde, and others). The study by American scientists from the University of Texas at Austin, published in 2000, outlines that the measured value of the volatile organic compounds reached 7500 micrograms per m^3 on the first day of one new vehicle sampling. The researchers identified over 60 chemicals within the interior of four vehicles [4]. A two-year study describes a number of health problems arising from the effect of volatile substances released from the interior of new vehicles. There were reported cases of disorientation, headache, and irritation in some drivers of new vehicles. The main substances found in the new vehicle interiors are: carcinogen benzene, two other potential carcinogens cyclohexanone and styrene, and several other toxic substances.

The research that was carried out at the University of Defence in Brno in cooperation with the Mendel University of Brno in 2009 approved that the materials of steering wheel covers, lubricants, and service fluids (oils, greases, cool and brake fluids) contain highly toxic phthalate acid esters (PAEs) [1]. PAEs represent a risk to human health, since exposure can occur through inhalation, oral ingestion or dermal absorption [5].

The level of ambient air pollution is caused by emissions from different sources due to human activities (e.g. traffic, combustion, industrial production, and others). Pollutants emitted from the source are distributed in the atmosphere and may influence the air quality both nearby the source and

in remote areas. There are a number of legal standards for monitoring, evaluating and controlling the air quality. These standards define the maximum permissible levels of air pollution (air pollution limits, target values and long-term emission limits) for the thirteen pollutants, which have proven harmful effects on the human health, ecosystems and vegetation [6], [7].

It appears that relatively little attention has been given to the fact that many drivers spend a considerable time in the enclosed space of the vehicle cabin. During the process of breathing, is inhaled oxygen and exhaled carbon dioxide. Inhaled air contains 0.04 percent carbon dioxide (i.e. 400 ppm CO_2) and air exhaled by an adult contains in average 4 % percent carbon dioxide (i.e. 40 000 ppm CO_2). In other words, exhaled air contains about 100 times the concentration of carbon dioxide that inhaled air does [8].

This problem occurs in the case of military vehicles when the filter-ventilation unit (FVU) is in the mode of hermetic sealing (fresh air is not supplied, the vehicle is hermetically sealed and crew breath is only circulate inside the vehicle cabin).

With this in mind, it would be appropriate to specify a method of the cabin air quality prediction for cases of a sealed container that contains people and a limited supply of air. Such cases may be for example: a vehicle cabin, a submarine or a space ship, for that matter.

2 MATHEMATICAL MODEL OF CO_2 PRODUCTION ASSESMENT

We accept the following assumptions:

- The driver and crew workload is considered moderate.
- The respiratory rate for adult n is from 13 to 18 breaths per minute.
- The breathing capacity C is from 0.4 to 0.5 litres per breath.

From where the quantity of inhaled air is given by

$$V_{air} = n\,C \text{ , it is from 312 to 540 litres per hour and per person.} \quad (1)$$

Considering 4 % percent vol. carbon dioxide contain in the exhaled air, the amount of carbon dioxide produced by breathing is

$$P_{CO_2} = 0.04\,V_{air} \text{ , it is from 11 to 19 litres of } CO_2 \text{ per hour and per person.} \quad (2)$$

The concentration time profile of carbon dioxide in ppm is given by [2]:

$$x(t)_{CO_2} = x(0)_{CO_2} + t\left[\frac{i\,P_{CO_2}\,10^6}{3600\,(V - i\,V_i)}\right]\delta \quad \text{[ppm } CO_2 \text{ per second]} \quad (3)$$

where:

- $x(0)_{CO_2}$ - the initial concentration of CO_2 in the vehicle [ppm CO_2]
- t - time [hours]
- P_{CO_2} - production of CO_2 by one person breathing [litres per hour and per person]
- i - the number of persons in the vehicle [-]
- V - internal volume of the vehicle [m^3]
- V_i - the volume of a person [m^3]
- δ - coefficient of vehicle sealing [-] (for hermetically sealed space is $\delta = 1$ and for open space is $\delta = 0$)

By using equation (3), we can predict the time profile of CO_2 concentration in various vehicles. It should be noted that the cabin air quality is strongly dependent on the degree of ventilation. The influence of the degree of the vehicle hermetic sealing has not been completely observed yet.

3 RESULTS OF SOLUTION AND VALIDATION OF RESULTS

With using the previous mathematical model, the calculation has been performed and experimentally checked time production of carbon peroxide. $c(t)_{CO_2}$.

The initial concentration of CO_2 in the vehicle was $c(0)_{CO2} = 450$ ppm, the internal volume was $V = 8$ m^3, the person volume was $V_i = 0{,}1$ m^3, the respiratory rate for adult $n = 18$ breaths per minute and the vehicle is considered to be hermetically sealed, so the coefficient of sealing is $\delta = 1$. The results of calculation are shown in Fig. 2.

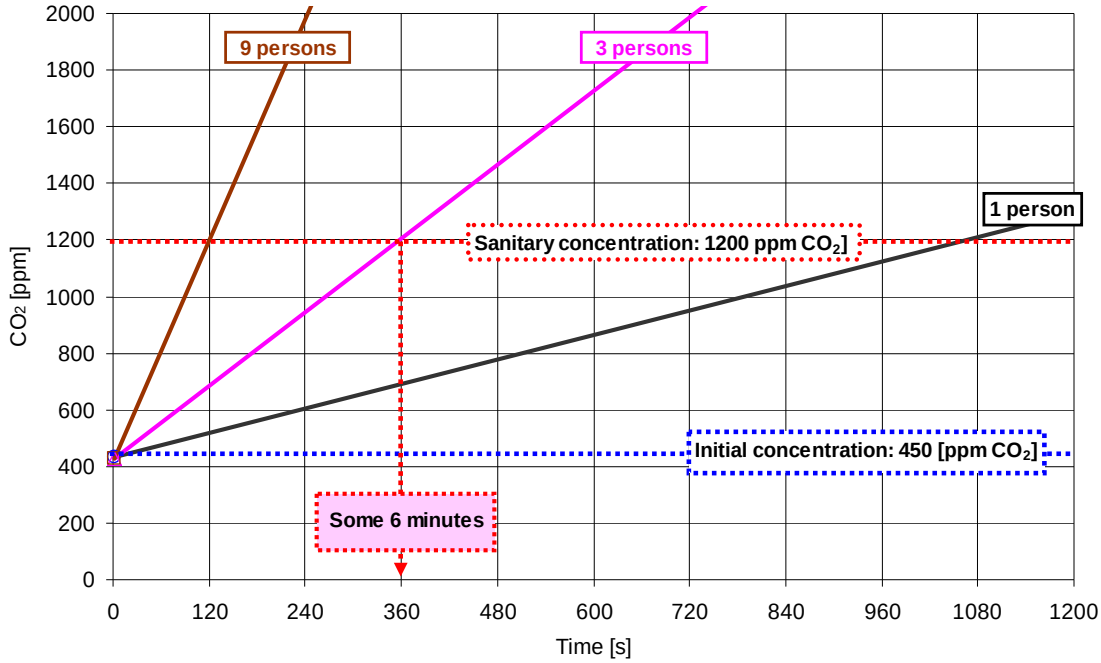

Fig. 2 The increase speed of CO_2 concentration in the vehicle for different number of persons

It is seen from the results in Fig. 2 that the breathing in the confined space without any ventilation causes the rapid increase in CO_2 concentration up to relatively high values. Is very complicated to discover what is the permissible concentration of CO_2 in the vehicle because this topic is not completely worked up and very often ignored [3].

As the source of information for the solution of given problem may be the results of research on the indoor air quality in residential buildings [9]. The recommended concentration of CO2 in the confined spaces should be below 1000 ppm. The requirements for the maximum amount of CO_2 in air in selected countries is following: Finland and Estonia 1.500 ppm; Germany, Great Britain, Norway, Estonia and ASHRAE Standard 1.000 ppm [8], [9]. In Czech Republic the hygienic air quality class in buildings according to the EN CR 1752, is 1200 ppm CO_2 [11]. Maximal permissible limits (PEL) and the highest permissible concentration (NKP-P) valid in Czech Republic are mentioned in the publication [7].

For the initial concentration $c(0)_{CO2}$ = 450 ppm CO_2, for one person in the vehicle (driver) the hygienic limit was achieved in 1070 second (cca 18 minutes), for three persons (crew and driver) in 360 seconds (6 minutes) and 9 persons in 120 seconds (2 minutes).

As the concentration of carbon dioxide rises, it becomes a toxin. According to the research [13], the increased concentration of CO_2 in the air causes decrease the productivity and performance. The elevated CO_2 concentration leads to drowsiness, lethargy, fatigue, unpleasant feeling due to foul air and limits the ability to concentrate. The influence of the high concentration on the human organism is very dangerous and the sum of main symptoms of Carbon dioxide toxicity is in Table 1 [9], [10],[11],[13].

For the correctness checking of achieved result is necessary to experimentally check these results.

For verification of measured results is necessary to discover not only the increase curve of carbon dioxide as well as other quantities for example the temperature course, humidity ,seal workplace in the vehicle, hermetic sealing mode etc. From the previous is perceptible practical verification of the mathematical model exceeds this scope of this paper and therefore it will not be presented in this paper.

Table 1 Main symptoms of Carbon dioxide toxicity [9],[10],[11],[13]

Volume CO_2 in air [%]	Human organ	Effect
1	System central nervous (CNS)	Drowsiness
3	System central nervous (CNS)	Mild narcosis
	Auditory	Reduced hearing
	Heart	Increased heart rate and blood pressure
5	System central nervous (CNS)	Dizziness, Confusion, Headache
	Respiratory	Shortness of breath
8	System central nervous (CNS)	Unconsciousness
	Skin	Sweating
	Muscular	Tremor
	Visual	Dimmed sight

4 CONCLUSION

The optimization of environment inside of military vehicles, make it possible long- time activity in the comfortable climatic conditions. The mathematic model which was proposed, make it possible to observe the air contamination in the vehicle in consequence of carbon oxide increase, whose source is a respiration of persons.

The results which were achieved by mathematic model proved, that small space of vehicle driver and his insufficient ventilation are the main reason of carbon dioxide increasing (CO_2).The high concentration of carbon dioxide has an influence on the sleepiness, lethargy, fatigue etc. [12].

For the correctness checking of achieved result is necessary to experimentally check these results. For verification of measured results is necessary to discover not only the increase curve of carbon dioxide (CO_2), as well as other quantities for example the temperature course, humidity , seal workplace in the vehicle ,hermetic ability etc. From the previous is perceptible the practical verification of mathematical model exceeds this scope of this paper and therefore it will not be presented in this paper.

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CHANGE IN SHAPE OF FRACTURE SURFACE OF C15E MATERIAL AFTER HEAT TREATMENT

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Abstract: Toughness is resistance of a material against failure (fracture). Opposite property of material is called fragility. Surface on which the fracture occurred gives us an idea about the specimen material properties. In terms of energy required to break the specimen one can say that the fracture is ductile or brittle, in terms of fracture surface appearance one can distinguish plastic fracture or brittle fracture. Achieving the marginal state depends on the dynamics of damage accumulation, which is a function of sub-structural and structural state of the material, technological characteristics of production, of external loads, environment and time of action of these factors. The paper discusses the changes in the shape of fracture surface for impact bend tests depending on the steel heat treatment.

Keywords: Toughness. Hardness. Material chemical composition. Heat treatment. Fracture surface.

1 INTRODUCTION

For the material to be used as construction material the critical assets are its mechanical properties and the price. Among the mechanical properties of materials resistant to damage the one of particular interest is toughness. In the present work C-15E material was subjected to experimental examination of its mechanical properties in laboratory conditions and changes in the shape of fracture surface were observed in dependence of the heat treatment of the steel. The steel is designed for use in carbonized or hardened state. In first stage we paid attention to changes in fracture surface of non-carbonized specimen. In the paper the results of tests for temperatures ranging from -30°C to +20°C are published. The temperature was gradually increased by +10°C. For the purpose of the work, rod specimens (10x10x55) mm with V – notch were used. The notch in the shape of V is 2 mm deep and has 0.25 mm radius on its root. The arms of the notch clench at 45° angle.

2 BASIC CHARACTERISTICS

In order to observe changes in material we have chosen few basic characteristics which include toughness, hardness, chemical composition of material, selected heat treatment, temperature for impact bend test and analysis of fracture surface of testing specimens.

2.1 Toughness

Toughness is resistance of material against failure (fracture). The opposite is fragility. Surface on which the fracture occurred is giving us an idea about the properties of the specimen. In terms of energy required to break the specimen we can say that the fracture is ductile or brittle, in terms of fracture surface appearance the fracture can be plastic or brittle. Achieving the marginal state depends on the dynamics of damage accumulation, which is a function of sub-structural and structural state of the material, technological characteristics of production, of external loads, environment and time of action of these factors [1]. Free enthalpy of the system is reduced during fracture.

Fracture area is characterized by a specific shape of the surface. It documents deformation under triaxial tension, which occurs in the notch during bending [2].

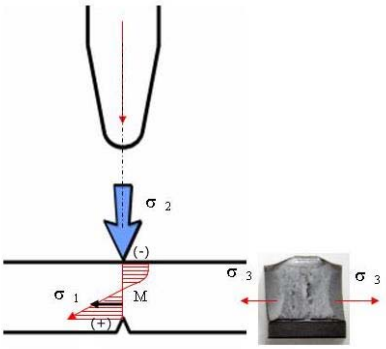


Fig. 1 Schematics of deformation under triaxial tension

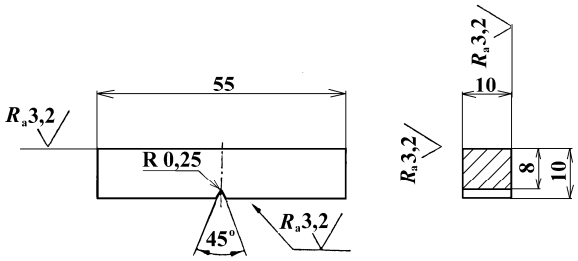


Fig. 2 Test rod with V-notch

In general it can be stated, that the shape of fracture surface is primarily dependent on the crystal lattice of the given metal. While the metals with face centered lattice have tendency to ductile fracture, materials with hexagonal lattice at normal temperature have tendency to brittle fracture, with increasing temperature plastic fracture can be

achieved, the type of fracture of metal materials with body centered lattice is determined by temperature, loading speed and tension (wall thickness, notches), depending on the loading conditions the fracture character is changing. At higher temperatures the fracture is usually ductile, at low temperatures it is brittle fracture. The change in fracture behavior due to the drop in temperature is called transit fracture behavior and the temperature is transit temperature.

2.2 Hardness

Material hardness or hardness is the ability of solid material to manifest resistance against penetration of other bodies. For mutual comparison of hardnesses evaluated by various methods and for their conversion to tensile strength conversion tables are compiled for steel materials (i.e. STN ISO 4964 Steel. Hardness comparison diagrams). For practical use and quick reference using hardness tests it is possible to obtain information about the strength of treated material [3].

2.3 Chemical composition of material

Properties of individual steels are very dependent on the chemical composition resp. on the amount of various components present in steels. The strength of steels increases with increasing content of C but only until 1.2 % of volume. At the same time brittleness, hardness and hardenability increases. The weldability deteriorates and the melting point decreases. The molten steel due to manganese deoxidizes, reduces sulfur content, thereby reducing the risk of breaking when hot forged. Manganese content lower than 0.2 % increases strength and ductility of mild steels. These steels are susceptible to overheating and badly welded. For a content above 12 % the steel is very tough, hardly machinable and wear resistant. Increasing silicon content increases the yield point, strength, fatigue and reduces the ductability at cold-working and weldability. Chromium significantly increases strength, hardness and wear resistance. In content above 12 % increases corrosion resistance, chemical and temperature resistance. Nickel content lower than 0.5 % refines the grain and thus increases toughness. Copper in quantity in range from 0.2 to 0.3 % increases the strength of hot steel and corrosion resistance [4]. Adverse effects have sulphur and phosphorus, their influence begins to manifest significantly at concentration above 0.035 %.

2.4 Chosen heat treatment

Tested material was subjected to following heat treatment:

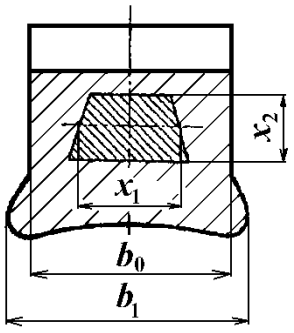
1. Hardening using electric furnace or welding torch to heat the material.
2. Tempering.

2.5 Temperatures used for notch toughness test

Applied temperatures for the impact toughness test were set in range from -30°C to +20°C increasing gradually by 10°C, i.e. the specimens were tested at 6 different temperatures.

2.6 Importance of the fracture surface of tested specimens

The appearance of the fracture surface after breakage is very important. It characterizes plastic or cleavage fracture, it allows to determine the transition temperature. Transition temperature 50 % ($T_{50\ \%}$) is temperature, at which the percentage of plastic fracture on the fracture surface reaches just 50 %. The percentage of plastic fracture P_L [%] is determined by measuring the dimensions of crystalically fractured area on the fracture surface S_{KL} (Fig. 3). By fracture surface evaluation it is possible to obtain also another deformation characteristics – so called lateral expansion Δb, which is determined as the difference between lengths b_1 and b_0



$$S_{KL} = x_1 \cdot x_2$$

$$P_{KL} = \frac{S_{KL}}{S_0} \cdot 100$$

$$P_L = 100 - P_{KL}$$

Fig. 3 Evaluation of plastic fracture percentage P_L and lateral expansion Δb

3 FRACTURE SURFACES OF OBSERVED MATERIAL

The test specimens were made from bar with cross-section 10x10 mm. Total number of specimens for the purposes of experiment was 48. Hardness of the material in supplied state was in average 218 HV10. Test on each specimen was performed according to STN EN 10045–1: Metal materials – Impact bend test by Charpy. Part 1: Test method (V and U notches). Hammer with nominal energy 150 J was used. Chemical composition of specimen is shown in Table 1.

Six groups of tests were performed altogether (range from -30°C to +20°C with increase by 10°C), each group consisted of two specimens.

3.1 Specimen in supplied state

Average hardness of the specimens in supplied state was 218 HV10. Measured values of impact work were 15.16 J.

Fracture surface shape can be seen in Fig. 4.

Table 1 Chemical composition of specimen

Chemical composition of material %									Transition pts. in °C			
C	Mn	Si	Cr	Ni	Cu	Mo	P	S	Ac_1	Ac_3	Ar_3	Ar_1
0,1476	0,2787	0,455	0,1366	0,1033	0,1610	0,0139	0,0230	0,0170	735	863	840	865

Table 2 Measured value of impact work for specimens in supplied state

Specimen group	Temperature [°C]	Energy [J]
1	-30	10
2	-20	10
3	-10	11
4	0	15
5	10	21
6	20	24
Average value:		**15.16**

Fig. 4 Fracture surface of specimen in supplied state

The fracture surface represents brittle fracture. Despite of various values of impact work the fracture surface was the same for all specimens in supplied state. *Visual brittle fractures*, in which the plastic deformation is limited to the advancing crack tip and macroscopic the fracture is without visible plastic deformation. In the case of brittle materials the work is consumed on local plastic deformation overcoming cohesion subsidized by elastic energy zone at the crack tip and the fracture propagates abruptly.

3.2 Specimen hardened from supplied state

The hardening was carried out in two ways, by heating the specimen in electric furnace to temperature 850°C, holding the temperature for 10 minutes and afterwards cooling in water. Measured hardness after hardening was 247 HV10. Next group of specimens was heated by acetylene torch followed by cooling in water. Measured hardness after hardening was 369 HV10. Measured values of impact work are shown in Table 3.

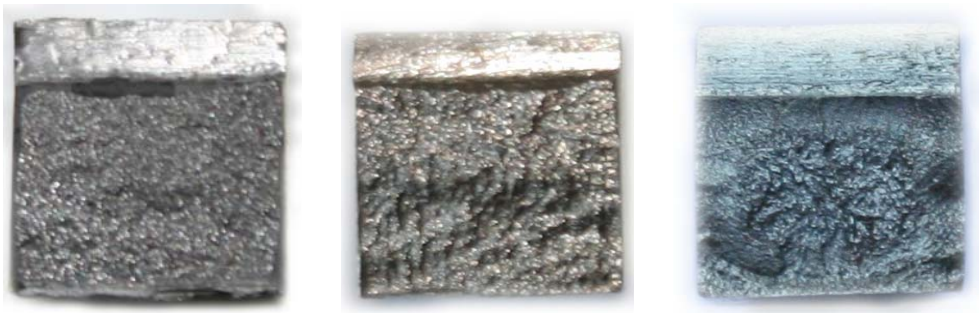
Table 3 Measured values of impact work for specimens hardened, heated in electric furnace

Specimen group	Temperature [°C]	Energy [J]
1	-30	10
2	-20	16
3	-10	42
4	0	48
5	10	62
6	20	64
Average value:		**40.33**

Table 4 Measured values of impact work for specimens hardened, heated by welding torch

Specimen group	Temperature [°C]	Energy [J]
1	-30	19
2	-20	37
3	-10	65
4	0	71
5	10	79
6	20	82
Average value:		**58.83**

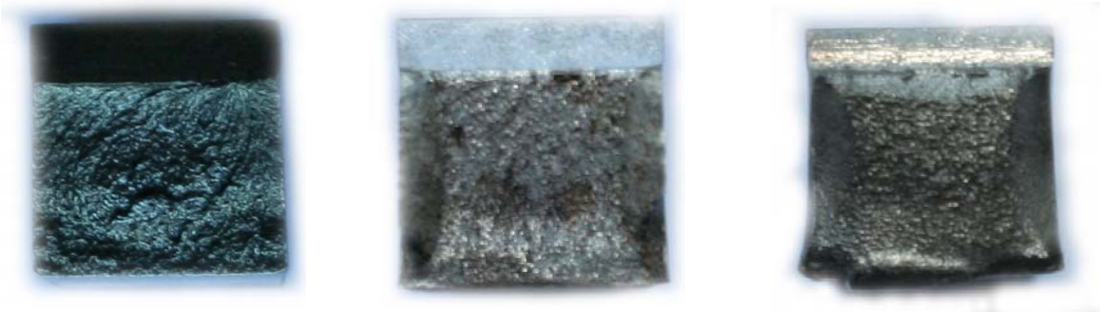
Shapes of fracture surfaces differed from each other depending on the temperature by the test.



a) b) c)

Fig. 5 Fracture surface of specimen hardened from supplied state heated in furnace
a)fracture charakteristic for temperature -20°C and -30°C, b) fracture charakteristic for temperature -10°C, c) fracture charakteristic for temperature above zero

Fracture surface shows combination. It is brittle fracture (a, b) and mixed fracture, with deformation, about 60 % brittle fracture (c).



a) b) c)

Fig. 6 Fracture surface of specimen hardened from supplied state heated by torch.
a) fracture charakteristic for temperature -30°C, b) fracture charakteristic for temperature -20°C , c) fracture charakteristic for temperature -10°C and temperature above zero

The fracture surface represents a combination. It is brittle fracture (a), mixed fracture with large deformation, brittle fracture less than 10 % (b) and plastic fracture with large deformation – fine grained (c). The fracture b) and c) manifest the charakteristics of ductile fractures, showing all signs of triaxial stress state effect. *Visually ductile fractures* are those, which creation is preceded by extensive plastic macro-deformation, visually manifesting itself by a contraction of material around the fracture surface, or eventually by specimen elongation. Such fractures are transcrystalline and their surface is matte and slightly fibrous.

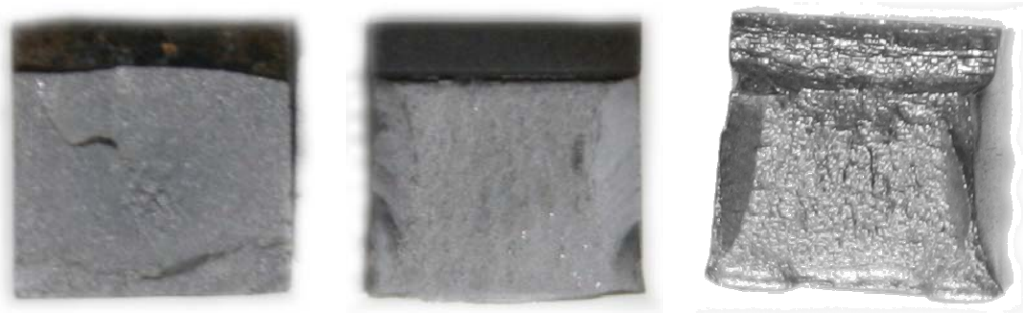
3.3 Specimen tempered after hardening

Samples hardened after heating in furnace were tempered from temperature 550°C with temperature lasting 55 minutes, cooled on air. Measured hardness 206 HV10, is thus lower than in supplied state. Measured values of impact work are shown in Table 5.

Table 5 Measured values of impact work for specimens tempered

Specimen group	Temperature [°C]	Energy [J]
1	-30	42
2	-20	51
3	-10	65
4	0	84
5	10	88
6	20	92
Average value:		**70.33**

Shapes of fracture surfaces differed from each other depending on the temperature during the test. However the fracture surfaces represent plastic fractures, which show all signs of triaxial state of stress – extensive plastic macro-deformation, visually manifesting itself by contraction of material around the fracture surface and by material elongation on fracture border. Change in the amount of impact work in the temperature range is indeed significant.



a) *b)* *c)*

Fig. 7 Fracture surface of tempered specimen
a) fracture characteristic for temperature -30°C, b) fracture characteristic for temperature -20°C,
c) fracture characteristic for temperature -10°C and temperature above zero

Shapes of fracture surfaces differ to each other depending on the temperature during the test. Fracture in the figure a) represents mixed fracture with about 10 % of brittle fracture. In figure b) and c) fracture surfaces represent plastic fractures with large deformation, they show all signs of triaxial stress state effect.

4 RESULTS EVALUATION

In macrostructural analysis the focus is laid on characteristic marks on fracture surface. Overall we can assess whether the fracture was accompanied by plastic deformation or not. On the Figures 4 and 5 is evident that we deal with low energy fractures, without visible macroscopic deformation. In Figures 6 and 7 significant deformation can be seen, which changed originally rectangular cross-section (8x10 mm) into irregular shape. Lower part of the fracture extended significantly compared to original. This deformation can be considered as a manifestation of fracture work and ration of original width to new width at fracture base can be expressed as lateral expansion. On the brittle fracture surface usually not

only a fracture initiation point can be determined, but also contours showing direction of fracture propagation. Depending on the dominant type of loading the fractures of metal materials are classified into three main groups: mechanically induced fractures, thermally induced fractures and fractures caused by corrosion.

4.1 Evaluation of fracture surface of test specimens

a) **Test specimens made of material in supplied state:** Test specimens made of material in supplied state show brittle fracture without deformation for all temperatures. Fracture surface is coarse grained.

b) **Test specimens made of material hardened with heating in furnace:** Test specimens made of material hardened with heating in furnace show brittle fracture without deformation for all temperatures below zero. Fracture surface is coarse grained. Specimens tested at temperatures above zero show mixed fracture with deformation, about 60% of brittle fracture.

c) **Test specimens made of material hardened with heating by torch:** Test specimens made of material hardened with heating by torch show brittle fracture without deformation for temperature -30°C. Fracture surface is coarse grained. Specimens tested at temperature -20°C show mixed fracture with large deformation, brittle fracture less than 10% and all other specimens show plastic fracture with large deformation – fine grained.

d) **Test specimens made of material hardened and tempered:** Fracture at temperature -30°C represent mixed fracture with about 10% of brittle fracture. Specimens tested at temperature -20°C to +20°C represent plastic fractures with large deformation, fine grained, all signs of triaxial state of stress are manifesting on them.

4.2 Lateral expansion

Values of lateral expansion of various specimens are shown in Table 6.

Table 6 Characteristic lateral expansion Δb

Lateral expansion	In supplied state, hardened in furnace	Hardened by torch	Hardened by torch	Tempered	Tempered	Tempered
	all specimens	-20°C	-10°C to +20°C	-30°C	-20°C	-10°C to +20°C
b_0	0	10.37	10.8	10.22	10.54	10.68
b_1	0	6.68	6.38	9.6	7.25	6.91
Δb	**0**	**3.69**	**4.42**	**0.62**	**3.29**	**3.77**

4.3 Importance for practical application

The obtained values of impact work and shape of fracture surfaces prove that the tested material in presented treatment is of limited use.

An interesting finding is the difference of values and behavior of the material hardening with heating in an electric furnace and heating by acetylene torch. While after hardening with heating in electric furnace the results were as expected corresponding to phase changes in low carbon steels, the specimens heated by torch achieved better values of deformation characteristics and also surface hardness. It can be assumed that during heating by torch also carbon diffusion into specimen surface took place simultaneously, which caused better hardening.

5 CONCLUSION

Mechanical properties are final properties of given material, which determine its suitability for its intended function and use in practice. To know and to improve the mechanical properties of construction materials is motivated by their optimal use in the manufacture of machinery and equipment.

The paper does not present transit curves. The figures of fracture surfaces alone document enough that the dependence on temperature for this material has dramatic effect. Nonetheless the experience gained from heating of specimens by acetylene torch before hardening show, that the properties of material are different compared to heating in electric furnace and are closer to properties of ductile material.

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A METHOD OF CONTROLLING THE TOPOLOGY OF AERIAL REPEATERS NETWORK TO IMPROVE STRUCTURAL INFORMATION CONNECTIVITY OF WIRELESS AD HOC NETWORKS

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Inna O. NECHYPORENKO

Abstract: In this paper we define the structural information connectivity of wireless ad-hoc networks, which takes into account not only the structural connections, but also ensure information exchange between a given pair of sender-recipient. To quantify the degree of structural information connectivity suggested two indicators: the capacity of the network and k-connectivity. Proposed a method for controlling the topology of the network overhead of aerial repeaters to improve each of the proposed indicators.

Keywords: Wireless ad hoc network. Unmanned aerial vehicle. Connectivity. Topology control.

1 INTRODUCTION

In a missing or destroyed terrestrial infrastructure (natural disasters, military conflicts, etc.) become widely used wireless ad hoc network (WAHN), which are able to quickly deploy to the organization of information exchange personnel fire units, soldiers and others. Typically, these networks represent wireless local network in which nodes have the same status (peer) and are able to interact directly with each other in the radio visibility zone, or relaying messages through other nodes, thus forming a intermittent networks with arbitrary structure [1]. However, the mobility of nodes, fast changing terrain, limited radiolink's energy leads to instability of connections between nodes and, consequently, to a deterioration (or losses) connectivity of WAHN. So there is actual scientific problem of increasing connectivity of WAHN. One way to increase the connectivity of WAHN is to use of telecommunication systems based on air-based platforms (planes, helicopters, blimps, etc.) [2,3]. Example of architecture of such networks using a miniature unmanned aerial vehicles (UAVs) is shown below (Fig. 1).

The first (ground) level of such network consists of the network of mobile subscribers (MS), which interact with one another, forming a WAHN. The second (air) level is the network of UAVs that operates as nodes, repeaters and provide better connectivity problem areas of the network (as shown in Fig. 1).

One of the key tasks of UAVs network management is the task of UAVs network topology management, i.e. finding the required number of UAVs, their placement and movement in space [4]. It was not enough solved the problem of optimal control of UAVs network topology by the criterion of increasing connectivity WAHN. Ways of ensuring connectivity separated areas of land nodes presented in [4-6]. Increasing the connectivity of network nodes with one UAV studied in [7]. Thus, the purpose of this work is to study the problem of increasing connectivity with the group of UAVs. And the first step of research is quantification of the connectivity of this WAHN.

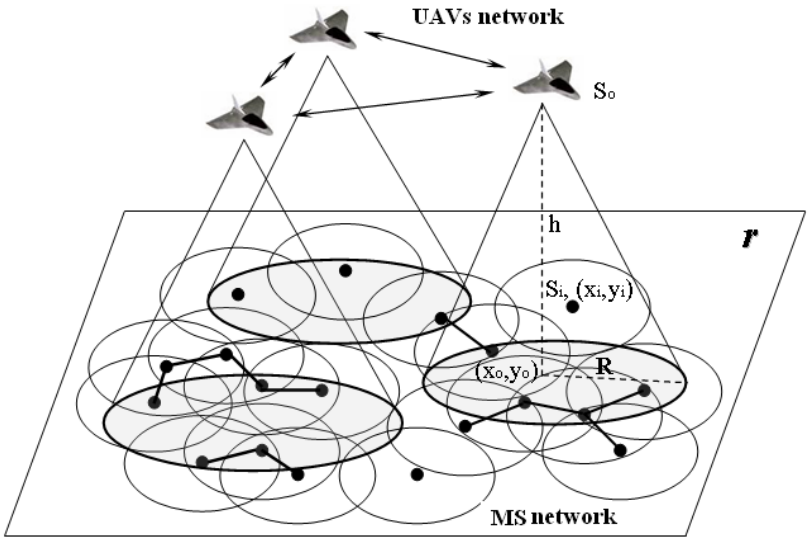


Fig.1 The example of WAHN architecture using UAVs

2 THE DEFINITION OF STRUCTURAL AND INFORMATION CONNECTIVITY OF WAHN

The general definition of connectivity. Network connectivity is the ability of any pair of nodes to share information by using intermediate nodes as repeaters [4]. Because information interaction takes place at different levels of Open Systems Interconnection (OSI) model, then under connectivity we can understand the good functioning of the single level protocols of OSI (in the narrow sense) or the implementation of conditions and protocols of several levels for the guaranteed information exchange between network nodes (in the broadest sense) [1]. At the physical layer between a pair of nodes the sender-recipient ab, $a,b=\overline{1,N}$, N – the number of MS in the network, there must be a physical radio channel or a route m_{ab} serially connected radio channels that are characterized by distance of radio links between each pair of neighboring nodes d_{ij}, $i,j \in m_{ab}, i,j=\overline{1,N}$ or transmitter power of each node in route $p_i, i \in m_{ab}$. In the case of fulfillment the conditions $\Omega_1 : \{d_{ij} \le d^0, \forall i,j \in m_{ab}$ $(p_i \le p^0, \forall i \in m_{ab})\}$, d^0, p^0 - permissible value range (power) transmission, we can speak about the presence of physical connection or *structural connectivity* (SC) of the sender-recipient pairs *ab*. At the data link and network levels the information exchange is guaranteed by the chosen of multiple access (MA) protocol and routing protocol, on the one hand characterized by system parameters such as capacity of selected route data $s(m_{ab})$, and on the other hand - user parameters, such as average delay of data packet transmission between the sender-recipient pair *ab* (or the number of hops in the route $l(m_{ab})$). The intensity of the outgoing flows $g_{ij}, \forall i,j \in m_{ab}$ is determined by the gravity matrix

$$\Gamma = \left\| \gamma_{jk}(t) \right\|, \quad \sum_{i=1}^{N} \sum_{j=1}^{N} \gamma_{ij} \le \gamma_{\max}, \; i \ne j .$$

In the case of fulfillment the conditions $\Omega_2 : \{s(m_{ab}) \ge s^0, \overline{t_з} \le t_з^0 \; (l(m_{ab}) \le l^0),$ $g_{ij} \le s_{ij}(m_{ab})\}$, we will speak about the availability of guaranteed information exchange or *information connectivity* (IC) by sender-recipient pair *ab*. Note that the availability of information connectivity is possible only if the structural connectivity is here.

Then the structural and information connectivity of network as a whole can be determined by the connectivity matrix:

$$[A] = \begin{cases} 1, \text{if } \Omega_1, \Omega_2 \text{ are fulfilled} \\ 0, \text{otherwise} \end{cases} . \quad (1)$$

If for all pairs of sender-recipient *ab* executed all conditions (all matrix elements equal to 1), then the network will be considered connected structural or information. But such definition of connectivity reflects only the presence of connectivity and does not give information on the stability of connectivity of such network. So the next step is a quantification of the indicators of structural and information connectivity, which show the degree of connectivity of the network.

Determination of parameters structural and information WAHN connectivity. To quantify the degree of WAHN connectivity are offered two parameters depending on the task (increase the structural connectivity or improve information connectivity of network): *k*-connectivity and the capacity of the network. After defining these measures of connectivity in the next section we show how they can optimize with the predictive management of network topology UAV relay.

1. *K-connectivity*. In order to define a quantitative measure of structural connectivity, you can use the k-connectivity (k3). Imaging WAHN as a non-directional weighted graph *G(N,A)*, consisting of *N* vertices (network nodes) and set of edges (communication channels) *A*, tagged with a certain weight, for example, expressed by the distance between the corresponding pair of neighboring nodes d_{ij} under the conditions Ω_1. According to [8] such graph is *k*-connected if it remains connected when removing from it the (k-1) vertices. Also, according to Menger's theorem, if the graph is *k*-connected, then between any pair of non-adjacent nodes is at least *k* pairwise independent paths. Then k3 can be defined as the smallest degree among all vertices:

$$U^{kC} = k . \quad (2)$$

2. *Network capacity*. When it is necessary to provide guaranteed information exchange between each pair of sender-recipient, the network capacity (NC) can be a measure of information connectivity. Unlike the previous case, the weight of graph edges denotes the capacity between the corresponding pair of neighboring nodes $s_{ij}, i,j=\overline{1,N}, i \ne j$, on condition that Ω_1 and Ω_2 are fulfilled. Then NC can be defined as follows [10]:

$$U^{NC} = S(A) = \sum_{a=1}^{N}\sum_{b=1}^{N} s(m_{ab}), a \neq b, \quad (3)$$

where $S(A)$ – network capacity;

$s(m_{ab}) = \min\limits_{(i,j)\in m} \{s_{ij}\}$ - capacity of the shortest route m_{ab} between the sender-recipient pair *ab*, $a, b = \overline{1, N}$, which is defined as minimum capacity of channel (edge) in this route.

The introduction of additional nodes to the network, which can be UAVs, may significantly increase the indicators of connectivity.

3 THE FORMULATION OF THE PROBLEM

Set: multitude of terrestrial nodes V_i, $i = \overline{1, N}$, where *N* - number of terrestrial nodes (MS), distributed in some areas r, $км^2$, a multitude of UAVs B_j, $j = \overline{1, K}$, where *K* - number of UAVs; *R = const* - the radius of coverage of each UAV (if they are on the same height *H* relative to the Earth surface), m; D^0 (P^0) – radius (power) of transmission of each UAV. Each node of network V_i at the time *t* is described by a variety of parameters: location coordinates and velocity $(x_i, y_i), S_i$, $i = \overline{1, N}$, relative to the earth's surface height *h* (we assume that *h = 0*), radius (power) of transmission d^0 (p^0); route table of the shortest routes Π_i; gravity matrix

$$\Gamma = \left\| \gamma_{jk}(t) \right\|, \sum_{j=1}^{N}\sum_{k=1}^{N} \gamma_{jk} \leq \gamma_{\max} \text{ for } j \neq k.$$

Gravity matrix is homogeneous, i.e. all subscribers have no priority of service and create the same level of traffic. Requirements to capacity s^0 and packet delay $t_з^0$ are identical for all channels and defined by requirements to the quality of service (QoS) of the specified traffic type (data, voice etc).

Connectivity between nodes of network on the data link layer supported by the protocol CSMA and in network level - one of the routing protocols [11].

Then the **statement of a problem** can be formulated as follows: find in a real-time impact of such managerial influence C_T (coordinates that show placing UAVs in space $(x_{0j}, y_{0j}, z_{0j}), S_{0j}$, $j = \overline{1, K}$ that determine the connectivity matrix A^j), which provides maximum connectivity objective function, determined from the expressions (2) or (3).

The mathematical statement of the problem in the case of structural connectivity will have the form:

$$A^j = \arg \max_{C_T \in \Omega_1} U^{kC}$$

$$\Omega_1 : \left\{ \begin{array}{l} d_{ij} \leq d^0, D_{ij} \leq D^0, \forall i, j \in m_{ab} \\ (p_i \leq p^0, P_i \leq P^0, \forall i \in m_{ab}) \end{array} \right\} \quad (4)$$

The mathematical statement of the problem in the case of information connectivity will have the form:

$$A^j = \arg \max_{C_T \in \Omega_2} U^{NC}$$

$$\Omega_2 : \left\{ \begin{array}{l} d_{ij} \leq d^0, D_{ij} \leq D^0, \forall i, j \in m_{ab} \, (p_i \leq p^0, P_i \leq P^0, \forall i \in m_{ab}); \\ s(m_{ab}) \geq s^0; \overline{t_з} \leq t_з^0 \; (l(m_{ab}) \leq l^0); \; g_{ij} \leq s_{ij}(m_{ab}) \end{array} \right\}. \quad (5)$$

Also, while solving all these problems we introduce additional restrictions:

$$\Omega_{ad} : \left\{ k \geq k_{\min}, N \leq 200; \; K \leq 10; \; r \leq 10 \times 10 \, km^2 \right\}. \quad (6)$$

4 METHOD OF NETWORK TOPOLOGY UAVS MANAGEMENT TO ENHANCE THE STRUCTURAL AND INFORMATION CONNECTIVITY OF WAHN

Management of network topology UAVs includes the following steps [4]: planning, deployment (redevelopment) and operational management.

Stage planning control by management center of network UAVs. Content planning is (based on forecast conditions and available resources):

1. Planning UAVs network topology (finding the required number of UAVs, determine their starting location or movement in space), which implements a goal of management (increasing structural and/or information network connectivity) arising from the requirements for the network parameters and the requirements for sending traffic.

2. Distribution of resources (apparatus, frequency, energy, spatial) network UAVs, the choice of specific parameters and modes of means (methods and control algorithms).

Deployment stage is to launch the specified number of UAVs and manage their flight in specified areas of patrol (the place of their original location). At this stage of the deployment problem (re-topology) network of UAVs can be performed on stage of operational management with significant changes in the network (its damage, the introduction of new groups of nodes, etc.). Controlling the flight of UAVs and its onboard systems is a network management center.

At the *stage of operational management* with accepted effectiveness criteria continually assesses the state of the network, and taken measures (according to the plan and the real situation) to retain effectiveness indicators (*k*-connectivity and capacity) within specified limits or their optimization. Objectives of operational management (the difference in planning problems) solves by a mixed way (centralized / decentralized) in real time, and by the meaning repeats many times.

Block diagram of a method of network topology UAVs includes the following steps (Fig. 2).

Step 1. Gathering information about the initial network topology and input output data (at the planning stage) (box 1):

- parameters of ground nodes: *N*, $(x_i, y_i), S_i$, $i = \overline{1, N}$, and pre-output UAVs $(x_{0j}, y_{0j}, z_{0j}), S_{0j}$, $j = \overline{1, K}$ (obtained, for example, by GPS);
- permissible values of the parameters in (4)-(6) $d^0(p^0); s^0; t_з^0\ (l^0); D^0(P^0); R; k_{\min}$;
- the number of UAVs in operation *K*;
- parameters of MA protocol and routing protocol.

All these parameters and constraints determine the initial network topology WAHN without using UAVs $A^j, j = \overline{1, K}$, where j=0 - number of iterations of finding a solution (serial number of UAVs).

Step 2. Analysis of the structural connectivity (blocks 2,3,5):

1. The calculation of parameter d_{ij} and the degree of connectivity *k*.

2. Checking of constraints Ω_1. If the conditions are met, then check the additional condition $k \geq k_{\min}$ (unit 5), otherwise proceed to step 3.

3. Test additional condition $k \geq k_{\min}$. If the condition is satisfied, then go to step 4, otherwise proceed to step 3.

Step 3. Implementation of the algorithm 1 of structural connectivity (blocks 4, 11-14):

1. Selection of problem vertices (nodes), which degree is $k < k_{\min}$.

2. Find new solutions (topology using current UAVs) A^{j+1} that provide cover as many troubled peaks. In detail this procedure is shown below.

3. In the case of new solutions that fulfill the conditions Ω_1 (or cover as many troubled peaks), $A^j = A^{j+1}$, the output is performed UAVs in a given position (deployment stage) and the adaptation of parameters MA protocol to real operating conditions in accordance with procedures specified in [9] (operative management stage).

4. Check for instrumentation resources (UAVs). In the presence of ($j < K$), go to step 1, otherwise - END.

Step 4. Gathering information on the functioning of the network (block 6):

- matrix of the shortest routes;
- Matrix of gravity *Γ*.

Gathering this information can be made at the planning stage in the case of the abandoned UAVs (through the channel of communication with the control center) or at the stage of deployment by "read" data from any ground node WAHN (using one of the routing protocols [11]).

Step 5. Analysis of the information connectivity (blocks 7,8):

1. Calculation parameters of the network $g_{ij}, s(m_{ab}), \overline{t_з}(l(m_{ab}))$ according to the relations specified in [12].

2. Checking of constraints Ω_2. If the conditions are met, then proceed to step 7, otherwise proceed to step 6.

Step 6. The algorithm 2 for providing information connectivity (blocks 9, 11-14):

1. Selection of problem edges (for which the condition $s(m_{ab}) \geq s^0$ or $g_{ij} \leq s_{ij}(m_{ab})$ are not satisfactory) and/or problematic routes (for which the condition $\overline{t_з} \leq t_з^0$ $(l(m_{ab}) \leq l^0)$ are not satisfactory).

2. Find new solutions (topology using current UAVs) that provide cover as many troubled parts of the network. To reduce the complexity of the search can be used centric or lattice initialization, which are considered in detail in [3].

3. Construction of route tables $\Pi_i(A^{j+1})$ that are defined matrix of gravity and an accepted method of routing. Redistribution of flows g_{ij} by $\Pi_i(A^{j+1})$. Calculation parameters $s(m_{ab}), \overline{t_з}(l(m_{ab}))$ of the existing sender-recipient pairs.

4. Checking compliance with conditions Ω_2 for A^{j+1}. In the case of (or cover the maximum number of problem areas of the network) $A^j = A^{j+1}$, UAVs are output in a given position (deployment stage), and adaptation parameters of MA protocol to real operating conditions in accordance with procedures specified in [9] (operational management stage).

5. Check for instrumentation resources (UAVs). In the presence of ($j < K$), go to step 1, otherwise - END.

Step 7. Performance of algorithm 3 for increasing information connectivity (blocks 10-14):

1. Find new solutions (topology using current UAVs), maximizing capacity. Since it is NP-hard problem, to reduce the complexity of the search can be used centric or lattice initialization, which are considered in detail in [3].

2. Construction of route tables $\Pi_i(A^{j+1})$ that are defined matrix of gravity and an accepted method of routing. Redistribution of flows g_{ij} by $\Pi_i(A^{j+1})$. Calculation parameters $s(m_{ab}), \overline{t_з}(l(m_{ab}))$ for the existing sender-recipient pairs.

3. Checking compliance with conditions Ω_2 for A^{j+1}. If Ω_2 not implemented, or $S(A^j) < S(A^{j+1})$ reject A^{j+1}, otherwise $A^j = A^{j+1}$, UAVs are output in a given position (deployment stage), and and adaptation parameters of MA protocol to real operating conditions (operational management stage) in accordance with procedures specified in [9].

4. Check for instrumentation resources (UAVs). In the presence of ($j < K$), go to step 1, otherwise - END.

In case of the launch of all UAVs each of them periodically on operative management stage realizes discussed above scheme to verify the need to change its position (in this case all nodes are fixed in a given time). The realizing period of control method in this case should be large enough to build routes and transfer along them the minimum amount of data and at the same time small enough so that the network topology has not changed significantly.

Also assume that during the initial collection, calculations and output of UAVs in a given position, the network topology does not change significantly.

Algorithm 1 (providing of SC). Since *k*-connectivity is defined by the least degree vertices of WAHN, so placing UAVs should be performed so as to bind the top of the slightest degree with the greatest possible number of other vertices. This task belongs to the class of calculated geometry. Let the node A, which should increase the degree, and UAVs, which has a fixed radius of radio coverage R (Fig. 3). You must find the coordinates of the center of the circle with radius R, which includes the specified peak A and the largest possible number of other peaks. Obviously, the region of possible solutions is limited to a circle of radius *2R* centered at the top of *A*. Then the algorithm for solving this problem may have the following steps:

1. Selection of nodes within a radius of 2R from the given node A. Construction of circles described around a given node *A* and a pair of other network nodes.

2. Selection of the circles, which radius not exceeding *R* and includes a network node *A*.

3. The choice among the constructed circles such that when UAVs positioned in the center it will be covered with the largest number of other network nodes.

This algorithm reduces the computational complexity compared with the algorithm in [7] and provide increasing *k* degree of node at least two points.

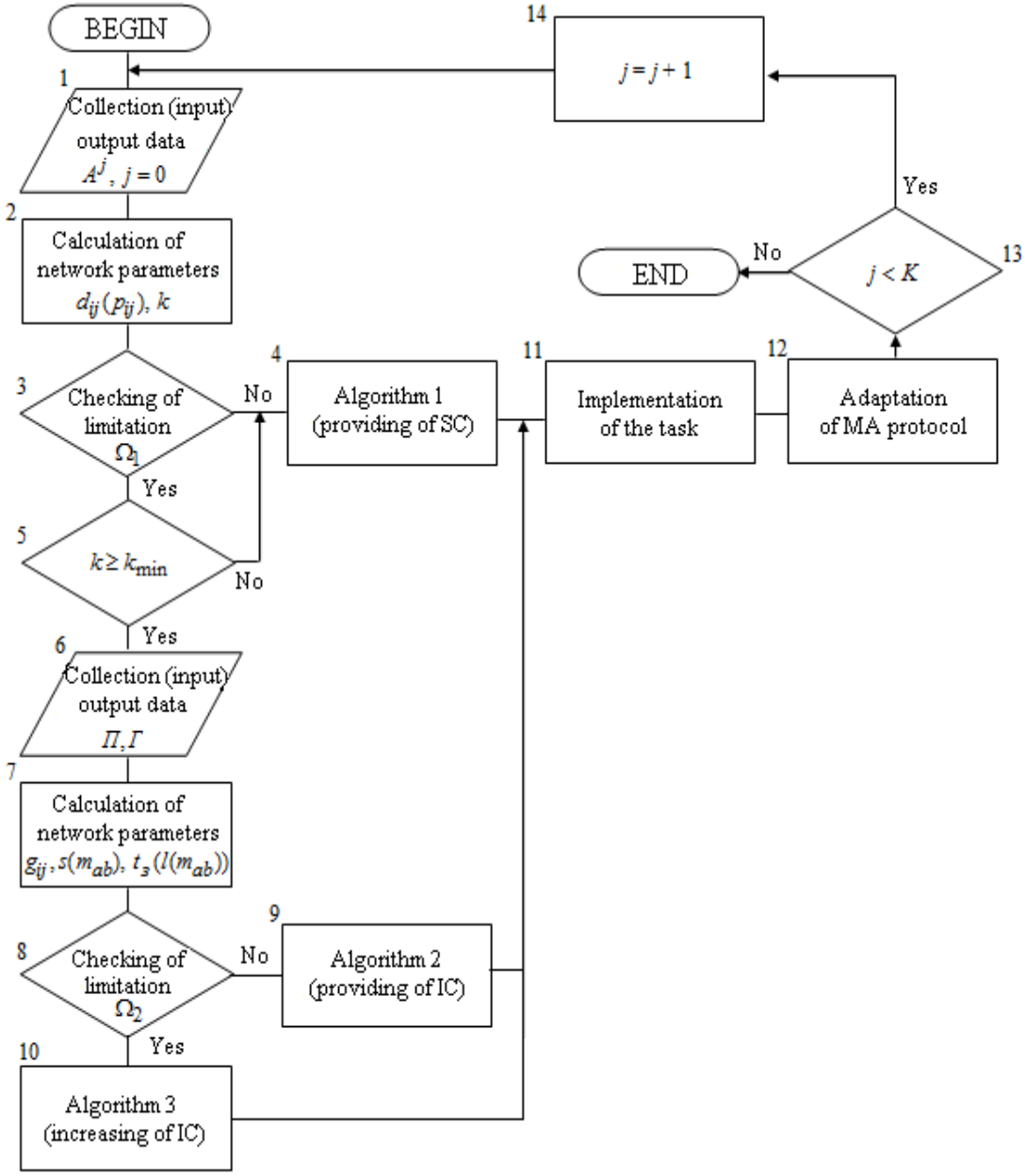


Fig. 2 Block diagram of the control method of UAVs network topology

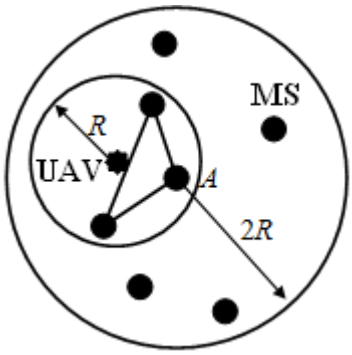


Fig. 3 Example of algorithm placing UAVs in the case of k-connectivity

5 IMPLEMENTATION OF THE PROPOSED ALGORITHMS

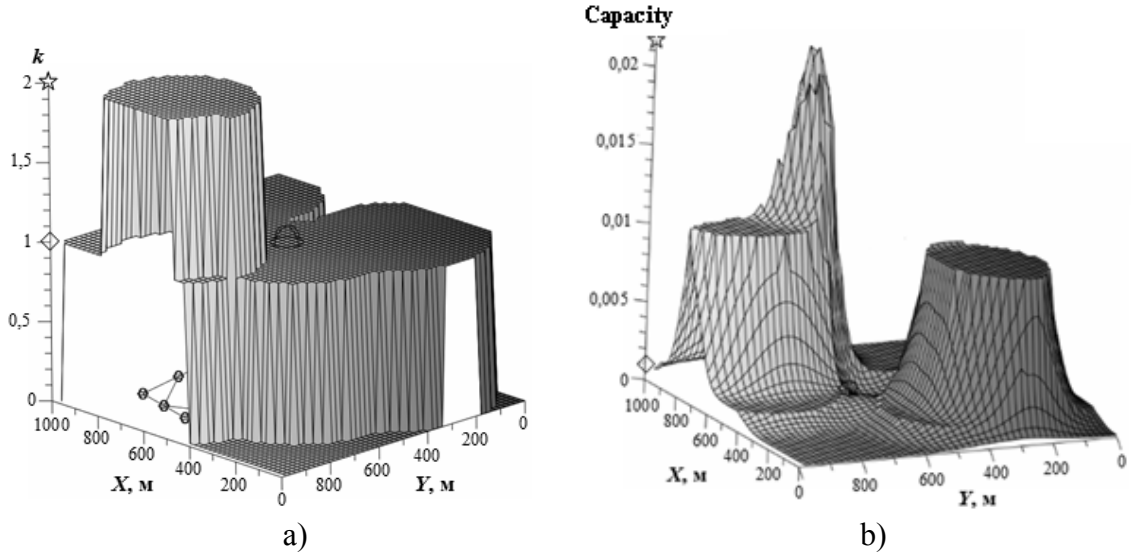
Implementation of the proposed algorithms implemented on the computer environment Maple. For their implementation the following output is used: the number of MS N = 8,12 or 16, which are randomly placed on the surface within the area of deployment $r \le 1000 \times 1000\, m^2$. Valid values for MS and UAVs: d^0 = 100m, D^0 = 300m, R = 200m, s^0 = 0,5, l^0 = 5, $k_{\min} = 1$. Number of UAVs in operation amounted to K = 5. To simplify the calculations it was considered that averaged load of each MS $\overline{g_i}$ = 5. The length of the package was L = 1000bit. The width of frequency bands for each channel network (MS-MS, MS-UAVs, UAV-UAV) was Δf = 300 kHz. BPSK used as the carrier modulation. At the data link layer MS-MS used flexible CSMA in channels UAVs-MS (UAV-UAV) - CSMA using adaptive reservation [9]. To calculate the shortest route it was used the Dijkstra's algorithm. As a metric of the route it was used the number of retransmissions.

Using the proposed algorithms for placing a set of UAVs, the plots of parameters were obtained showing the structural and informational connectivity (k-connectivity and network software) to coordinate placement of one UAV (Fig. 4) and the number of UAVs K at different amount of MS N (Fig. 5 a, c) and at different area of deployment MS r (Fig. 5 b, d).

Analyzing Fig. 4b we can see that the capacity has a global optimum and multiple local optimums. The maximum value of capacity (if used only one UAV) in the graphs marked with an asterisk, and the minimum value (without using the UAVs) - rhombus. For example, when placing UAVs in the global optimum point with coordinates (302,261) capacity reaches its maximum value. Increasing of network capacity uses one of UAVs in this case amounts to several times. Unlike capacity the plot of k-connectivity (Fig. 4a) has a stepped appearance. When using single UAV the degree of k may increase at best for unit.

Analyzing Fig. 5 we can see that connectivity can be further increased when using multiple UAVs. The effectiveness of a using the multiple of UAVs depends on the number of MS nodes in the network and size of MS deployment area. With a large number of MS or less in area of MS deployment connectivity will be more for a given number of UAVs (Fig. 5), because the MS will have a strong connectivity between them. UAVs may be put out until the level of connectivity will be reached.

In further work it is planned to determine the period of testing the proposed method of control depending on the level and nature of MS mobility.



a) b)

Fig. 4 The plots of k-connectivity and capacity of network from location of one UAV

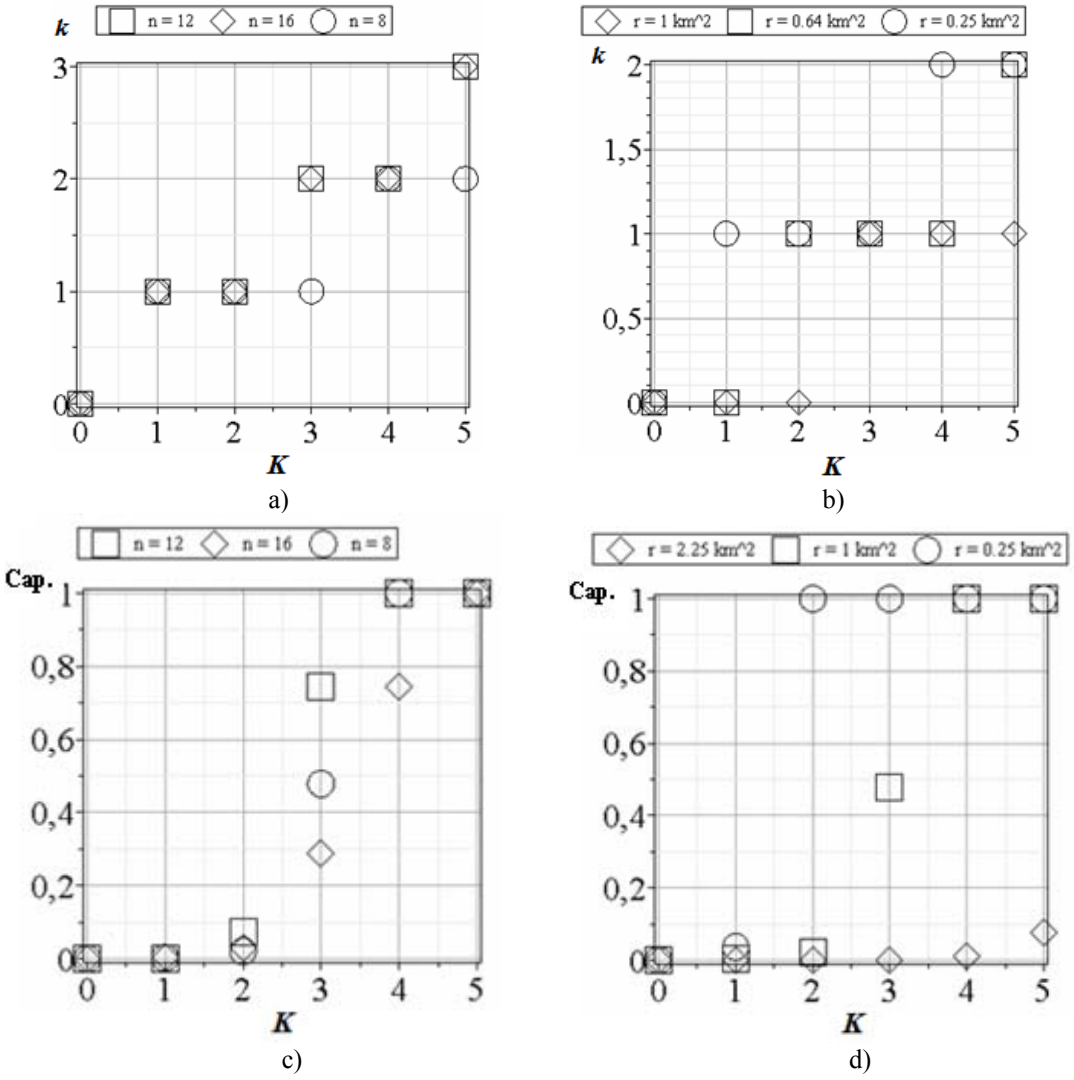


Fig. 5 The plots of *k*-connectivity and capacity of network from the number of UAVs

6 CONCLUSION

In this article the definition of the structural and information connectivity of wireless ad hoc networks was given that takes into account not only the presence of structural connections, but also guaranteed the information exchange between a given pair of sender-recipient. To quantify the degree of structural and information connectivity of wireless ad hoc networks there was proposed two measures: *k*-connectivity and capacity.

The method of UAVs network topology management was developed to increase indicators of structural and information connectivity of wireless ad hoc networks, which consists of adaptive algorithms for optimal UAVs placement in space. Using of heuristic techniques initial approximation helps to significantly reduce the complexity of finding the optimal placement of UAVs and increase the possibility of entering the global optimum.

Results of computational experiments show the effectiveness of proposed algorithms. Application of at least one UAV can increase the network capacity by several times. Using group of UAVs allows to further improve the performance of structural and information connectivity.

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15 YEARS OF SLOVENIAN ARMED FORCES' PARTICIPATION IN MULTINATIONATIONAL OPERATIONS AND MISSIONS

Alojz ŠTEINER

Abstract: The Slovenian Armed Forces have been involved in multinational operations and missions with the UN mandate and under the auspices of the UN, NATO, the EU or OSCE for fifteen years. Slovenian contribution also has some specifics deriving from the two decade long development of the Slovenian Armed Forces up to the present moment. From the initial dispersion and involvement of individuals and groups, the contribution has gradually developed to low-level tactical units. In 2007, for the first time an entire battalion was deployed abroad. It should be specifically stressed that multinational operations and missions are an important and efficient tool for the transformation of the armed forces, integration to allied structures and multinational force structure, and the provision of interoperability in a military area.

Keywords: Multinational operations and missions. Slovenian military contribution to multinational operations and missions. Characteristics of Slovenian contribution to multinational operations and missions.

1 INTRODUCTION

The beginnings of the Republic of Slovenia's participation in peace support operations date back to May 1997, when Slovenian soldiers were deployed to the OSCE Operation Alba in Albania. By the end of 2011, the Slovenian Armed Forces (hereinafter: SAF) have deployed more than seven thousand military personnel to twenty multinational operations and missions (hereinafter: MNOMs[1]) on three continents. It should be noted that without participation in MNOMs, the SAF would still be deep amid transition process, with the territorial national defence army merely observing the international environment. Characteristic of Slovenia's participation in MNOMs is its continued growth which is closely linked with the transformation of the military, its transition from conscription to professional army, and building of deployable capabilities based on international standards and improved through lessons learned from various engagements.

[1] The outstanding unresolved issue is the definition of the common term within the UN, NATO and the EU. The United Nations Peacekeeping Operations include: conflict prevention, peacekeeping, peacemaking, peace enforcement and peace building (UN PKO Principles and Guidelines 2008: 10–11). NATO-led non-Article 5 crisis response operations are categorized as peace support operations which include (a) conflict prevention, (b) peacemaking, (c) peace enforcement, (d) peacekeeping and (e) peace building and humanitarian operations. In addition, non-Article 5 crisis response operations and tasks may also include (a) support to humanitarian assistance, (b) search and rescue, (c) combat search and rescue, (d) support to non-combatant evacuation operations, and (e) military aid to civil authorities (AJP-3.4 2008: 4-1, 4–11). The term multinational operations and missions (acronym: MNOMs) denotes a general notion of military, peace and even humanitarian and rescue operations and missions, which are led by various international organizations and include military forces.

2 MULTINATIONAL OPERATIONS AND MISSIONS AS A TOOL FOR INTEROPERABILITY, INTEGRATION AND TRANSFORMATION OF THE MILITARY

Multinational operations and missions constitute a very important pillar of the function conducted by the UN and NATO, but also of military relations within the EU. The participating nations regard MNOMs as their foreign policy instrument that, in addition to the national resources involved, can also bring benefits, not only politically, but also economically, provided that the comprehensive approach and compliance with national interests are ensured. With reference to MNOMs, the links with the defence planning, building of military capabilities, integration to multinational command structures and affiliation to multinational force structures should also be taken into account.

The influence of MNOMs is particularly important in the provision of interoperability and joint combined action in the international arena, including the integration into command structure of multinational operations. This comprises joint multinational planning of future operations, capability building for operations and force generation for operations, preparation of commands and units for the participation in operations and consolidation upon the conclusion of operations.

The reasons and benefits for the military to participate in MNOMs may be that they: (1) enable the gaining of international experiences in the military field; (2) are direct indicators of the achieved development and training levels for the participation of military forces in a multispectral international environment; (3) may significantly affect the morale of soldiers and allow for comparison with other armed forces at a personal level; (4) have important influence on the development and verification of values in individuals and organizations; (5) provide an opportunity to enhance public image of the military,

notably when contributing to peace, humanitarian aspect and life saving, and provision of secure environment; (6) contribute to the understanding of multinationality and operation in the environments often affected by crises.

The role of MNOMs as a military transformation tool should also be highlighted in terms of developing new military capabilities, implementing operational experiences and developing multinational integration and joint combined operation. As a transformation tool used both at the national and international levels, MNOMs incorporate the experiences and examples of good practice that provide answers to a number of strategic, operational and tactical issues relevant for the deployment of military forces and capabilities. The operations are used to test new equipment and assets, as well as to validate some experiments by applying new capabilities or tactics. It can, therefore, be concluded that MNOMs are an important if not a major tool of military interoperability and integration into multinational security structures and related transformation of the militaries.

3 INDICATORS OF THE 15-YEAR LONG SLOVENIAN PARTICIPATION IN MULTINATIONAL OPERATIONS AND MISSIONS

In order to provide a full picture of the past Slovenian military participation in MNOMs and recognition of the foreign policy and participation strategy, some of the indicators will be described and used as a basis for some conclusions. Past Slovenian deployments to MNOMs have been characterized by the dominance of the military component and limited involvement of other structures or assets. Military capabilities have been deployed to two or maximum four areas of operation, and focused on the Western Balkans, where a need for comprehensive presence[2] has been evident. The basic feature of Slovenia's military contribution lies in a steady increase of its proportion, according to the changing status of the country in foreign policy on the one hand, and the development and professionalization of the military on the other hand. Worth mentioning is the fact that over the past participating years there have been no fatalities or severe injuries reported among seven thousand participants in MNOMs.

3.1 Oerview of the past Slovenian deployments

Since 1997, the Republic of Slovenia has participated militarily in twenty MNOMs (thirteen of which have been concluded). Slovenia has deployed its troops, to 13 countries on three continents. As shown in Table 1, eight operations were led by NATO (five of them concluded), six by the EU (four of them concluded), five by the UN (three of them concluded) and one by the OSCE (concluded).

This overview gives the total number of MNOMs with SAF participation in individual years. Based on the information, it can be concluded that up to 2003, Slovenia participated militarily in two areas of operations, i.e. in the Balkans and the Middle East, with Slovenian representatives present in four to six MNOMs. Following the accession to NATO and the EU, Slovenian contribution increased significantly, both in terms of the number of MNOMs, areas of operations and number of participants. The ceiling was reached in 2006 when SAF members were deployed to nine MNOMs in four areas of operations.

The SAF first joined an MNOM in May 1997 when 21 troops were deployed to the international military operation Alba in Albania, under the auspices of the OSCE. It was followed by the UN-led operation Unfycip in Cyprus. The Partnership for Peace (PfP) programme served as a framework for the participation in the NATO-led crisis response operation SFOR in Bosnia and Herzegovina. With the participation of SAF troops in KFOR in 2000, the Balkan area of operations became a priority for Slovenia. In 2003 and 2004, when Slovenia expected and eventually received the invitation to join NATO, the participation in MNOMs intensified to include an average of approximately 190 military personnel per year. A sufficient number of professional soldiers and required capabilities was also attained during this period. This allowed Slovenia to first deploy a company-size unit to Bosnia and Herzegovina in 2003.

The Republic of Slovenia's membership in NATO and the EU is considered to be an important milestone in approaching MNOMs. This reflected in the increased levels of military participation in the period between 2005 and 2006. Moreover, Slovenia had successfully taken on the role of a fully-fledged member of both organizations where a joint resolution of the issues shared by both organizations in the areas of foreign policy, security and defence

[2] The aim of the Comprehensive Approach is to effect adjustments to the increasingly obvious complexity or multi-layered character of modern MNOMs. This applies mainly if the military component is not the prevailing element. According to AJP-3 (A) contemporary MNOMs should be understood as a 3D network expanding upwards toward strategic and also political levels where the recurring challenges are addressed through the comprehensive approach. The downward movement spreads toward the tactical level with effect-based operations concept, while the sideward movement includes several military and civilian groups and organizations involved in contemporary MNOMs.

had become a necessity. Slovenian engagement in the Western Balkans has gradually risen and culminated in the deployment of a battalion to Kosovo in 2007. The gradual approach in increasing military contribution is also characteristic of the ISAF operation, where a reconnaissance group was deployed in 2004 and a reinforced motorized platoon and a group of specialists have operated within OMLT since the end of 2008. With the deployment of an almost entire 10th Motorized Battalion to Kosovo from the end of February to the beginning of September 2007, the SAF, for the first time in their history, deployed their biggest unit abroad. Considering the statistics, almost one thousand troops have taken part in MNOMs or seventeen times more than at the beginning of Slovenia's military participation in 1997. After 2008, the sustainable contribution of military personnel was maintained between 450 and 510. Due to the economic crisis, however, the numerical size of the post-2009 national contribution (which exceeds 6 % of the peacetime structure) has been impacted by limited financial resources.

When analyzing the number of SAF troops participating in MNOMs, a distinction should be made between the average annual number of participants in operations and the total number of troops deployed to operations in 6-month rotations. Table 2 shows the average annual number of Slovenian troops participating in the past MNOMs from 1997 to 2011. In this period, the total annual average national contribution amounted to 3,791 of SAF personnel.

Table 1 Participation of the SAF in Multinational Operations and Missions from 1997 to 2011

MNOM			Led by	Year														
				97	98	99	00	01	02	03	04	05	06	07	08	09	10	11
1.	ALBA		OSCE	X														
2.	UNFICYP		UN	X	X	X	X	X										
3.	SFOR	Joint Guardian	NATO	X	X													
4.	SFOR	Joint Forge	NATO			X	X	X	X	X	X							
5.	UNTSO		UN	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
6.	UNMIK		UN			X	X	X										
7.	AFOR		NATO			X												
8.	KFOR	Joint Enterprise	NATO				X	X	X	X	X	X	X	X	X	X	X	X
9.	OHR BiH		UN					X	X									
10.	CONCORDIA		EU							X								
11.	EUFOR ALTHEA		EU								X	X	X	X	X	X	X	X
12.	ISAF		NATO								X	X	X	X	X	X	X	X
13.	NATO PAKISTAN		NATO									X	X					
14.	EUFOR KONGO		EU										X					
15.	AMIS II		EU										X					
16.	NTM-I		NATO										X	X	X			
17.	UNIFIL		UN										X	X	X	X	X	X
18.	EUFOR TCHAD/RCA		EU												X	X		
19.	EUFOR NAVFOR		EU													X	X	X
20.	NATO JBA (HQ)		NATO													X	X	X
Total MNOMs				4	3	5	5	6	4	4	5	5	9	6	7	7	7	7

Source: GS SAF: SAF data on participation in MNOMs[3] 2011.

[3] Concluded SAF deployment in MNOMs is marked with shaded background.

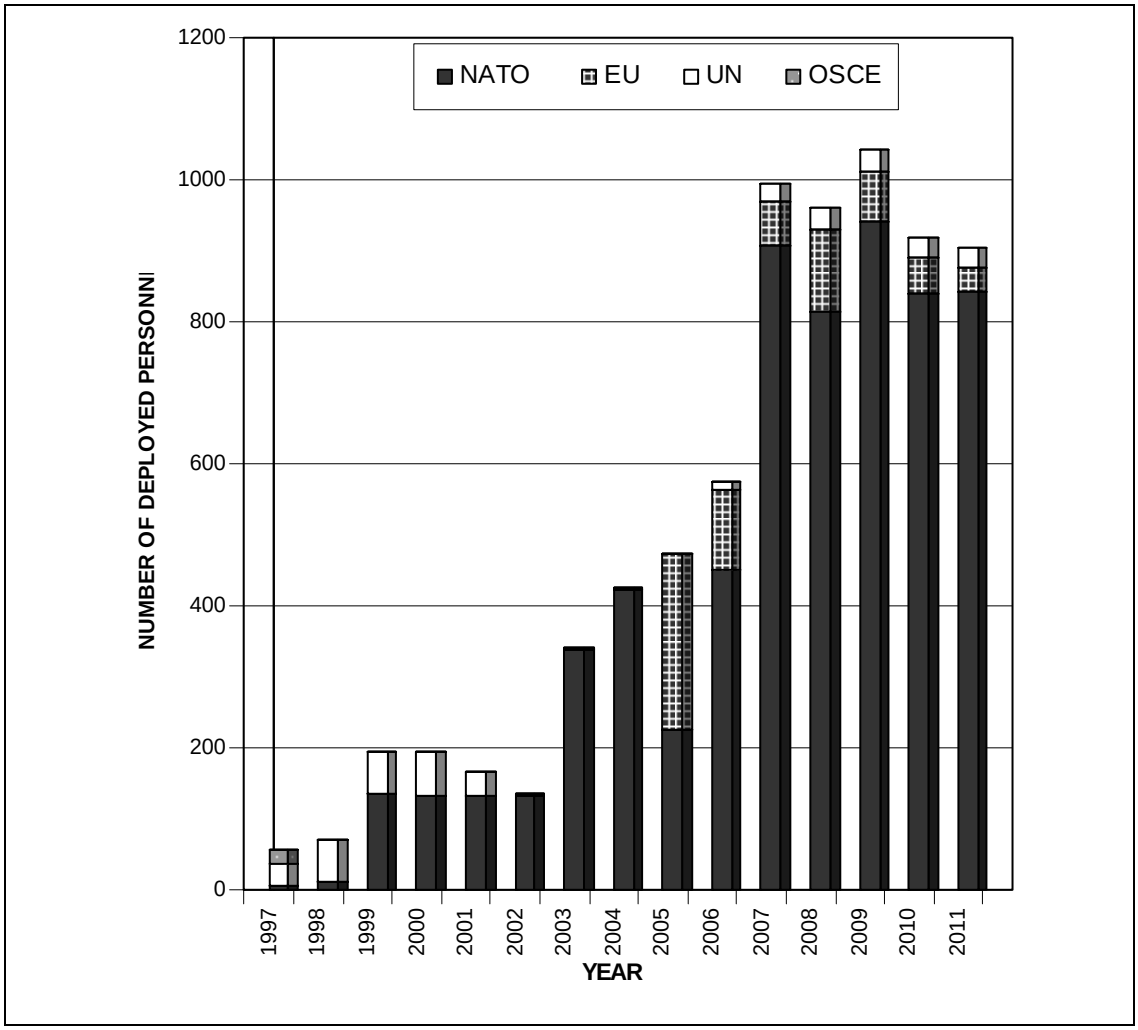
Table 2 SAF deployment to Multinational Operations and Missions (approximate annual number) from 1997 to 2011

1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
57	36	108	97	99	69	174	199	238	284	542	456	512	468	452

Source: GS SAF: SAF data on participation in MNOMs 2011.

Slovenia´s deployments to MNOMs and the building of national military capabilities are interconnected and directly proportional. This is also confirmed by the data in Graph 1, which show the growth of the total annual deployments to MNOMs and the milestones for individual deployments of SAF capabilities. The total sum of SAF participants deployed over the considered period is 7,452, with the highest number reached in 2009. After 2009, Slovenian contribution has slightly fallen. Changes also occurred in the structure of the participating forces, which in mainly composed of companies and lower-level units.

Graph 1 Total number of SAF troops in Multinational Operations and Missions from 1997 to 2011



Source: General Staff of SAF: SAF data on participation in MNOMs 2011.

3.2 Periods and forms of Slovenian participation in MNOMs to date

The 15-year long participation of the SAF in MNOMs can be divided into three periods: the first one from 1997 to 2002, the second one from 2003 to 2006 and the third one after the year 2007. The first period was marked by the participation of small and simple modules of up to the platoon level. The second period saw progress in terms of quantity and quality despite the greatest dispersion of national contributions. The third period, on the other hand, is

characterized by the challenges of comprehensive approach to MNOMs, facilitating the integration of Slovenian companies to multinational task force structures and creation of national structures in the form of battalion battle groups, which also include the modules of other countries. While during the first period Slovenian soldiers appeared in the international environment and gathered experiences, the second period was marked by the search and gaining of maturity within multinational environment. Throughout these periods, Slovenian contingents have, in some respect, still depended upon partner or framework nations, notably due to the restrictions of the strategic air lift and limited availability of Slovenian support capabilities for remote areas.

All three periods have also been characterized by the growing sustainability of Slovenian contingents depicted in Graph 2. The sustainability of the national contribution should be understood in terms of the size and scope of units capable of annual rotations in individual MNOMs. The sustainability of the national contribution after 2008 includes three companies with an average annual participation of 447 to 512 troops.

Further analysis of past SAF participation in MNOMs suggests three typical forms of participation: simple, complex and specialist. Based on the presented growth of Slovenia's contribution (progressing from individuals and platoon modules to company in 2007 and 2008, and then battalion level before falling back to company level), it can be concluded that the SAF have progressed from simple to specialist and complex forms of participation.

The simple forms of MNOMs participation included mainly tasks such as force protection, patrolling and movement control in security areas, or logistic and medical support tasks. Our findings show that Slovenian units were mostly subordinate to framework nations or components of larger units as a result of their size (teams or platoons).

Complex forms of participation began in 2007 in Kosovo when a battalion task force assumed its area of responsibility and was directly integrated into the KFOR command and control system. The Slovenian Hawk Battle Group included generic motorized companies tasked with basic assignments, while the Battle Group HQ, composed of the 10th Motorized Battalion, exercised direct command over various modules, such as military police, engineer team, ROLE 1 medical unit and CIMIC. The HQ was also responsible for autonomous gathering of intelligence and intelligence support to operations, which rounded off the autonomy of stabilization operations. Worth mentioning is also the fact that during the operations of the battle group national caveats for crowd and riot control were lifted for the first time. Slovenia's contribution to Operation Joint Enterprise in KFOR, Kosovo, has adapted to the changes in force size and structure in the transition period between GATE 1 (2009-2010) and GATE-2 (2010-2012). It now continues to pursue with the intention for changes in GATE-3 as well.

Specialist contribution typically involved individual elements of Special Forces or relevant specialists, or merely staff elements or specialists in various structures with no classical character of military units. Specialist forms of participation included members of the Special Forces unit, reconnaissance troops, medical experts and teams, helicopter crews, military police and other personnel functioning independently or as part of multinational specialized units. The participation in the multinational integrated logistics unit was also included. The other part of specialist forms of contribution was linked to advisory or training tasks, such as NATO training missions in Iraq, Afghanistan and Kosovo, or Liaison and Observation Teams in the EU operation in Bosnia and Herzegovina. Specialist contribution comprised primarily of tasks associated with the building, transformation and training of the armed forces in the countries or in the areas with ongoing operations. They could also include teams advising to government authorities in the development of the defence system and armed forces. Typical of this form of participation is that the groups are composed of specifically selected personnel from various commands and units in order to obtain advanced forms of preparation, and specific expertise and experiences of the members involved. Specialist forms of contribution also include staff specialists filling up commands of individual MNOMs. Special features of staff specialists also include their knowledge of allied staff procedures and standards, as well as English language, but also their preparedness to function in a multicultural and multinational military environment, and hence to demonstrate a high level of adaptability and resourcefulness.

3.3 Slovenian strategy

In November 2009, the Government of the Republic of Slovenia adopted the Strategy of the Participation of the Republic of Slovenia in Multinational Operations and Missions, where it defined strategic interests and its vision of the participation, and determined the basic principles and other issues regarding the implementation of the Strategy. Slovenia thereby obtained a document defining all types of national contributions to international security and ensuring a comprehensive use of a wide range of political, military and civilian mechanisms. The Strategy's basic provisions concentrate on foreign policy goals and the comprehensive approach, and try to find a response to the complexity of MNOMs as well as the inter-

ministerial and inter-agency cooperation. This is to achieve complementarity, coherence and interoperability of national contributions. It also aims at finding a relevant ratio for various international contributions implemented through peace operations, crisis response operations (including peace-support operations), international rescue operations, development cooperation, humanitarian aid and other forms of support.

The MNOM strategy is owned and implemented by the Ministry of Foreign Affairs, Ministry of the Interior, Ministry of Defence and the Administration of the Republic of Slovenia for Protection and Disaster Relief. Every year, a report is written on the implementation of the Strategy. It is discussed by the National Assembly and, prior to that, by special parliamentary foreign policy and defence working bodies. It is also worth mentioning that the Strategy substantially contributes to a changed approach to MNOMs and their understanding as well as to an improved coordination of various national contributions and use of available resources, also financial. Here, special importance is attached to the media exposure of MNOMs, and the public communication strategy in the Republic of Slovenia as well as within the involved ministries and the SAF.

Since the deployment of a battalion to KFOR in 2007, Slovenia has been recognising the significance of the comprehensive approach to MNOMs in Slovenia's political arena, and the challenges gaining ground also in the military. In accomplishing tasks, some considerations of the comprehensive and effect-based approach to operations are directly incorporated into practice. Successful implementation of comprehensive approach in routine activities proves that this concept is known to the SAF and is also appreciated, both by, Albanian and Serbian parties in Kosovo. The transformation of the Slovenian contribution to operation ISAF in Afghanistan in 2010 by taking over and independently leading an Operational Mentor and Liaison Team, and by connecting with civilian functional specialists (CFS), has helped to implement the national-level comprehensive approach in this operation as well. Thereby we witness multi-service structures with mixed military-civilian or even civilian-military and humanitarian components becoming increasingly important, which indicates that, for quite some time, military capabilities and elements have been complemented with other elements as well.

4 CONCLUSION

Slovenia attaches special importance to the issues of concentration and dispersion of forces as well as to the participation, and maintaining focus mainly on the Western Balkans or, better said, to finding a new focus, when this will no longer be possible in the Western Balkans. With an increased reduction of forces in operation KFOR, transition from an executive to a non-executive character of operation Althea in Bosnia and Herzegovina, and transition in operation ISAF in Afghanistan, it now faces new challenges, These challenges include the issues of future participation in MNOMs that will facilitate the implementation of national interests, improve the recognisability of the Republic of Slovenia and its contribution to international security, as well as the fulfilment of obligations towards the UN, NATO and the EU. On the other hand, it is also important how to accomplish a step forward in quality and utilize lessons learned, notably for a more comprehensive, coordinated and efficient operation with the resources available.

The SAF's developing path of participation in MNOMs was very intensive and colourful. However, the experiences of fifteen years' participation in various MNOMs can be upgraded in the future. This is necessitated by the changes to objectives and mission, methods of their implementation and the processes of planning, preparing and organizing national contingents, as well as the execution and completion of MNOMs. It should be stressed that the international community has always appreciated Slovenian soldiers, their excellent performance and trustworthiness in MNOMs.

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ASPECTS IN OBTAINING NEW MULTI-LAYER STRUCTURES USING NONCONVENTIONAL METHODS

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Abstract: This paper sets out to treat some aspects related to the employment of the welding by explosion mechanism in obtaining new metal structures used in special industries, such as chemical industry, aeronautics, mechanical engineering, and may find application in the defense industry.

Keywords: Multilayer structures. Nonconventional methods.

1 INTRODUCTION

To understand the process of explosion welding of metal plates, the paper presents a principle method highlighted by practical experiment. Some of these mechanisms suggest that the process, is fundamentally, one of melting.

It is taken into consideration that at the welding-interface, the kinetic energy transforms into thermic energy (accompanied by an energy dissipation), which acts as source of heat, enough to cause bilateral dissolves through the interface, the diffusion of the shells occurring later. This diffusion of the metals into liquid state, takes place gradually, concerning the structure of the welded metals and the distance from the interface.

According to the studies concerning the waves at the welding-interface, "the whims" and the marks of melted and solidified metal cannot be explained through the mechanism of welding in the solid state, or by the dissolving mechanism.

The deformation of the granules at the interface and the appearance of the waves defines that the phenomenon of welding through explosion is based on a hydrodynamic process of inflows.

2 THE PROCESS

The researchers have experimentally established that during the process of welding, important transversal tensions (of detrusion) form on the interface, resulting an effect of warming of the interface. This phenomenon could lead to an adequate warming of the superficial shells to produce the welding and can also explain the appearance of the waves at the interface [1].

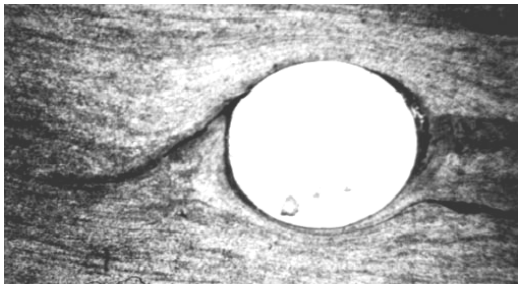

Fig. 1 Example of an interface obtained at the plating through explosion of the metallic layers

The new testing procedures have revealed that, at the collision of the welding pieces, only a very thin layer of melt forms on the interface. The assigned value of refrigeration of the remained melting layer is 10^5 ^{0}C/s, this value is so high because of the line of contact between the components.

The existence of amorphous layer, inside the welding zone, has been taken into account for different metallic combinations and explained by the scientists as being the material reason of welding through explosion's fundamental mechanism (Mustaţă, 2003:96-112;Belmas et al.,1996:217-222).

The welding mechanism with jet configuration is able to incorporate the influence of the main technological parameters and can somehow envisage a "working" domain for the welding parameters, for any metallic combination.

According to these assertions, it is generally accepted that the well-known phenomenon of the formation of the jet in d point is a collision, it is a fundamental condition for the process of welding through explosion. It deals with, because the formed jet represents the agent that cleans mechanically the welding areas, removes the impurities and the oxides, allows that the atoms of the two materials collide at interatomic spaces, thus resulting the welding through explosion.

As defined in the specialty language, the *p* pressure resulted by every metal in the collision point, is obtained by the following formula:

$$p = \rho \ u \ D \qquad (1)$$

where: p - is the pressure of the shock at the interface between plates;
ρ - the volume body of the material;
u - the material speed of which the materials form the interface move;
D - the speed of the shock wave inside the material, this speed is approximately equal with the speed of the sound (the speed of the longitudinal waves).

Besides the dimension of the impact speed between the mobile and the fix material, the welding through explosion (fără *it*) is only possible if at the level of the impact and collision interface exist plastic leaks. In practice, this condition is defined, as

follows: the speed of the collision point, sometimes named the welding speed, must have a lower value than the speed of the sound inside the value.

Also, in order for the welding process to be obtained, the angle of dynamic collision β must excel a minimum value. This angle has very low values.

The speed of the collision point is obtained by the following formula:

$$V_c \approx \frac{V_p}{\sin \beta} \quad (2)$$

where: V_c – is the speed of collision;
V_p – is the speed of propulsion;
β – dynamic angle of collision.

The study to obtain some layered materials through the unconventional process mentioned above, is essential also because of the energetic independence provided by the technology, such as the adequate energy to detonate explosive load.

To obtain the process of plating through explosion, after the construction of half-finished materials and bringing them to desirable sizes, the covers of the explosive loadings are being built, with the function to maintain the geometric sizes of the explosive loadings, under the explosive's character and its granulation. In this instance, the boxes belonging to the explosive loadings, have been made of cardboard .

Determined the testing conditions, the assembly of the technologic system to create the process of plating through explosion begins. Therefore, across the base plate the spacers are put.

The spacers are mechanic elements with the function to create the best distance between the plates, for the process of plating to succeed.

The experimental technological system, created to generate the process of plating through explosion is shown in Fig. 2 (Mustață, 2003:96-112).

Fig. 2 Lateral angle of the experimental assembly used for the process of plating through explosion

The 2D Finite Elements Model from simulate the Explosion Cladding Process are presented in Fig.3 [3].

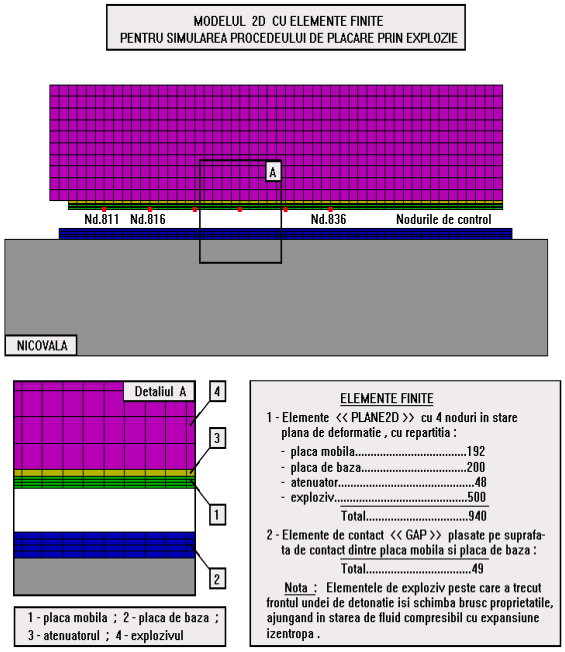

Fig. 3 2D Finite Elements Model from simulate the Explosion Cladding Process

To obtain a multilayer metallic structure with private characteristics, by the process of plating through explosion, attempts have been made to create a multi-layered metallic material, underlying aluminium alloy plates type 3105, 3 millimeters thick; between these plates, a stainless steel fibre is inlayed, with the role of consolidation (Mustață, 2003:96-112).

The stereomicroscopic image of the layered structure obtained by explosion cladding process is presented in Fig 4.

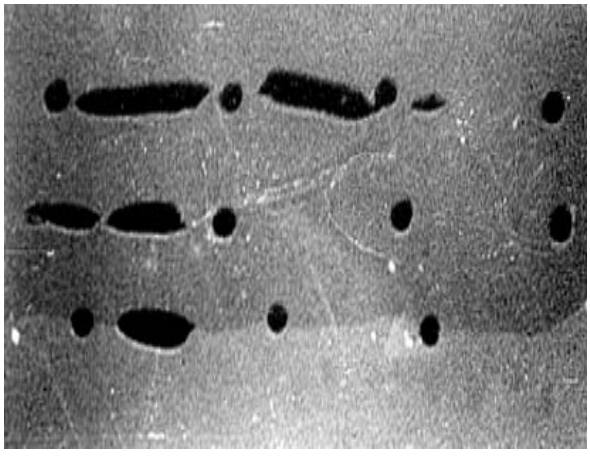

Fig. 4 The stereomicroscopic image of the structure obtained through the explosion cladding process

The moving from the movable plate and the dynamic collision angle, can be represented schematically and principled as Fig. 5.

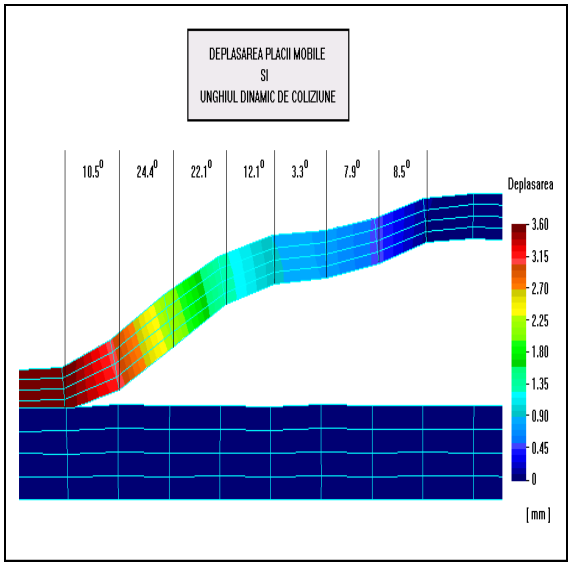

Fig. 5 Moving from the movable plate and the dynamic collision angle

Figure 6 presents the graphic of the moving speeds of the control nodes from the mobile plate [2].

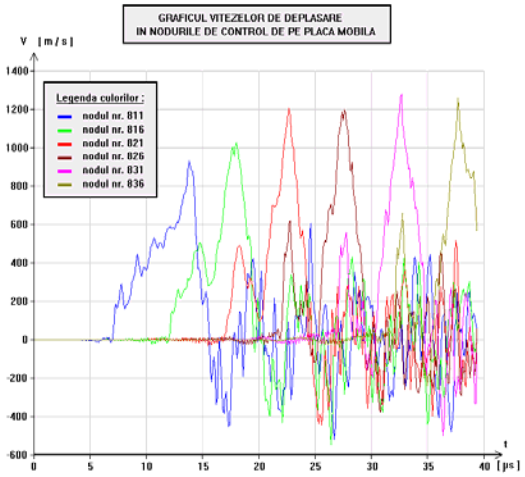

Fig. 6 The Graphic of the moving speeds of the control nodes from the mobile plate

Based on the image obtained through the simulation of the plating through explosion from the Method Finite Elements process, it can be observed the deformed image of the mobile plate at different moments of time [2].

The types of materials submitted, including those obtained by using explosive cladding process once again underline the fact that the layered materials are those that due to the properties they own, can meet the requirements largely [2].

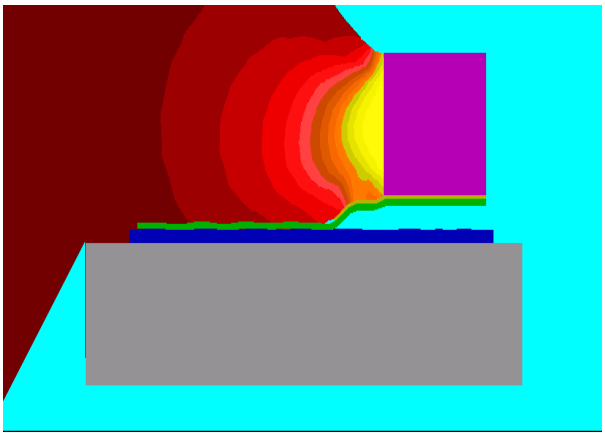

Fig. 7 Presure field in detonation products

Besides the beneficial effects of explosive cladding technology in Fig. 7, some imperfections due to the quality and coated surfaces can be observed.

3 DETERMINATION OF RESISTANCE TO IMPACT STRUCTURE OBTAINED

After obtaining the multilayer samples by the method mentioned previously, we proceeded to the study of resistance to perforation of the structures obtained.

Testing on the perforation resistance of laminated material was achieved by studying its behavior is impacted by infantry ammunition.Images layered structures after impact with infantry ammunition in Fig. 8 and Fig. 9.

After analyzing the test samples puncture found a tendency to stall boards that are part of multilayer structures.

This demonstrates that the presence of steel fabric in the composition of the layered structure corresponding plates plating prevented by reducing the contact surface between them.

Also, you can see that using the area of impact between infantry ammunition and structure of a surface coated with low hardness, favors drilling structure, so the amount of energy consumed is directly proportional to the contact surface hardness. For this reason, the literature recommends using a hard material surface with a role of impact to energy realizaun bigger impact, ammunition, thus decreasing the likelihood of perforation of layered structure studied

Fig. 8 The multilayer structure-mesh stainless steel impact tested

Fig. 9 The multilayer structure impact test your

4 CONCLUSION

Experiments concluded that, in order to obtain multilayer structures using the explosive welding process, various metallic materials proved useful in obtaining sandwich of different materials, in particular, thin slabs, which sometimes is impossible by using traditional welding processes.

From the above, it can be concluded that the trend in the field of research is to obtain new multi-layer materials with high mechanical properties able to satisfy the most demanding technical requirements imposed by the peak.

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DESIGN TELEMAINTENANCE IN THE ARMY OF THE CZECH REPUBLIC

Jan FURCH

Abstract: In this article the author describes particular maintenance systems used in the past, some of which are used also at present. The basic maintenance systems include maintenance after use, preventive maintenance with predetermined intervals, and conditioned-based preventive maintenance - predictive maintenance. These maintenance systems were continuously improved and new ones were added – so called computerized maintenance management system, reliability centred maintenance, and total productive maintenance. The article further describes new methods of performing the maintenance based on so called proactive maintenance with using so called telemaintenance, which may be simply explained as remote-controlled maintenance.

Keywords: Telemaintenance. Maintenance. Corrective maintenance. Preventive maintenance. Predictive maintenance. Computerized maintenance management system. Reliability centred maintenance. Proactive maintenance.

1 INTRODUCTION

Quality and reliability control and the choice of optimal maintenance methods cannot be realised at present without properly functioning technical diagnostics. Thanks to the use of technical diagnostics, the maintenance itself has reached a new level which in a sense may be labelled as a completely new, generation different maintenance system.

Technical literature provides a number of definitions of "maintenance", more or less influenced by their authors or by the force of a norm upon which they are based. For the purpose of this article, the following definition according to [1] is used: "Maintenance is a combination of all technical, administrative, and managerial activities during a life cycle of an item aimed at maintaining the item in condition, or returning it to condition, in which it can perform a required function."

2 DEVELOPMENT OF MAINTENANCE APPROACHES

A vehicle is either in usable or unusable condition. Our aim is to maintain the vehicle in usable condition, which means to prevent its failures and limiting condition. This aim shall be achieved upon the lowest vehicle life cycle costs possible while keeping inherent reliability of the vehicle for the whole operating time. This is manifested in particular maintenance systems since the 1930's until the present, which is shown in Fig. 1. In general, maintenance system approaches may be divided as follows:

1. Corrective maintenance system.
2. Preventive maintenance system – schedule based.
3. Preventive maintenance system – condition based:
   a) predictive maintenance system,
   b) proactive maintenance system.

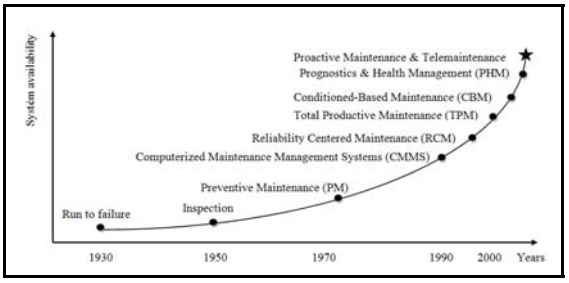

Fig. 1 Development of maintenance approaches since the 1930's [5]

2.1 Corrective Maintenance System

This maintenance system represents the lowest level of the maintenance approach. It is maintenance performed after failure condition has been detected and aimed at bringing the item to condition in which it can perform required functions of the given equipment. In practice this means that the equipment is operated without supervision for its whole durability and maintenance is performed only when a failure occurs. In this case repair costs are high, including loss due to the vehicle being out of operation.

Corrective maintenance (1st generation maintenance) my be applied to simple and cheap machinery in which 100 % backup and prompt repair or replacement may be provided. This type of maintenance is obviously suitable only in these cases:

- The broken part may not be repaired or is not worth repairing.
- The machinery is cheap compared to maintenance costs.
- The part replacement is very fast, technically feasible and economically acceptable.
- No other maintenance method is possible to be performed.

In later years, corrective maintenance started to be completed with so called *Inspection*, the aim of which is to verify the compliance by measuring, monitoring, checking or comparing significant

characteristics of the vehicle performed during the primary failure removal.

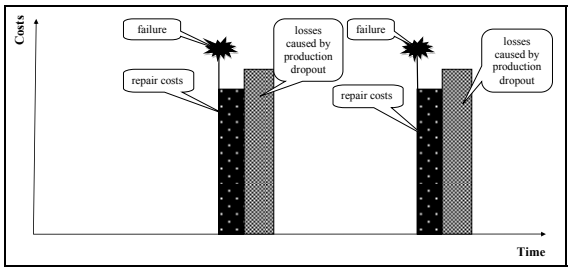

Fig. 2 Cost diagram of corrective maintenance [5]

2.2 Preventive Maintenance System with Predetermined Interval

This system is still frequently used since in principle it comes from the theory of reliability. Upon theoretical reliability and practical experience from a similar technique fixed time intervals are set for performing the "service maintenance", it is so called "schedule-based maintenance". Preventive maintenance is maintenance performed in predetermined intervals or according to specified criteria, and aimed at reducing the probability of failure or degradation of the item operation [1].

An advantage of this system is the prevention of failure and thus reduction of corrective maintenance costs. However, preventive maintenance costs will increase. The aim is to keep the maintenance costs as low as possible. In practice the total maintenance costs are relatively high, but in the overwhelming majority of cases lower than for "corrective maintenance", see Fig. 2 and 3. Another advantage is even distribution of costs in time, and the fact that costs incurred by a vehicle dropout are lower and mostly planned in advance.

A fundamental drawback of scheduled maintenance is the fact that the period (maintenance interval) is often shortened due to the reduction of failure risks and the action is performed on a vehicle which does not exhibit wear signs. Therefore maintenance costs increase and actions performed reduce planned durability of the vehicle. It is true that every useless dismounting and mounting of a part or assembly, or disassembling and assembling the whole vehicle, changes distribution of clearances and brings further unknown static and dynamic loads to the run-in vehicle. This leads to its increased wear and fatigue damage occurrence.

This maintenance system was gradually developed and completed in order to achieve maintenance costs reduction and keep inherent reliability of the vehicle. Higher efficiency was achieved by introducing so called "*Computerized maintenance management system - CMMS*" which leads to significant improvement of the maintenance efficiency by making information on performing individual types of maintenance more available [2].

The schedule-based preventive maintenance system was further completed with so called "*Reliability centred maintenance – RCM*". This method is based on a systematic approach for the identification of purposeful and effective tasks of preventive maintenance which are performed in compliance with a specific set of procedures for determining intervals between the maintenance tasks. The aim is to improve overall safety, availability, and efficiency of the operation. It is also based on monitoring the total vehicle life cycle costs.

Further improvement of the schedule-based preventive maintenance system brings so called "*Total productive maintenance – TPM*". The performance of each organisation depends especially on work organisation, utilisation of basic equipment, and qualification level of its employees. To achieve maximal performance the organisation must utilize optimally the vehicle productivity. In terms of losses, the vehicle maintenance represents a significant area where productivity should be increased and resources for cost reduction sought. TPM utilizes abilities and skills of all employees with the aim to significantly reduce downtimes of vehicles and individual losses in their usage. On this account, organisations are strongly advised to use this progressive approach.

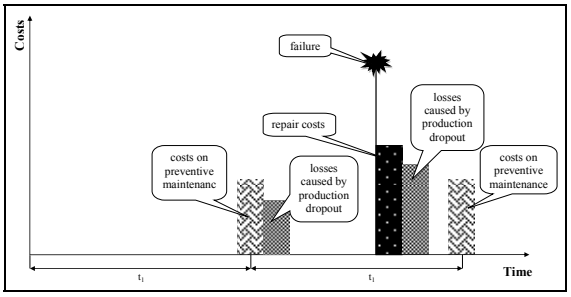

Fig. 3 Cost diagram of preventive maintenance system with predetermined interval [5]

2.3 Preventive Maintenance System – Condition Based

Technical condition based maintenance was gaining importance in past decades with the expansion of technical diagnostics. It is preventive maintenance comprising of monitoring performance or parameters and of consequent measures [1]. 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. This technical condition-based maintenance system may be divided to:

a) predictive maintenance,
b) proactive maintenance.

ad a) Predictive maintenance

This is condition-based maintenance performed upon a prediction derived from an analysis and evaluation of significant parameters of the item degradation [1]. An action is performed on the item only when it is technically and organisationally justified sufficiently enough to maximally exhaust technical durability of the critical part, and at the same time unexpected accident was prevented. In other words, this is maintenance residing in a statement that only that is necessary to be repaired on the item and only then if it is indispensable. The maintenance itself is based on periodical evaluation of technical condition. Maintenance mechanisms applied to the vehicle allow yielding information on the change of technical condition of monitored parts. Such information is processed with the aim to estimate remaining durability, and thus to commence the process of a technical action (remedy). For monitoring signs of developing damages "Condition Monitoring", usage of specialised instruments is required, designed for collecting and evaluating information. These instruments utilize so called technical diagnosis. The equipment is to be monitored and evaluated constantly, or at least periodically.

Costs of the maintenance itself are several times lower than in the previous alternatives. The vehicle downtime for the time required for preventive maintenance is usually negligible in comparison with corrective maintenance. However, initial costs of purchasing the diagnostic systems are relatively high. Therefore it is necessary to consider whether these costs of purchasing the technical diagnostics instruments together with maintenance costs will/will not be higher than maintenance costs without using technical diagnostics.

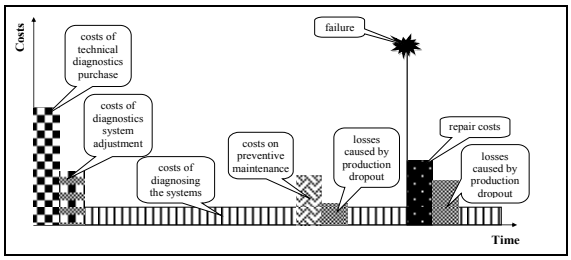

Fig. 4 Cost diagram of predictive maintenance system [5]

ad b) Proactive maintenance

Proactive maintenance is considered another higher level of maintenance. It is completely based on the previous predictive maintenance which it further improves so that its basis is the 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.

3 NEW TRENDS IN MAINTENANCE SYSTEMS

One of the latest trends in maintenance systems is proactive maintenance completed with so called "telemaintenance". The proactivity is manifested also in the fact that new vehicles are designed with respect to an easy access to their integral diagnostics. Possible connection of diagnostic systems, location of sensors and measuring spots for monitoring vibrations, temperatures, lubricant sampling and detection of other selected parameters should be considered during the vehicle design.

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

- 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.

Proactive approach means not only monitoring and evaluating the vehicle condition, but especially performing such actions that prevent or at least postpone damage occurrence. New aspects brought by proactive maintenance [3]:

1) Emphasis laid on long-term stability of the vehicle technical condition. It is monitored with diagnostic signals and statistical methods of their processing. The objective is thus a complex reliability of the vehicle.
2) Consideration of the item technical condition with emphasis laid on future development. The future condition is forecast a longer time ahead and with more complex procession of diagnostic signals. Proactive maintenance lays stronger

emphasis on the analysis of the failure causes and on activities which should prevent them in future.

3) Broad cooperation of all company sections related to the maintained item. An important aspect is strengthening the team in the work of which a broader spectrum of personnel responsible for the item activity participates. Proactive maintenance holds elements of a system scientific approach, to which employed methodical, metrological as well as software instruments must correspond.

4) Bigger interconnection of maintenance and production. Maintenance becomes another tool of the process statistical regulation. Technical condition variation is a source of the variation of qualitative indicators.

5) Qualitative broadening of predictive maintenance while utilizing its advances and information potential. In this meaning it shares with predictive maintenance especially practical performance of individual activities.

The employment of proactive maintenance especially significantly decreases costs of the introduction of diagnostic systems for periodic or constant monitoring of the vehicle operation. Thanks to this the proactive maintenance costs are lower than predictive maintenance costs. Utilisation of "on-board technical diagnostics" leads to the reduction of failure occurrences, which further leads to the reduction of maintenance costs. Further, time to a preventive action is extended and thanks to these indicators costs of losses incurred by vehicle downtimes are lower. Indeed, the vehicle purchase cost will increase. Therefore the main criterion is the total costs of the vehicle life cycle which should be lower.

The latest trend in the maintenance area is so 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 [4]. It is based on wireless transmission of technical data about the vehicle. The main field of its utilization is in companies specializing in long-distance transportation and also in military environment. This method enables on-line monitoring of parameters upon sensors integrated in the vehicle and wireless transmission of the information to a remote computer. This is utilized especially for securing missions in a foreign territory.

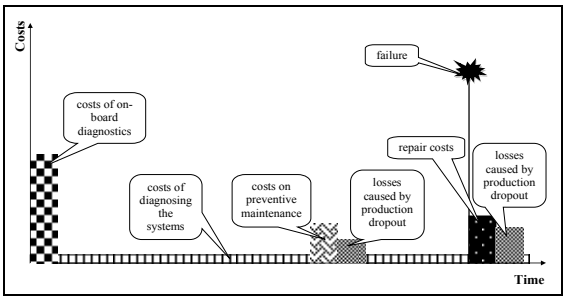

Fig. 5 Cost diagram of the proactive maintenance system [5]

Telemaintenance may be divided to the four following levels:

1. Diagnosed vehicle with a driver.
2. Support logistics centre where a computer processing the 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.

The Fig. 6 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. Here, in case of error messages an advisor informs the driver about the problem severity and advises on the possible problem removal or provides necessary service support.

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

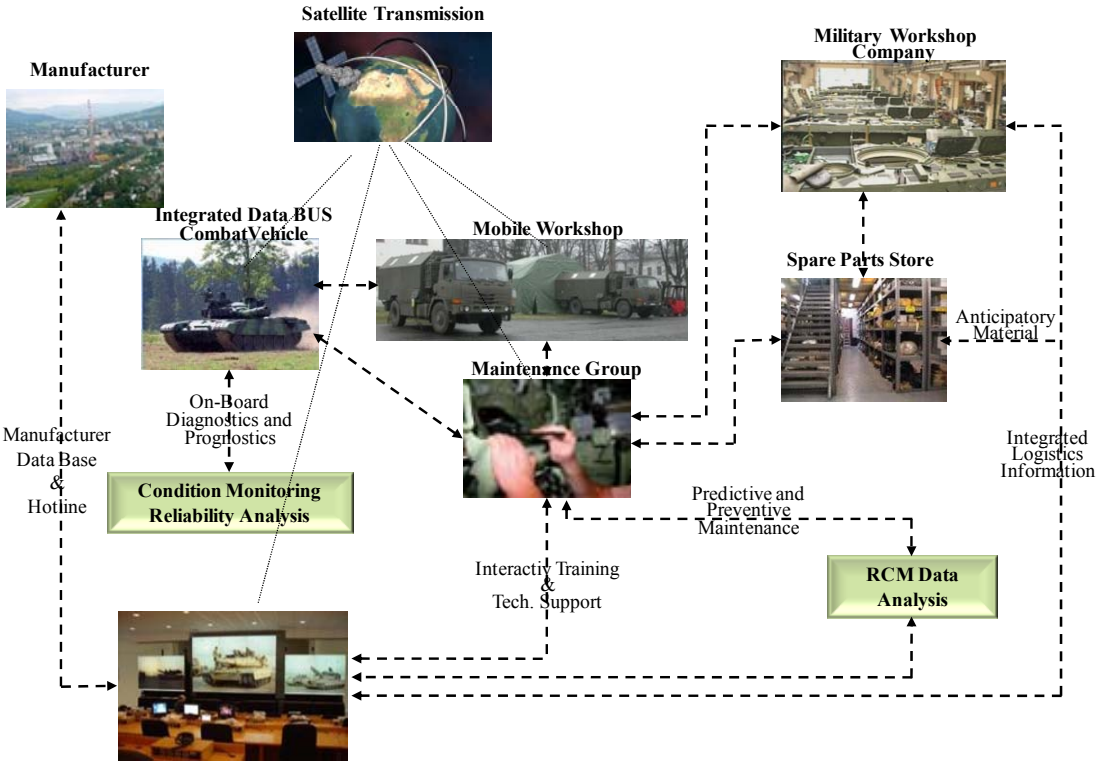

Fig. 6 Telemetry in maintenance system [6]

4 CONCLUSION

The purpose of this article is to introduce to the reader the development of particular maintenance approaches since the beginning of the 20th century to the present. The final part brings a new approach to maintenance based on on-board diagnostics, which is on-line testing of diagnostic signals and their wireless transmission to the telemaintenance logistics centre

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TECHNICAL CONDITION DETECTION OF AIR TANKS IN THE ARMY OF THE CZECH REPUBLIC

Jan FURCH, Josef GLOS, Ondřej RAZÝM

Abstract: The aim of the paper was to make a methodology used for performing the air tank inspections of combat and special vehicles in the Army of the Czech Republic. The main asset of the methodology is introducing a suitable ultrasound gauge which would be able to take measures without removing a coating. After taking a lot of measures and comparing single gauges accuracy we came to a conclusion that the most convenient device is the DM 4 DL ultrasound thickness gauge. This device is suitable namely for finding out the wall thickness of non-dismountable air tanks.

Keywords: Technical condition of air tanks. Air tank inspection.

1 INTRODUCTION

First, it would be desirable to specify the term "air tank" and clarify the way of performing air tank inspection in the Army of the Czech Republic.

The vehicle air tank is a special kind of a stable pressure tank which serves as compressed air storage used for controlling some motor vehicle equipment, trailers and special equipment [1].

No later than every five years since the last inspection the air tank inspection is provided by inspecting certified personnel who observe "The Obligatory Guideline, the evidence number TZ 1/2000 SOTD". The air tank inspection itself consists of the following tasks:

- external examination and the check of coating,
- internal inspection and the check of coating,
- a pressure test,
- a tightness test [1].

After the air tank is mounted back on a vehicle, the tightness test will be performed only if the pressure test has been satisfactory, and the aim of it is to check the tightness of dismantleable joints. If we have reason to believe during the inspection that the wall of an air tank is thinner (because of corrosion for example), we proceed to check wall thickness with an ultrasonic thickness gauge and calculate strength (following Technological Procedure II) [1].

Air tank operation check is performed at least once a year and during this checking an air tank label and air tank condition is visually examined, and also sludge is removed from the air tank [1].

2 TECHNOLOGICAL PROCEDURES OF PERFORMING INSPECTIONS

In the Army of the Czech Republic there have been made two technological procedures. Technological procedure I is a basic document for providing air tank inspections. Technological procedure II is used only when little cracks or corrosion is found during air tank inspection, or an air tank´s label is missing or illegible.

2.1 Technological procedure I

The technological procedure I consists of four main parts. The first part is the shortest one and includes information on taking an air tank by inspecting certified personnel. The air tank is supposed to be clean and labelled. On the label there should be put a battalion number, a vehicle type and the year of vehicle manufacture, and a military number plate.

The second part deals with carrying out an external check during which a coating is examined. The coating should be clean and intact (with no cracks, fragments or hammer-marks). Next, case geometric shape requirements are determined with the maximum deviation 2 mm.

The third part describes the interior inspection of an air tank. First, the inner space of the air tank should be cleaned of impurities and sediments. Then, using and endoscope, the walls should be examined. The aim of the inspection is to find out whether there are cracks on the walls, or if an inner coating is intact, if there is corrosion there, and what the state of the most stressed spots is (edges, welding joints, etc.). When having reason to believe that there are cracks, a capillary test will be performed. Also a colour defectoscopy might be applied which is rather advanced technological procedure. If there are cracks or disintegration of a material due to corrosion, the air tank is examined with Technological procedure II, or is disposed straight away.

The fourth step to be taken is a pressure test. First, the air tank is filled with water. Then, overpressure corresponding with operation overpressure (nominal value stated on a tank label) is created in the tank with a hand pump. Finally by tapping weld joints with a little hammer (the hammer mass is specified by a particular standard) air tank tightness is checked. If no leakage is present, the overpressure will be increased to a test value (1,5 times the amount of a nominal value) and this overpressure is left in the tank till it is examined (at least for 3 minutes). After the test has been completed, we let the water out and the air tank dry up. [2].

The last step which is to be taken is renewing an air tank coating, punching a test date, the next test date and an inspecting certified personnel evidence number on an air tank label (in case the test was successful – no leakage, cracks, or permanent deformities were found). Test results will be recorded in the book of revisions of an air tank revision station.

2.2 Technological procedure II

Technological procedure II is divided into six parts. The first three parts are the same as in the Technological procedure I. Te fourth part describes the way of checking wall thickness with an ultrasonic thickness gauge. The checking is performed in the areas where corrosion was found during inner examination, while observing relevant standards (ČSN 015021 and ČSN 583-1,2,3). The identified value of the smallest wall thickness is later used during proof calculations.

The fifth part deals with a proof strength calculation. The calculation follows the standard ČSN 69 0010. Basic calculations are done for a cylinder case and a torospherical bottom and they are used for counting an allowed number of working cycles and specifying the date of the next air tank inspection. The sixth part of the Technological procedure is the same as the fourth one of the Technological procedure.

2.3 Inspection of non-dismountable air tanks

The previous two technological procedures describe the inspections of air tanks which are removed from a vehicle before the actual inspection. However, in the Army of the Czech Republic there are vehicles, the construction of which makes the dismantling of air tanks impossible, or the dismantling would be expensive and uneconomic. So the air tank inspection of such vehicles is to be tackled in a different way.

When inspecting these air tanks, we focus mainly on careful external examination. In the air tanks with an accessible cleaning valve it is desirable to perform inner inspection with a fibroscope. Following the inner inspection we check wall thickness in corroded areas using an ultrasonic thickness gauge. Before the check is carried out, it is necessary to remove a coating in order to make the measurement accurate. If the air tank is not equipped with an accessible cleaning valve, which means that it cannot be examined with a fibroscope, other air tanks which have been already checked will serve as the basis of determining its condition. After the measurement with an ultrasonic thickness gauge has been completed, braking system will be put into operating state, and by increasing the overpressure to the highest operating value (by a pressure gauge in a driver´s cab), the tightness will be checked, and then the measurement of critical places will be performed again using the ultrasonic thickness gauge. Finally the air tanks´ condition will be evaluated.

Air tanks cannot show signs of misuse, deformation, ruptured welded joint, bumps, the coating has to be compact. The inner part of an air tank can be corroded on the surface. But there cannot be point or inter-crystal corrosion there. The air tanks have to be tight during the highest operation overpressure, and when checking thickness with an ultrasonic thickness gauge, it cannot decrease by more than 5 percent.

3 METHODOLOGY PLAN TO FIND OUT TECHNICAL CONDITION OF AIR TANKS

A methodology plan is based on original technological procedures and the results of the performed accuracy measuring of the ultrasonic thickness gauge DM 4 DL. This gauge is considered to be the most suitable. There is a dual probe in this ultrasonic thickness device which means that a pulse reflection measuring method is applied, see Fig. 1. The device is compact and small sized having a robust case. It is supplied by two AA alkaline batteries providing up to 200 hrs of use. Dialog probes resolution, V path error correction (compensates for non-linearity of dual element probes), zero point adjusting and ultrasonic flow rectification are performed automatically by the gauge. The measuring range is from 0,5 mm to 500 mm, the displayed resolution ranges from 0,01 mm for the thickness of 99,99 mm, and 0,1 mm for the thickness more than 99,99 mm. The period of adjustable ultrasonic wave velocity ranges from 1000 ms-1 up to 9999 ms-1. The receiver bandwidth is from 300 kHz to 10 MHz (amplification setting is three-levelled – automatic, high and low). The measurement update rate is 4 Hz, but it increases up to 25 Hz in a minimum capture mode. [2].

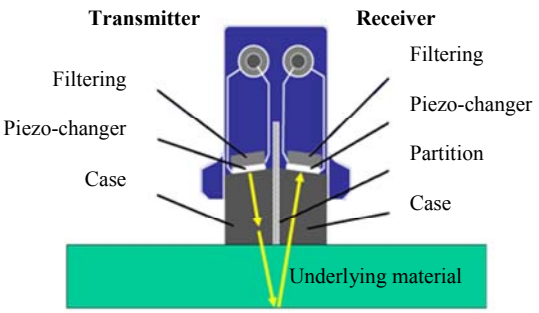

Fig. 1 Parts of a dual probe [6]

When measuring the thickness with the reflection method Dual-Multi, the ultrasonic wave is sent into

the material under test (gel is used as a contact material/interface between the probe and the material under test) and travels through the material until it encounters an interface, that is a material with different physical characteristics, such as air, paint, corrosion, etc. At the interface the pulse is reflected back to the probe, see Fig. 2.

We also measure the time needed for the wave to make this round trip. If we know the velocity of ultrasound proliferation in the environment *c*, it is possible to calculate the thickness of the material under test with the following equation (1).

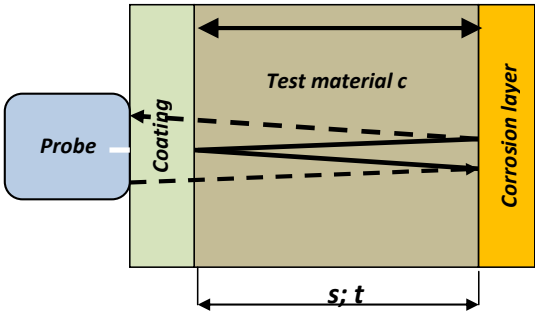

Fig. 2 The way of measuring thickness with the DM 4 DL gauge applying the Dual-Multi method

A mathematical expression of the thickness of the material under test is as follows [3]:

$$s = \frac{c \cdot t}{n} \text{ [m]} \qquad (1)$$

where:

s .....is the thickness of the material under test,
c..... is the velocity of ultrasound proliferation in specific environment,
t..... is the time for the ultrasonic wave to make its round trip,
n..... is a number of wave passages through the object under test.

In a common military environment are used simple ultrasonic thickness gauges which are calibrated to the ultrasound wave velocity typical for steel, which is 5920 ms^{-1}. More complex gauges, such as DM 4 DL, enable the velocity to be changed flexibly depending on the structure of the material to be measured.

A probe is an essential part of each ultrasonic thickness gauge. When measuring, two probes DA 451 (Fig. 3) and DA 312 B16 (Fig. 4) were used.

Fig. 3 Probe DA 451

Fig. 4 Probe DA 312 B16

The DA 451 is a commonly used dual probe. Its measuring range is from 1,2 to 200 mm, and contact diameter is 12,5 mm. The curvature of the surface to be measured with the probe should be at least 15 mm. Probe frequency is 5 MHz and accuracy ± 0,05 mm. The DA 312 B16 is a special miniature probe with a measuring range from 0,6 to 25 mm of 10 MHz frequency. Since the contact diameter is 3 mm, the probe is used for measuring very small radii and hole corrosion [4].

3.1 Plan of air tank methodological procedure

Air tank demounting (only for the air tanks which might be demounted from a vehicle) and taking for inspection.

An air tank is demounted from a vehicle and then taken for inspection. The air tank is to be free of dirt and provided with a label containing a device number, a type, the year of manufacture and a vehicle evidence number. In case the air tank cannot be demounted from a vehicle, the whole vehicle is taken.

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2) Air tank preparation for inspection

All valves and other parts will be removed from an air tank. If there is a label on the air tank which is not fastened enough, non-hermetically welded, or illegible, it will be replaced by a new one with the information taken from a service place revision book. The reason for removing the label is corrosion under the label which occurs rather frequently, because water and damp might get there (see Fig. 6). Next, all holes will be sealed and a surface will be cleaned depending on the amount of dirt. To clean it, organic solvents, such as petrol for technical use, paraffin oil and diesel are applied. As for non-flammable organic solvents, we use perchlorethylene, trichloroethylene, etc. Regarding alkaline water solutions, the cleaning agent of a Synalod production marking might be applied. If there is corrosion on the external side of an air tank, it can be removed either mechanically or chemically. To remove it mechanically, we use different brushes and sandpapers. In order to remove it chemically, we apply rust-removers like Rezol 2000, Loctite or Pragokor 100. As to the air tanks which cannot be dismounted from a vehicle, all the above operations

will be performed the same way, but with an air tank placed on a vehicle.

Fig. 5 Corrosion present under an air tank label

3) External air tank checking

The prime aim of external check is to examine whether a coating stayed intact. The air tank cannot show signs of hammer blows, cracks or breaches. If we have reason to believe that there are cracks, it is necessary to carry out the check using a capillary test. The conditions of welding joints and deviations from air tank geometric shape are also examined.

4) Internal air tank checking

When checking an internal tank, it is necessary to have the inner surface clean and free from impurities. If it is not, the surface is to be cleaned. After this, the visual inspection might be performed with a light viewer or an endoscope. Borescopes, fiberscopes and videoscopes work on the endoscope principle. The most up-to-date endoscopes are videoscopes which consist of a probe equipped with a miniature video camera. With software they enable us to quantify spotted defects. When performing the internal inspection, we concentrate on the presence of cracks, deformations, corrosion, the condition of bevelled spots and higher stress spots.

Following the actual results, relevant measures will be taken. If there is reason to believe that there are cracks or corrosion, a capillary test will be performed and the spot will be checked with the DM 4 DL ultrasonic thickness gauge.

5) Air tank checking with an ultrasonic thickness gauge

When checking air tanks with ultrasonic thickens gauge, it is highly recommended that the DM 4 DL is to be used. The biggest advantage of this gauge is its ability to measure through an external coating. The first step when using the gauge is the calibration of it, but since a standard calibration is impossible to make, all we can do is set the velocity of ultrasound waves in the material. At present the only alternative is to set the 5 920 ms^{-1} speed which is a speed for steal. But not all air tanks are made of the same material, therefore it would be advisable to develop a database containing speeds used for single air tanks. The database might be filled basically by two different ways. The first one is to get the information directly from the manufacturer, and the other one is to take the measurements of disposed air tanks. The air tanks will be cut in two and then, having gauge precise calibration, we will calculate ultrasound speed used later for measuring air tanks.

After the velocity is set, the areas which have been selected in advance will be measured. The areas will be chosen on the basis of internal check results. Generally, the most exposed areas are those at the bottom of an air tank, namely the ones close to cleaning valves, welded joints and under labels, as it has been mentioned before.

The measurement is taken after presetting the function Dual-Multi (that means without removing the coating) by moving slowly the probe DA 451 along a critical area. The device can be set for a few modes. The most convenient mode is called differential measurement where a nominal thickness value is set by the user. Then, the areas which approximate this value or are of smaller values are searched for. Another option is the mode MIN which is used to capture the thinnest value. Using this way, the weakest areas of an air tank are found. They are marked by inspecting certified personnel and the measurement of these areas are taken with the DM 4 DL gauge in the THK mode. Each area is measured three up to five times. The mean value of the measuring is calculated and then the values as well as the point location are recorded in a measuring report.

As for non-dismountable air tanks, it is determined that at the bottom part of an air tank the area of an imaginary rectangular, the length of which equals the air tank and the width equals one fifth of an air tank diameter value, will be checked by the DM 4 DL ultrasonic thickness gauge using the following formula:

$$d = \frac{D}{5} \text{ [mm]} \tag{2}$$

where:
d .... the width of an imaginary rectangular,
D.... an air tank diameter.

The thickness of an air tank wall must by no means drop below a critical thickness value which is determined as follows:

$$d_{crit} = 0{,}95 \cdot d_{nom} \tag{3}$$

where:
d_{crit} ...is critical air tank wall thickness,
d_{nom} ..is nominal air tank wall thickness.

If the displayed value is not stabilized in the ± 0,02 mm range, it will be necessary to use the probe DA 312 B16. Provided that the value is still not stabilized, inspecting certified personnel switch off the Dual-Multi function, remove the coating from the examined area and perform the measurement.

The record of the performed measurement will be available in the service place and will serve as a basis for next inspections. To calculate the strength

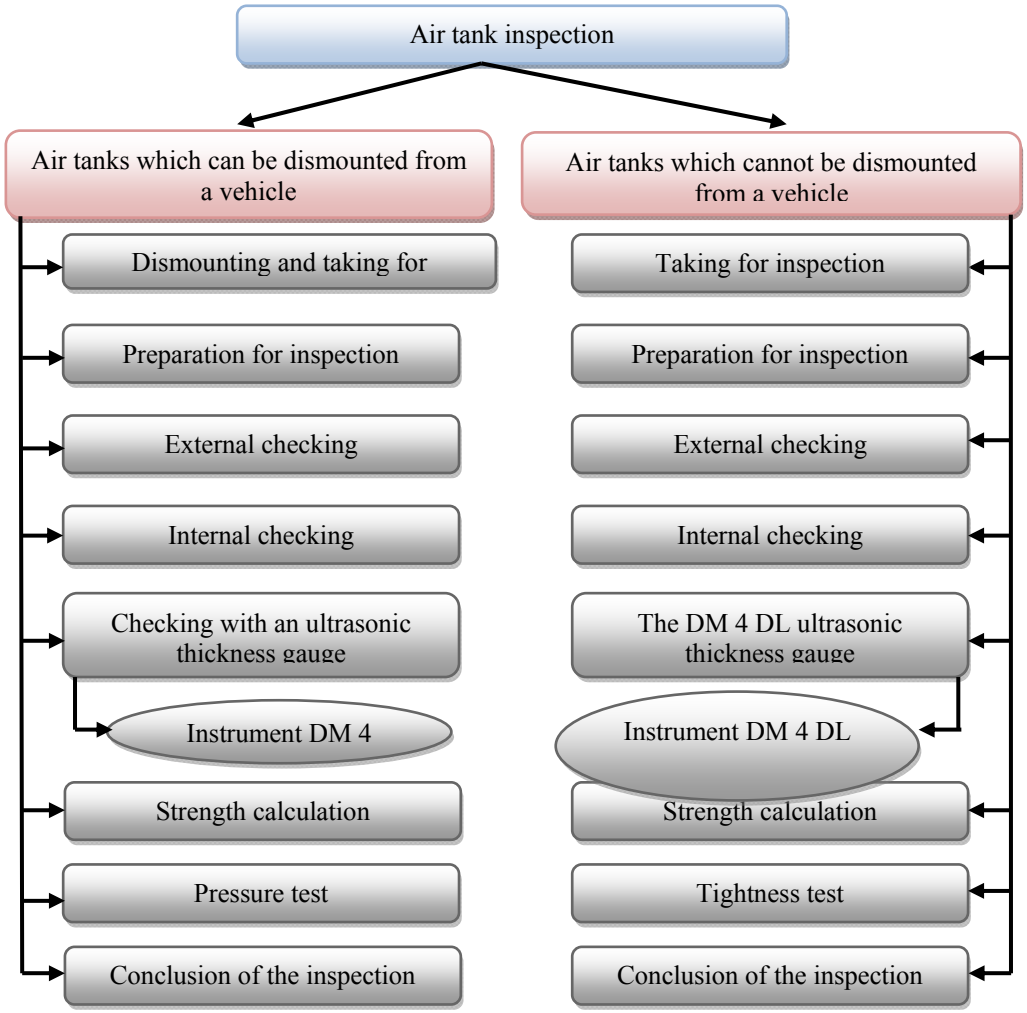

Fig. 6 Diagram of suggested methodology for performing air tank inspection

we need to have the measured value of wall thickness in the narrowest place.

6) Strength calculation of air tank thickness

To calculate the strength we need to have the measured value of wall thickness in the narrowest place. The calculation itself is done in compliance with the standards ČSN 69 0010 – 4.5, 4.7 and 4.12.

To calculate the wall thickness (minimum operational thickness) without added material we apply the following equation [5]:

$$s_R = \frac{p \cdot D}{2 \cdot \sigma_D \cdot \varphi - p} \text{ [mm].} \quad (4)$$

The minimum air tank wall thickness (operational thickness) is as follows [5]:

$$s \geq s_R + c \text{ [mm]} \quad (5)$$

where:

s_R ....wall thickness without added material,
p .....operating pressure,
D ....inside tank diameter,
φ .....longitudinal weld coefficient (0,5 to 0,8; for torospheric bottom it is 1),
σ_D ...tolerable stress of a cylinder case,
c .....material added for corrosion and manufacturing tolerance.

7) Pressure testing of demountable air tanks

The pressure testing of an air tank is the main activity when performing air tank inspections. While putting air tanks to test, the testing beds of pressure tanks having different designs and parameters are used. A more detailed description is available in the Technological Procedure II.

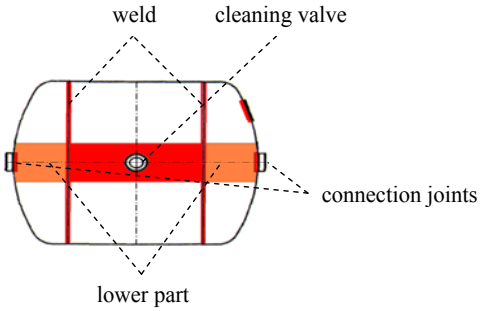

Fig. 7 The most corroded areas of an air tank

8) Tight testing of non-dismountable air tanks

A brake system including air tanks are put into operating state (pressure). Then, the operation overpressure of the braking system is checked using a metrologically certified pressure gauge placed in a driver´s cab. In case the pressure drops, the tightness of joints, pipes and air tanks is checked. The system tightness is verified with an ultrasound tightness detector. If the testing turns out to be positive, the air pressure will be decreased to the highest operation overpressure and the tightness of all air tanks will be checked. After ten minutes the tightness test is repeated again. The condition will be recorded in the documentation.

9) The end of inspection

When the inspection comes to an end, an air tank will be dried, a coating will be renewed, a cleaning valve will be screwed in and everything will be recorded in the documentation. Besides keeping a record in the book of revisions, a revision certificate will be written out, relevant data will be punched in an air tank label, or a new label will be attached. We expect in our methodological procedure that when the inspection comes to an end, ultrasound testing result will be evaluated and finally recorded in an information logistics system (compliance/rejection of the pressure testing results; in case of rejection, the graphical record of plot will be uploaded and described).

4 CONCLUSION

The aim of the paper was to make a methodology used for performing the air tank inspections of combat and special vehicles in the Army of the Czech Republic. The main asset of the methodology is introducing a suitable ultrasound gauge which would be able to take measures without removing a coating. After taking a lot of measures and comparing single gauges accuracy we came to a conclusion that the most convenient device is the DM 4 DL ultrasound thickness gauge. This device is suitable namely for finding out the wall thickness of non-dismountable air tanks.

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THERMAL STRESS SOLUTION OF A VEHICLE BRAKE SYSTEM

Vlastimil NEUMANN, Štefan ČORŇÁK

Abstract: Paper is focused to thermal stress (running) of the vehicle brake system, because the brake system function affects the vehicle safety. One of basic parameters, which affect brake system function, is brake fluid quality. Brake fluids on the glycol base are one of the most extended brake fluids. Because, these fluids are hydroscopic, is necessary to observe process of the brake thermal stress and running. Our research is focused to creating mathematic model of the brake and simulating the brake conditions. At the first it was created simplify mathematic model and made experiment. Created simplify mathematic model of the wheel-brake disk of the vehicle correlates with experimental measuring data. Outputs from the simplified simulation are starting data for the complex wheel-brake disk model creation and for simulation. For its finalization is necessary to make next experimental measuring of others input and reference data.

Keywords: Heat transfer. Breaks. Simulation.

1 INTRODUCTION

Function of the brake system fundamentally affects the vehicle safety. One of basic parameters, which affect brake system function, is brake fluid quality.

Brake fluid supports next functions: force transport (from main brake cylinder to brake frictional elements), lubrication and protection against corrosion.

Brake fluids on the glycol base are one of the most extended brake fluids. These fluids are hydroscopic, i. e. absorb water. Water is absorbed to the brake fluid mostly thought brake expansion tank cap in the practice operating. Result of the water rising in the brake system is gradual worsening of the brake system up to breakdown. During intensive breaking (long and protracted falling) the vehicle brakes are very stressed by the thermal load. This thermal load affects other ambient parts.

High friction elements temperature and high water content in the brake fluid could affect generation of steam cushions in the hydraulic system. This steam generation affects "free travel of the brake pedal" – just only gas compression in the hydraulic system (gas – steam is compressible in contrast to brake fluid) and operating force is not transmitted to the friction elements.

This is the reason, why is, from the operating view, necessary to monitor initial boiling point of the brake fluid during their using and process of the vehicle brake system thermal load in the operating.

The aims of the work are to make mathematics model of the vehicle brake system and proceed experimental measure of the brake thermal stress to the ensuring the mathematics model.

2 MATHEMATIC MODEL

Mathematic model was created for vehicle Land Rover 110 SW. Mathematic modeling and thermal solving (thermal load of the brake friction elements) were made by finite element method in software MARC/MENTAT MSC.SOFTWARE.

Mathematic modeling was divided to two parts. The 1st for verification of material constants (simplified brake model – without friction, input thermal load is defined by heat flow, which is fed into friction side of brake pad). This simulation is relatively fast and sufficient for material constant confirmation, especially of friction material constants.

Next step is brake mathematic model creating and thermal load monitoring depending on breaking intensity. This model is not still finished. For its finalization is necessary to make next experimental measuring of others input and reference data (like adherence pressure, temperature of wheel-brake disk, temperature of the brake fluid, pressure in the brake system, wheel rotation speed).

In this paper will be presented results from the 1st mathematic model.

2.1 Mathematic formula for thermal transfer

Fourier-Kirchhoff formula is basic formula for non-static thermal transfer solving:

$$\nabla \cdot (\lambda \cdot \nabla \cdot T) - \rho \cdot c \cdot \frac{\partial T}{\partial t} + Q = 0 \quad (1)$$

where: T – temperature [K], ∇ - Laplace operator, λ – Heat conductivity coefficient [$W \cdot m^{-1} \cdot °K^{-1}$], ρ – Specific weight [$kg \cdot m^{-3}$], c - Specific thermal capacity [$J \cdot kg^{-1} \cdot °K^{-1}$], Q - inside thermal sources intensity [$W \cdot m^{-3}$], t – time [s].

It is necessary to set conditions of definiteness for solving of the equation:

- geometry,
- physical properties of used materials,
- initial conditions,
- marginal conditions.

2.2 Initial and marginal conditions of the simulation

There are shown physical properties of brake component materials in the Table 1.

Initial temperature of the friction elements and surroundings temperature are the same as initial experiment temperature, it is 8,5 °C.

Marginal conditions: All elements remove heat to surroundings, there is not friction contact between the brake pad and wheel-brake disk, on the friction side of the brake pad is inducted thermal flow.

Thermal flow magnitude is defined by the next formula:

$$q_i = \frac{\frac{1}{16} \cdot m \cdot \Delta \cdot \left(v_i^2 - v_{i-1}^2 \right)}{S} \tag{2}$$

where: m – vehicle weight; Δ - braking allocation to the front axle during breaking; v – vehicle speed; S – friction surface.

Thermal flow process is shown in the Fig. 1.

Table 1 Physical properties of used materials

Material	Specific thermal capacity c [J·kg^{-1}·°K^{-1}]	Specific weight ρ [kg·m^{-3}]	Heat conductivity λ [W·m^{-1}·°K^{-1}]
Friction material	15	4700	807
Steel	19	7850	250
Cast iron	24	7270	470

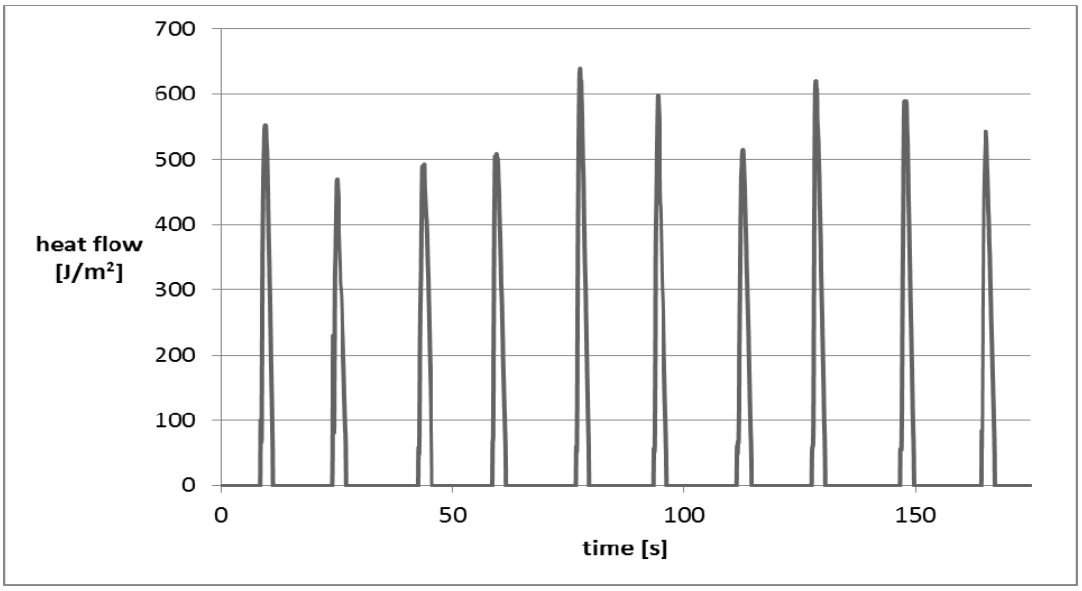

Fig. 1 Thermal flow, which is inducted to the friction surface of the brake pad

2.3 Created mathematics model

At the start, we have made very simplified model for material characteristics validation. It´s advantage is time saving. This model is shown in the Fig. 2 and results from the simulation in the Fig. 9.

Next step was creating more detailed model.Created model of the friction brake elements and the closest surround was parceled to the finite element net. There were used eight node finite elements HEX.

2.4 Simulation outcomes

Thermal load of the vehicle Land Rover wheel-brake disk was simulated for repeated intensive braking mode (from 60 km/h to 0 km/h).

There are shown elected outcomes from the simulation in the next figures. Temperature waveform is shown in the 3rd chapter.

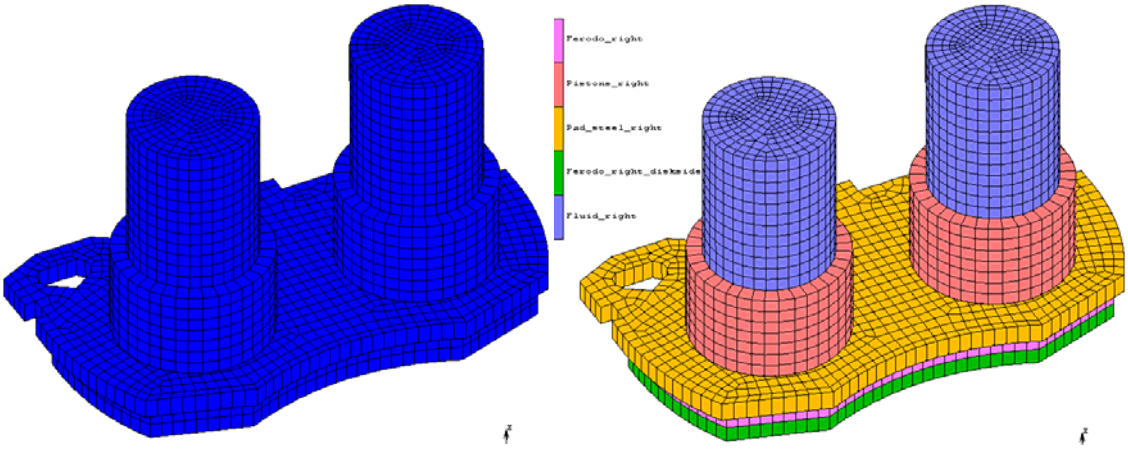

Fig. 2 Simplified mathematic model (at the start)

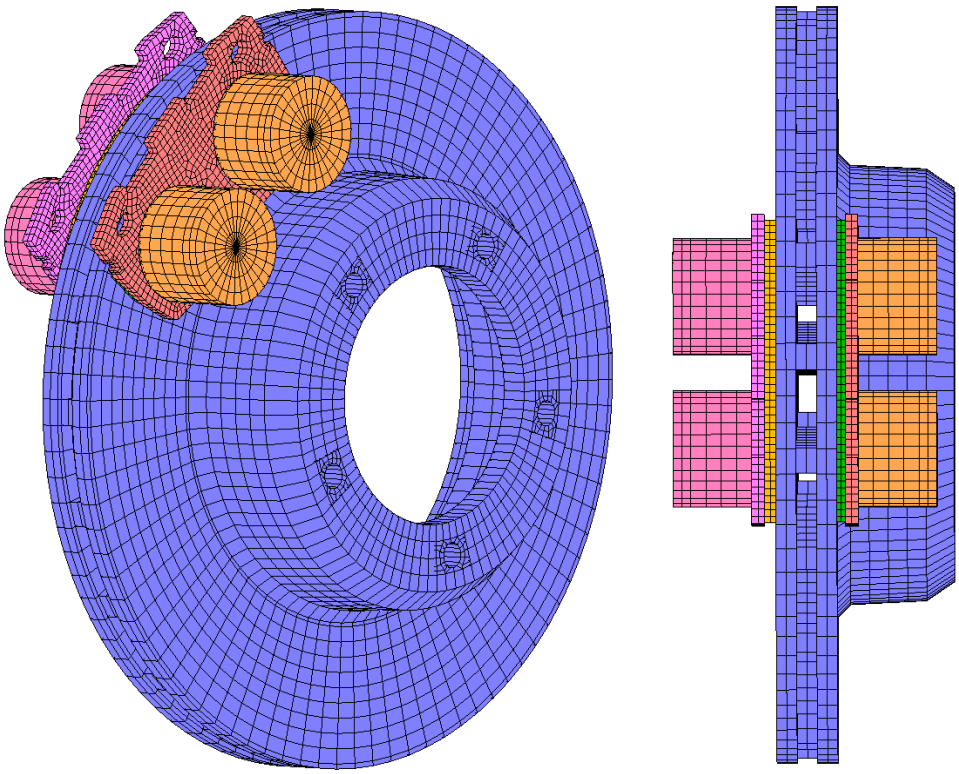

Fig. 3 Created mathematic model

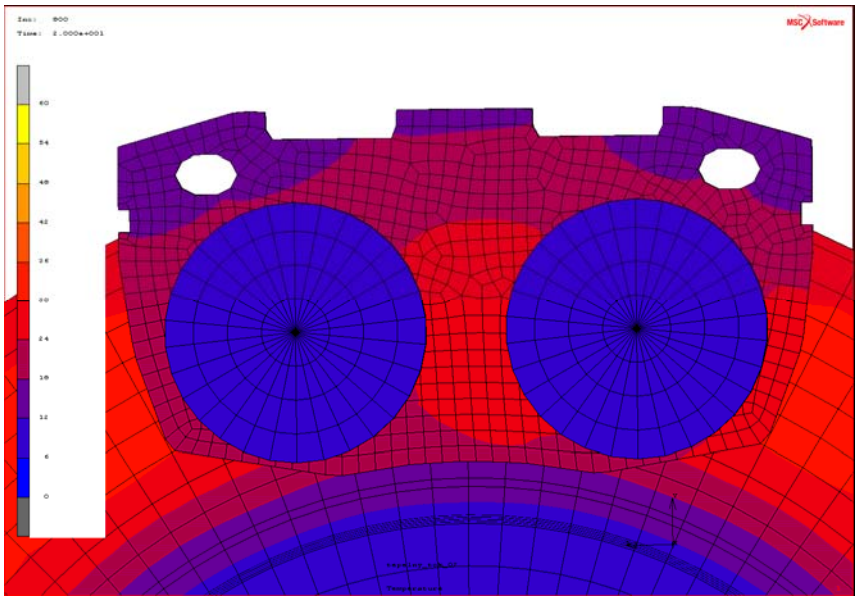

Fig. 4 Temperature field in time 20s

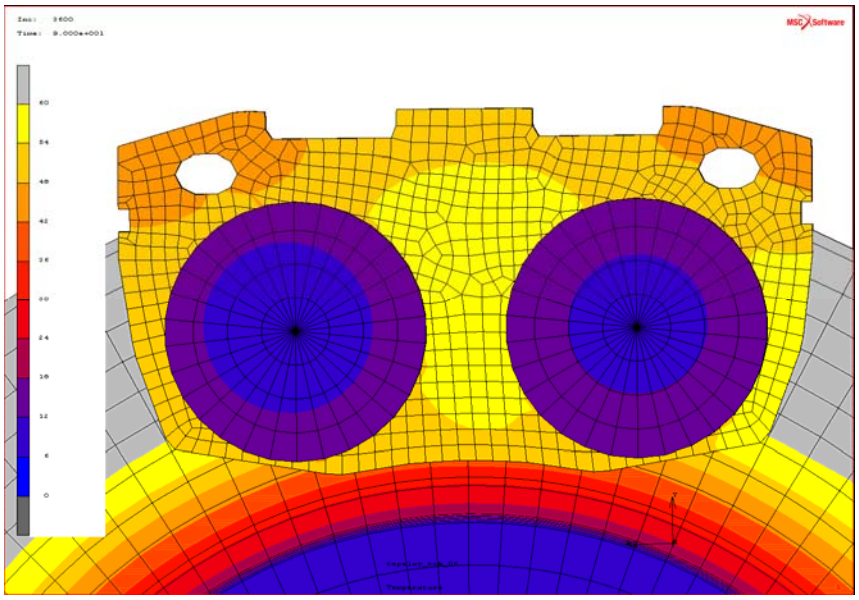

Fig. 5 Temperature field in time 90 s

3 EXPERIMENT

Experimental measuring was made on the vehicle Land Rover 110 SW, as well as simulation. There were chosen next methods to the monitoring of brake system temperature load:

- measuring of the brake pad outside temperature by thermojunctions,
- measuring of the vehicle acceleration (deceleration).

Measuring and recording technique:

- thermojunctions on the friction pads - TTOKO30, Omega, wire diameter 0,22 mm,
- accelerometer – capacitive B1, Seiko Kempten, ± 3 g, fm= 100 Hz, (4),
- universal amplifier BMC Messtechnik – thermojunctions processing,
- measuring system MU1, MaS Brno – digital recording, frequence 250 Hz.

3.1 Experiment preparation

Brake pad was adjusted for thermojunctions placing. There were applied used brake pads for the experiment (thickness 4,45mm on the left side (lb) and 3,36mm on the right side (pb)). There were rabbeted slots (width 1mm, depth 1mm) in the

middle part of the brake pads (at wheel cylinder side). The thermojunction was inputted to the slot and it´s measuring end was fixed to the bottom of the slot by soft copper. Whole slot with thermojunction was embedded by high temperature cement EP 250, HBM. Then, the brake pads were burned for one hour at 250°C temperature.

Accelerometer was fixated under rear line of seats by magnet.

Fig. 6 Brake pad with thermojunction

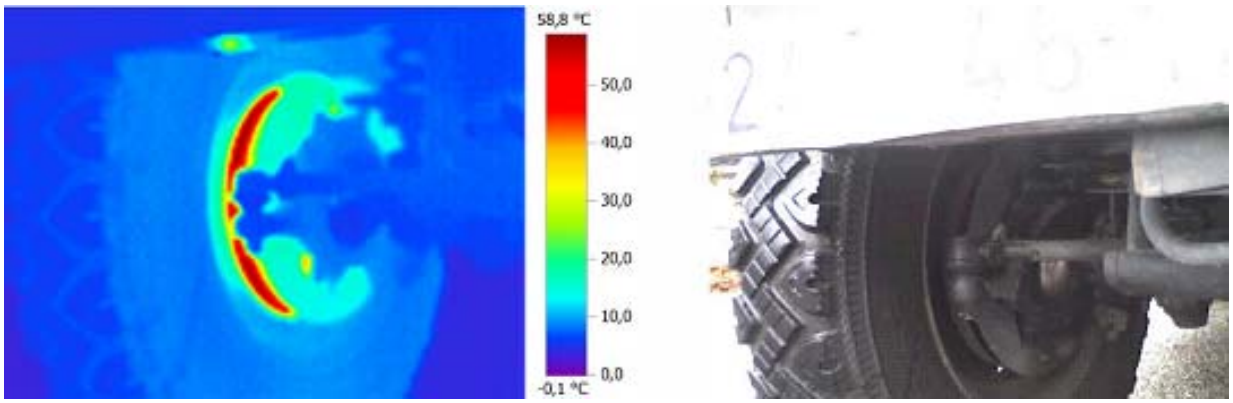

Fig. 7 Thermal field registered by thermo camera Testo 880

3.2 Process and outcomes of the experiment

Experiment was made during the repeated intensive breaking from 60 km/h to 0 km/h on the flat road inside the close object (22x). There are shown the outcomes of the measuring in the Fig. 8.

4 SIMULATION AND EXPERIMENT COMPARISON

There are shown the temperatures running in the Fig. 9 and Fig. 10.

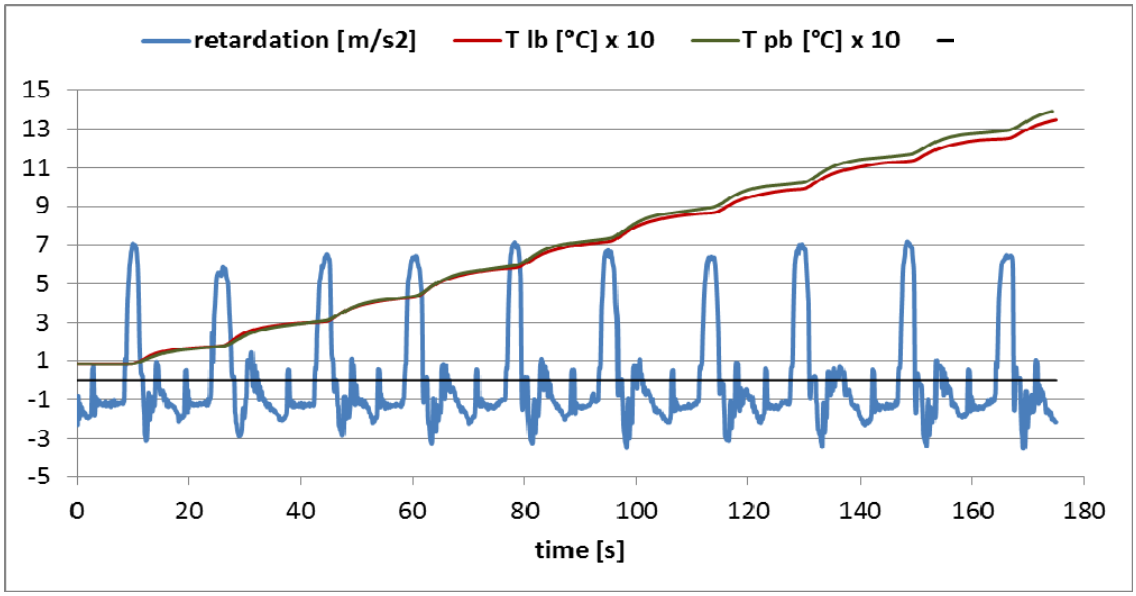

Fig. 8 Measuring data

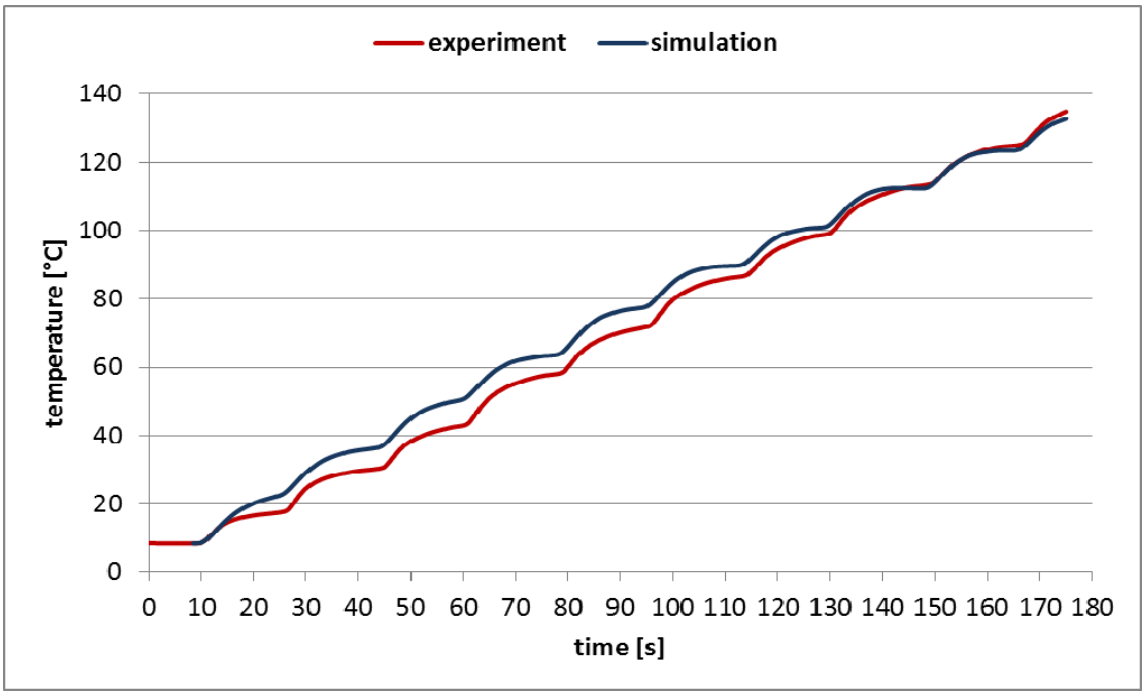

Fig. 9 Temperature comparison of the simplified – started model (in the selected point)

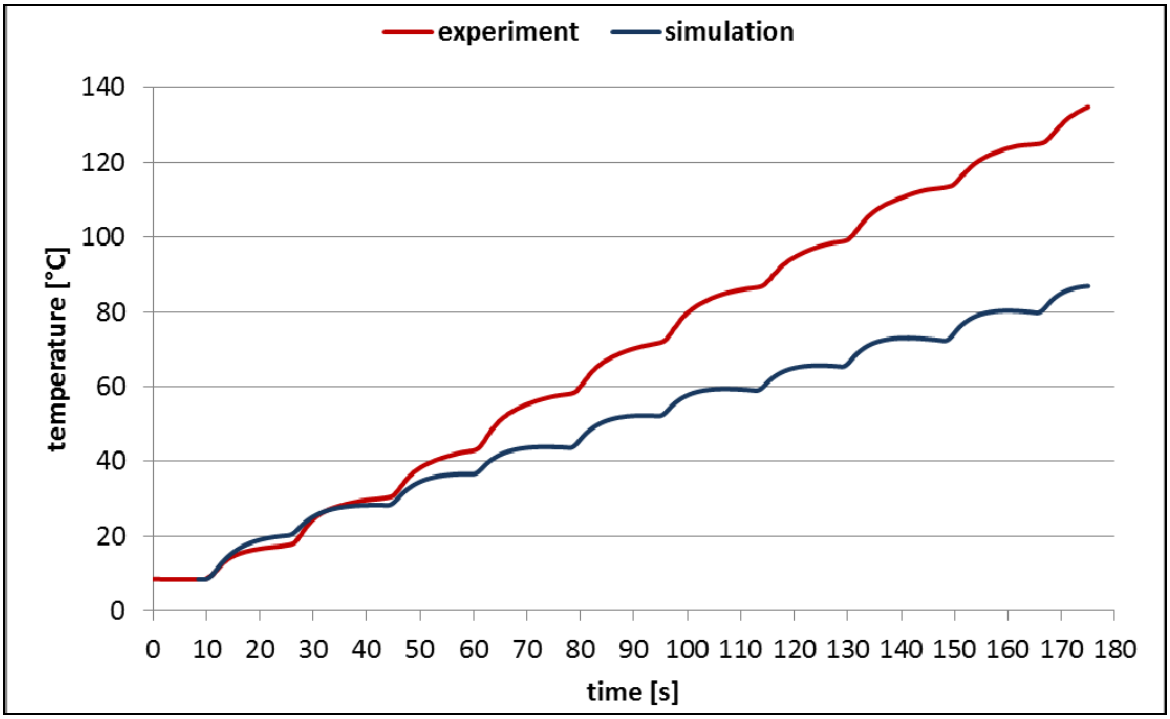

Fig. 10 Temperature comparison (in the selected point)

5 CONCLUSION

Created simplified mathematic model correlates with experimental measuring data. Material constants were verified (correlated) by this model.

There are shown some differences (Fig. 10 – temperature comparison) between the experiment and simulation data. Physical properties of used materials in the simulation were used constant. In the reality it is function of the temperature. Definition of the body contact has influence on results, too. So, this could be the main reasons for this difference.

Next steps of our work are to define these functions of the properties of used materials and make friction model of the brake. For its finalization is necessary to make next experimental measuring of others input and reference data, like adherence pressure, temperature of wheel-brake disk, temperature of the brake fluid, pressure in the brake system, wheel rotation speed.

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FRENCH EXAMPLE ON THE MECHANISM OF ORGANIZED METAL THEFT WITHOUT FRONTIERS

Gábor ERDEI

Abstract: The author has used French examples highlighted in the context of organized crime. The danger and the threat of criminal organizations have grown significantly. They are not properly regulated and controlled. Economic enterprises may be found behind the organized groups in which the qualified business and financial market enterprise are related to the crime. One of the economic aspects of organized crime is the illegal metal trade which continues to represent challenge and danger.

Keywords: Organized crime, social processes, lack of capital, illegal, or not properly regulated and controlled enterprises, tax laws, money laundering, organized crime groups, asset statements required.

The organized crime groups, that, during the professionally commited crimes, make efforts to bribe the competent public officers, are not shy to be violent if their interest requiers that. Nowedays the organized crime develops and depends on the political, social and economical developement of a given country. As an example we can talk about the italian mafia families and the chinese triads. [1] The organized crime knows no borders and only the effective and well coordinated international cooperation can fight them. [1]

One of the economical aspects of the organized crime is the illegal metal trade which is accomplished by the members of the organized crime. The definitions of the term "organized crime". The European Union specialist group (PC-S-CO) has determined the main characters of the organized crime which can be found also in the hungarian regulations. Three or more persons commit crime in organization on long term to profit from them or to get into power. The members of the group have concrete and well determined tasks, so they apply violance if needed, in order to extend their influence and to use the corruption as much as possible they put pressure on politicians, on the members of the media, on the public administration, on the organs of supervision, on the justice and on the members of the economical life. [2]

Compared with other countries we can say that in our country the crimes commited by groups smaller appeared later. It has two main reasons: social procedures were strictly supervised and the individuals suffered from lack of capital.The socialist administration denied the existence of this phenomenon for a long time because it did not fit the official ideology of those times. The organized crime is supposed to have appeared at the time of the so-calles pre-privatization but it was present untill the end of the privatization. The enormous accumulation of wealth and property could be realized because of the social and economical proderures and the errors of legal system. Now the organized crime has such a huge capital that it can purchase the most advanced technical means and it can corrupt the collaborators. [3]

After the change of system the creation of the criminal groups was promoted by the policy, the economical background and the legal system. The defects of the legal system, the lack of strict controll fomented the creation of illegal accumulation of wealth. The organized crime invests its wealth in other illegal activities but it also tries to find legal possibilities to invest. Within the European Union the capital, the goods and the individuals can circulate freely which generates not only positive affects. [4]

It makes it easier for the members of organized crime to hide the illegal wealth and to avoid to be tried. By crossing the hungarian border one enters automatically the EU and can circulate in the member countries freely. The elimination of the custom control of internal borders is a considerable problem. [2]

The organized crime groups can operate within not properely regulated and controlled companies and in this case the qualified and sophisticared economic and financial expertise is linked to the crime. [2]

In France the quantity of re-used precious metal grew from 1.3 million tons in 1999 to 1.7 million tons in 2006 which means a 144 % growth during 7 years. [2]

In some of the member countries of the European Union the provisions of law on taxation enable the authorities to distrain or confiscate the illegally gained wealth without any obligation of proof. That is why the "whitening" of illegally gained money into the legal economy is achieved by imitated transactions which virtually means the legalization of the money. The creation of the possibility of legal taxation is achieved by converting the gained wealth into the legal economy. [4]

Cases between 2006-2008 Taking into consideration the fact that establishing legality is not an easy task the authorities are enabled to find out whether the money transactions were instigated by criminal act. [6]

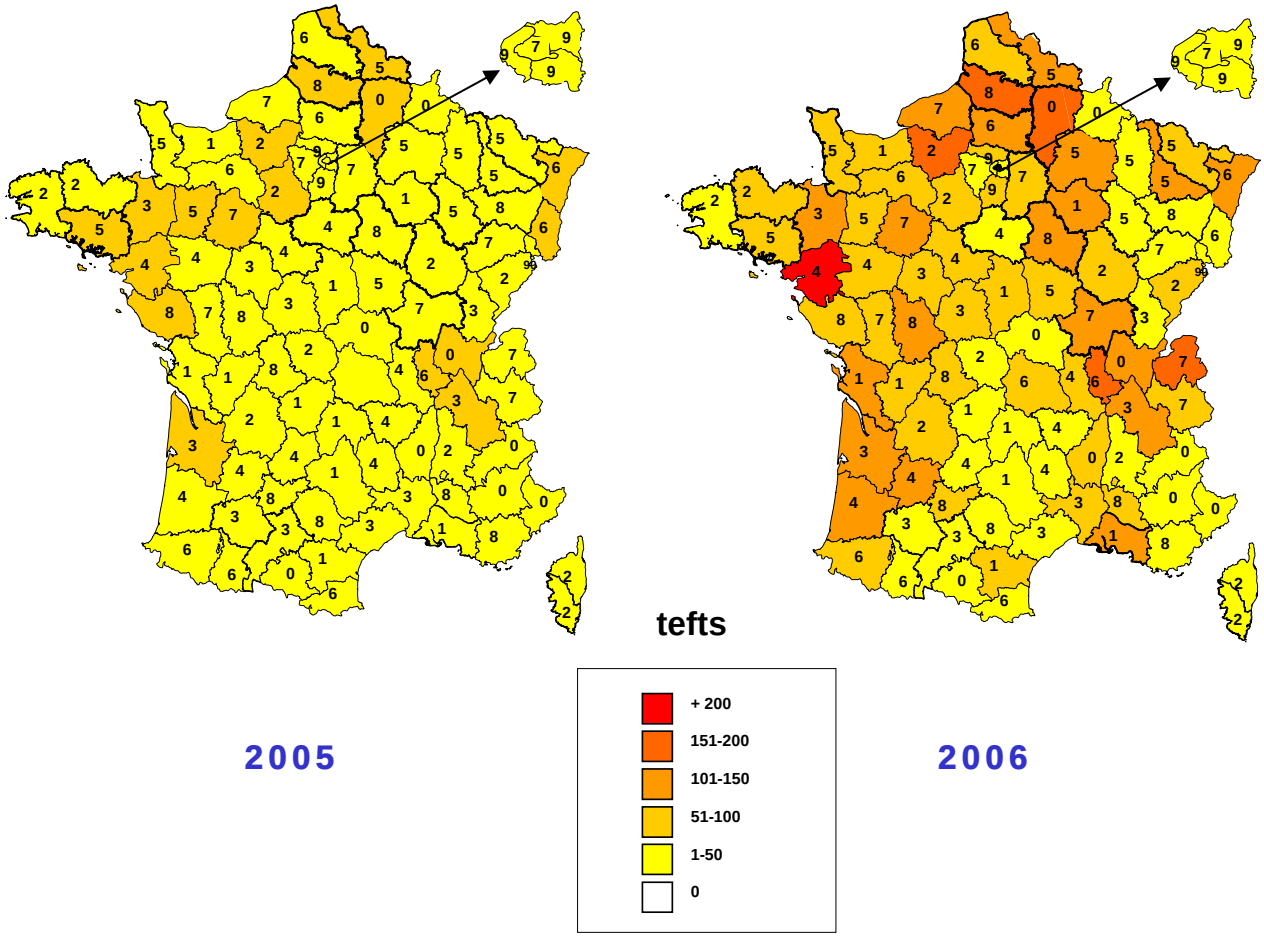

Fig. 1 2005-2006: + 144 % thefts
Source: ORFK Tájékoztató, 2008. [5]

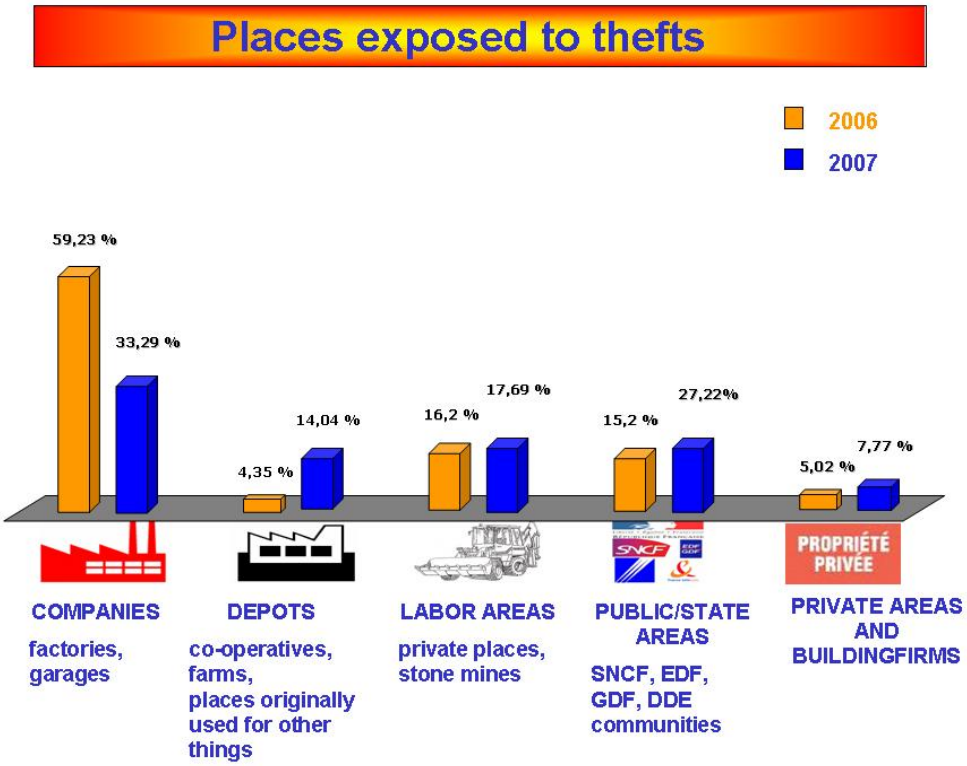

Fig. 2 Places exposed to thefts
Source: ORFK Tájékoztató, 2008. [5]

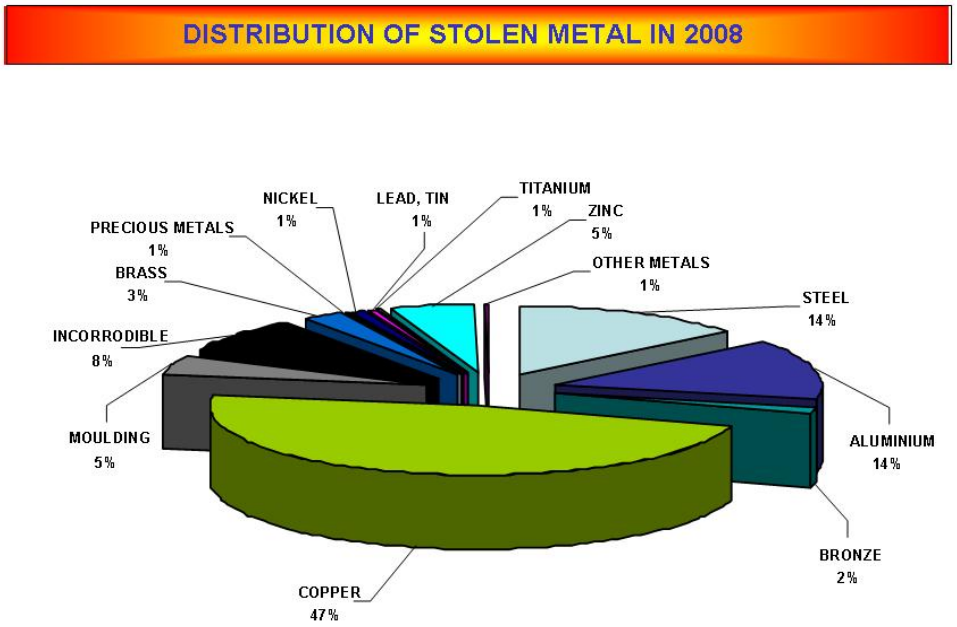

Fig. 3 Distribution of stolen metal in 2008
Source: ORFK Tájékoztató, 2008. [5]

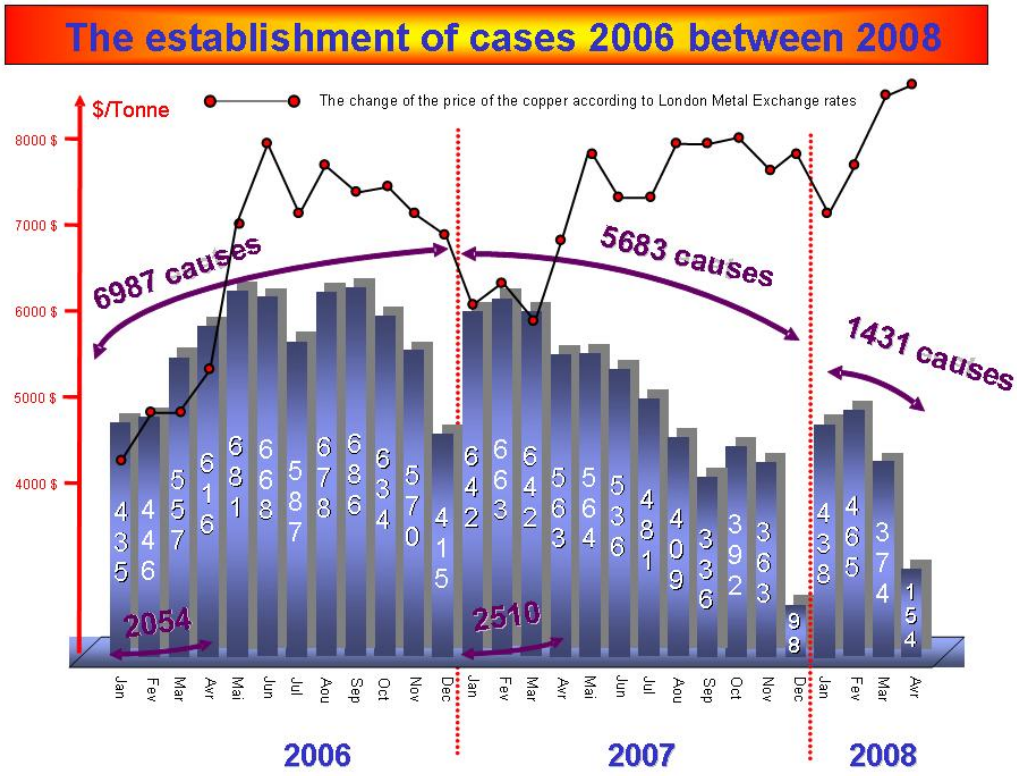

Fig. 4 The establishment of cases 2006 between 2008
Source: ORFK Tájékoztató, 2008. [5]

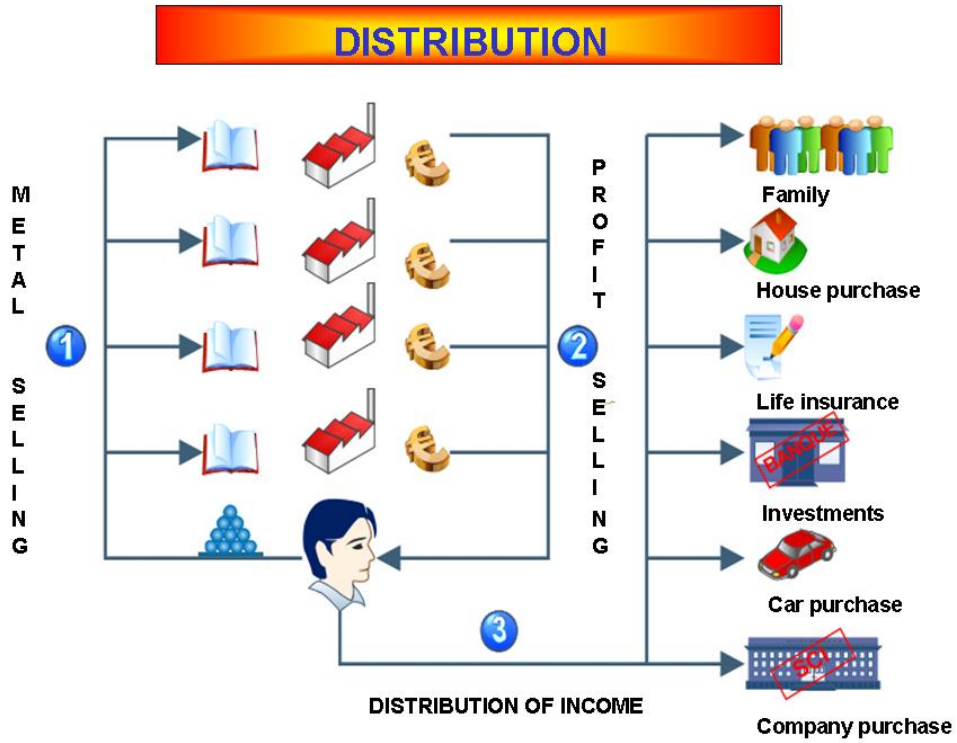

Fig. 5 Distribution
Source: ORFK Tájékozatató, 2008. [5]

The criminal organizations are more and more dangerous to the society. It is a rightfull expectation from the sociaty that the perpetrators of the most dangerous crimes be strictly punished. The background of the illegally acquired wealth must be investigated and confiscated. After making the laws more severe and eliminating the possibilities of avoiding the punishment people will be aware of the fact that capturing the perpetrators is only a matter of time and thus that kind of living form cannot be a constant way of living for anyone. The financial resources, the technical meanings and methods of the police together with the supervision or controll of other competent authorities are not enough to achieve comforting results. The correct flow of information and the use of the data bases between the competent authorities can lead to produce the requiered results. [2]

The leaders of the different criminal organization do not participate directly in the commitment of the crimes. They invest their previously gained financial resources into legal economic activities. They commit the criminal acts in several phases. The "capos" (bosses) assure the financial bases in order to make more profit. [2]

They participate in transactions that can be regarded legal but the management of their illegal economic affairs are done by indirect persons (brokers). To establish, purchase and administrate theit enterprise they prefere to employ highly qualified specialists on economic and legal field. [2]

It is unacceptable to everyone that certain individuals produce such a wealth accumulation whose legality can be questioned. The accumulation of real-estates and cars of great value, the huge investments and the considerable participation in numerous companies are destoying both the moral and the economic stability. The criminal organizations are hiding their illegally gained wealt from the authorities by investing it abroad or by despositing their money in foreign banks. Inspecting the accumulation of wealth of a suspect is not an easy task. One can commit a criminal act not only in a direct way. Wealth acquiring can be cleaned by investigating other crimes, too. [2]

The actual hungarian tax laws do not force the perpetrators to whitewash their money because they are not forced to legalize their wealth simply because they do not have to account for its origin. It is the Tax Office's obligation to prove that there was illegal money transaction or accumulation of wealth, the tax payer do not have to justify the origin of his wealth. Due to the lack of declaration of assets there is no reference point which later would justify the legality of a accumulation of assets. [2]

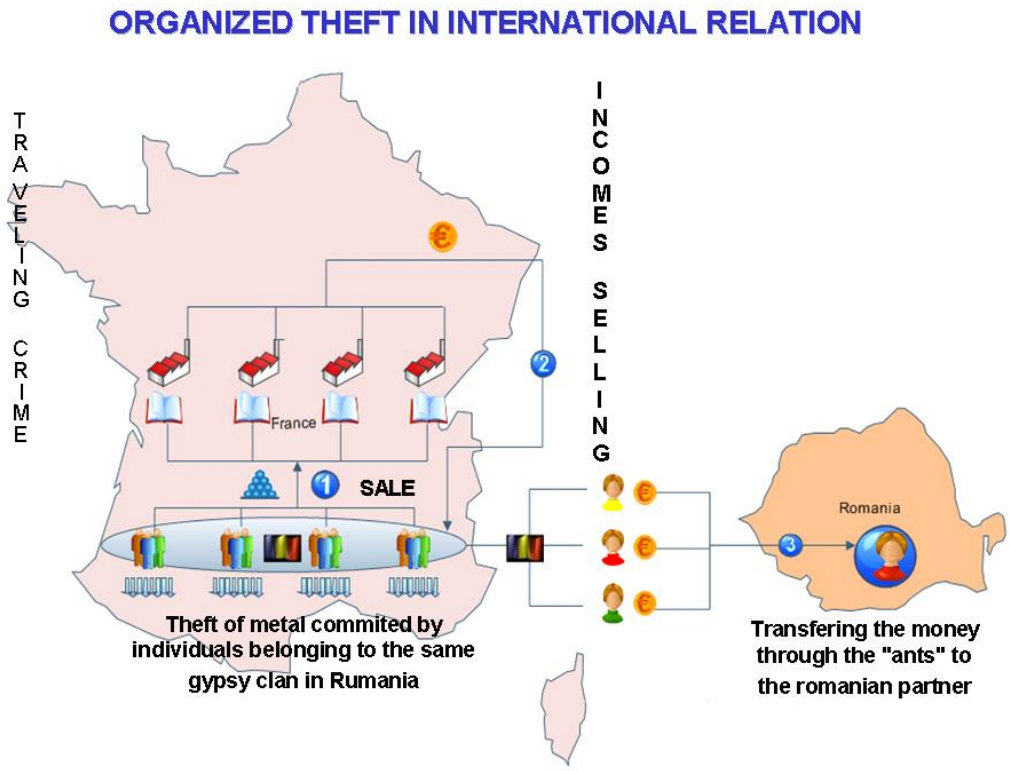

Fig. 6 Organized theft in international relation
Source: ORFK Tájékoztató, 2008. [5]

Organized theft in international relation income sale Theft of metal commited by individuals belonging to the same gypsy clan in Rumania Transfering the money through the "ants" to the romanian partner On 11. march 2008 11 individuals were detained (they had stolen more than 60 tons of precious metal). During their act they committed kidnapping, they shut the driver down and used violance. By selling the stolen metal the perpetrators earned more than 1.500.000 euros. They applied double accounting in order to meslead the competend authorities. [7]

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