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Dear readers!

Let me introduce the second issue of the Science & Military journal for this year. By publishing the Science & Military journal, the Armed Forces Academy created the space for publishing articles written by Slovak as well as foreign authors who are engaged in military science and research. The journal is actively used for development of scientific knowledge both at the national and international levels. During its nine years of existence, it has become a significant communication channel within scientific and academic publishing activities. Publishing activity done by university research and teaching staff is an important part of their scientific work's assessment. It reflects their achievements and its primary role is to make the scientific community familiar with the results of their scientific and research activities.

Dear readers, I am convinced that this issue, like the previous ones, contains interesting information and inspiring ideas that will broaden your knowledge and expand your horizons. It offers nine new articles that are undoubtedly interesting. Let me briefly introduce at least some of them:

The authors Daniel Kučerka et al. wrote the article titled "Material Supplies in an Enterprise and Transport". The aim of this article is to give a reader the overview of issues of some logistic activities and outline the basic questions of storage and transport of material.

The article written by Vlastimil Neumann titled "Mathematic Model of a Truck" is focused on usage of simulating technologies in vehicle evaluation. The paper presents development of a simplified mathematic model of the Czech military vehicle T-810.

The article titled "Differential Rationing of Linear Fuel Consumption of Buses and Truck under Different Traffic Conditions", written by Hrubel, M. et al., describes a proposed method of differential rationing of linear fuel consumption for trucks and buses that depends on prevailing traffic conditions.

The authors Jan Furch and Jozef Glos wrote the article titled "Possibilities of Temporary Repairs in the Army". The article deals with temporary repairs. The authors suggested procedure battle damage assessment and repair, which they expressed in the form of diagrams.

The authors Zbyšek Korecki et al. present the article titled "Modelling Life Cycle Cost Iveco and Tatra 810", which addresses the LCC with a focus on direct and indirect costs for selected military equipment of the Army of the Czech Republic.

The author Pawel Turczynski wrote the article titled "Development of the Potential of the Polish Army in the Second Decade of the 21st Century". The subject of this paper is analysis of a few armament initiatives for the Polish Army that are significant for national security and engaging the Polish economy on a large scale.

Dear readers, in conclusion, I would like to thank you for your interest in our journal on my own behalf and on the behalf of our editorial board. We wish you a merry and peaceful Christmas.

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MATERIAL SUPPLIES IN AN ENTERPRISE AND TRANSPORT

Daniel KUČERKA, Milan TIMKO, Iveta KMECOVÁ, Monika KUČERKOVÁ

Abstract: The aim of this article is to give a reader the overview of issues of some logistic activities and outline the basic questions of storage and transport of material. In order to explain the functions of the storage and material flow and refer to one of possible systems of warehouse management and ware housing. Last but not least the authors deal with the types of freight transport and they mention the possibilities of its practical use.

Keywords: Storage. Manufacturing enterprise. Transport. Handling equipment.

1 INTRODUCTION

Logistics is a very wide scientific discipline. In a lot of areas it influences the level of society. Logistic services in modern society facilitate the human life. We speak about the logistics also regarding the process of storage and transport of material. The logistics also deals with the questions of purchase, storage, picking and distribution of goods. Its aim is to satisfy the customer.

The customers´ demands on the reduction of time intervals of material delivery and on the lowest transportation and overhead costs increase nowadays. Transportation is the result of transport as the implementation of transport requirements. Transport requirements of customers are carried out directly from the manufacturing plant or from the stock. Material storage can be the effective or ineffective process.

2 STORAGE

Storage of the material is one the logistic tasks. It is considered as the negative element in the material flow. This process causes the disruption of material flow in the logistics chain.

Storage performs the following functions:

1. Levelling function, this is a bridge of problems which arise from problems in the own manufacturing process as a result of raw material or by sales problems (the need of certain products in a certain time – season).
2. Security function – caused by the uncertainty of gaining of material in a certain volume, in a certain date.
3. Speculation function, goods is storaged as a result of speculation which is associated with the development of the price levels, change of exchange rates, etc.
4. Cost function, it is induced due to the need to store the larger volumes of materials (e.g. due to the drying, freezing, etc.).
5. Completing function - is associated with the creation of the range of supply in a shop or enterprise.
6. Ennobling function – is associated with the qualitative change of the stored material (e.g. aging, fermentation, maturation, etc.).

The main tasks of the storage process are the input of material to store, transposition of the material in the warehouse and its identification in terms of quality and quantity, store material in warehouse (storage, allocation of space for storing, processing, identification data, etc.), preparing material for dispensing (planning preparation of materials for production, adjustment before dispensing, sorting, assembly etc.) and removal (initial outlay to check before production, transfer to production, etc.).

The warehouse management contains also technical resources. These include a palletizing and supporting units (pallets, containers, platforms, etc.), storage devices (different types of shelves (flow pallet racks (Fig. 1), automated pallet storages (Fig. 2), refrigeration and freezing chambers (Fig. 3), service and handling equipments (transport trucks, container stackers (Fig. 4), pallet stackers, systems of transport of containers (e.g. conveyors Fig. 5, 6).

For a comprehensive management of storage supply there are used different computer programmes. EasyWMS system is designed for the operational management of activities in the store.

Warehouse management system (WMS - Warehouse Management System) that integrates storage and distribution systems consists of series of interconnected applications and information tools, which together cooperate with the corresponding communication protocols. Together with the ERP system (Enterprise Resource Planning), warehouse management software manages and controls all warehouse operations (Mecalux, translated).

3 TRANSPORT

Transport in logistics is such logistic and transport system that meets the logistical management of circulation processes.

Logistics and transport system is such a management system that in addition to process control activities of the circulatory process optimizes the overall effect of the circulatory process through all the associated information processes.

Fig. 1 Gravity pallet racks and regulatory elements
Construction: 1 - frames, 2 - beams, 3 - shims, 4 - anchor bolts Roller track, 5 - bearingrail, 6 - rollers, 7 - brakingdrums, 8 - brakingrollers, 9 - brakingstrips 10 - brakingramps, 11 – catchersofpallets, 12 – protectionofrollers.

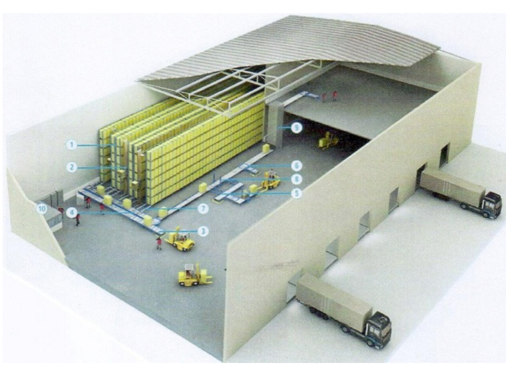

Fig. 2 Automated Storage Pallet [4]

Fig. 3 The system for cooling and freezing chambers [4]

Fig. 4 Folders of containers [4]

Fig. 5 Systems transportscontainers [4]
1 - roller conveyor, 2 - chainconveyor,
3 - controlgate of pallete.

a - palletlift b - paller lift

c - TheSystemRadio - Schuttle
Fig. 6 Systems of transports of containers [4]

In terms of the functions of the logistics system it is required to manage traffic from the following aspects:

- optimal service quality,
- optimal division of labour among the different modes in the logistic chain,
- minimizing the cost of the process for the removal and circulation processes globally.

In selecting the most appropriate mode of transport it is necessary to take into account the characteristics of the transport properties of the transported goods and different types of transport.

Characteristics of modes of transport are speed and reliable delivery at a specified time interval, traffic safety, the ability to transport any quantity, availability and usability of the vehicle, respectively of transport system, providing additional services during transport , increasing height of transport costs and the ability to create networks.

Considering the scale of transported processes and restrictive conditions, it is recommended to distinguish the subsystem:

- internal transport and handling, which is used to transport and material handling within the company. Basic criteria for selection of optimal transport system disappear within the company and we can influence them [1-4]. In-house transport system is created by transported material (effective performance of transport and handling operations), transport and handling units (process and the amount of traffic), vehicles and handling equipment (equipment to transport materials such as from stocks to the place of treatment), staff (management responsibility and output of performed operations) and the method and system of planning, organizing, managing and implementing transport and handling operations,
- off-site transport which is used to transport incoming materials from suppliers and shipping of finished products to customers . The selection of the optimal type is influenced by external conditions on which the enterprise has no direct impact.

For freight it is possible to use different systems and combine them with each other:

- sea,
- road,
- rail,
- air,
- pipeline,
- combined.

Combined transport is used mainly by large companies, logistic companies to transport on very large distances and forces to transport of such materials to the destination of peacekeeping missions and armed conflict for special and emergency measures.

4 CONCLUSION

Logistic and storage systems and services have their place in the manufacturing enterprise. Storage and transport are linked. Especially without transport we cannot imagine any major logistics projects. The transport system should provide the transport of material from the warehouse or directly from the manufacture to the seller or to the consumer. Transport should be organized as efficiently as possible at the lowest possible cost. Transporters associate the ways of more customers, even at extended intervals of time needed for loading and unloading in multiple collection points.

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MATHEMATIC MODEL OF A TRUCK

Vlastimil NEUMANN

Abstract: The paper is focused on usage of simulating technologies in vehicle evaluating. Simulating technologies are widely spread all over the world and military vehicle have to operate under various and operational conditions. These vehicles have to meet the requirements of lethality, mobility, protection, communication and fire power. Utilization of vehicles with similar mobility capabilities is very important condition for multinational units. Simulating technologies can be suitable for vehicle evaluating. In the paper is presented development of simplified mathematic model of Czech military vehicle T-810.

Keywords: Simulation. Mathematic model. Evaluation. Obstacle negotiation.

1 INTRODUCTION

Simulating technologies are widely spread all over the world. They are used in design and development stage of life cycle. Their main benefits are:

- shorten process of design, development and testing of products,
- enables optimization of manufacturing process – material saving, selection of accurate technology,
- enables assessment of various modifications of vehicles without real vehicle manufacturing,
- global outcome - expenses saving.

Military vehicle have to operate under various operational conditions. They have to meet the requirements of lethality, mobility, protection, communication and fire power. Fruition of these requirements is compromise. Balance between mobility, protection and fire power can be very complicated process. Military ground vehicles are created in various construction manners – different platforms, different mounting of weapon systems, various levels of protection, different possible power units, various basic characteristics like sizes and weights and mobility requirements.

Nowadays military units operate in joint missions, under joint command. Utilization of vehicles with similar mobility capabilities is very important for multinational units. Fulfilment of this capability requires the evaluation methodology improvement. Allied Vehicle Testing Publications (AVTP-1) are basic documents which are focused on these issues. These publications were accepted in 1994 and they contain only practical informations. In the section no. 3 there are defined basic possibilities of obstacles negotiation but with no any evaluation system. Nowadays expansion of simulating technologies opens possibility for utilization of this manner for vehicle evaluation, too. Updating of current publications is needed for implementation of the simulation technologies for vehicle evaluation.

Mathematic simulations can be used for assessing, evaluating and comparing of basic capabilities amongst vehicles. The main advantages are:

- possibility of comparing different vehicles in the same operational environment (e.g. on the same obstacles),
- simulation of various critical operational states and in-service behaviours of vehicle (e.g. destruction of wheel),
- evaluation of different modifications (modernization) influence on vehicle mobility,
- development of capabilities – mobility, survivability and reliability.

Simulating technologies have some disadvantages, too. The main key point is input data – either insufficient or lack of them.

The purpose of this paper is to demonstrate utilization of simulating technologies (mathematic model development) for vehicle movement evaluation.

2 MATHEMATIC MODEL DESCRIPTION

I have selected Multibody Dynamics software ADAMS (Automatic Dynamic Analysis Mechanical Systems) of MSC software company for mathematic model development. Adams improves engineering efficiency and reduces product development costs by enabling early system-level design validation. Engineers can evaluate and manage the complex interactions between disciplines including motion, structures, actuation, and controls to better optimize product designs for performance, safety, and comfort. Along with extensive analysis capabilities, Adams is optimized for large-scale problems, taking advantage of high performance computing environments. For dynamics vehicle development and testing MSC offers module ADAMS/Car. With Adams/Car engineering teams can build and test functional virtual prototypes of complete vehicles and vehicle subsystems. Working in the Adams vehicle environment, automotive engineering teams can exercise their vehicle designs under various road conditions, performing the same tests they normally run in a test lab or on a test track, but in a fraction of time.

Czech military vehicle T-810 has been selected for application of simulating technology. Vehicle T-810 is medium off-road truck which meets requirements of high terrain throughput, robustness, endurance, airway, seaway and railway transportability. Picture of this vehicle is shown in the Fig. 1.

Fig. 1 Military vehicle T-810

Basic tactical-technical specifications of the vehicle T-810:

- operation weight 8500 kg (weight ratio: front axle 4500 kg, rear axles 200kg),
- overall weight 13000 kg,
- length 7490 mm,
- width 2550 mm,
- maximum height 3320 mm,
- clearance height 460 mm,
- maximum speed 105 km/h.

Determining of purpose and target of the mathematic modelling is essential in the beginning of the whole process of the mathematic model development. This is really very important step because setting up target has an effect on the model construction and its simplification. For example - analysis of vehicle movement effect on a driver is purpose of presented model. Preparation of model input data (dimensions, weight, kinematics, parameters of suspension system) is next step which comes before the model development. Basic dimensions of the vehicle T-810 are shown in the Fig. 2. In the Fig. 3 you can find picture of the chassis.

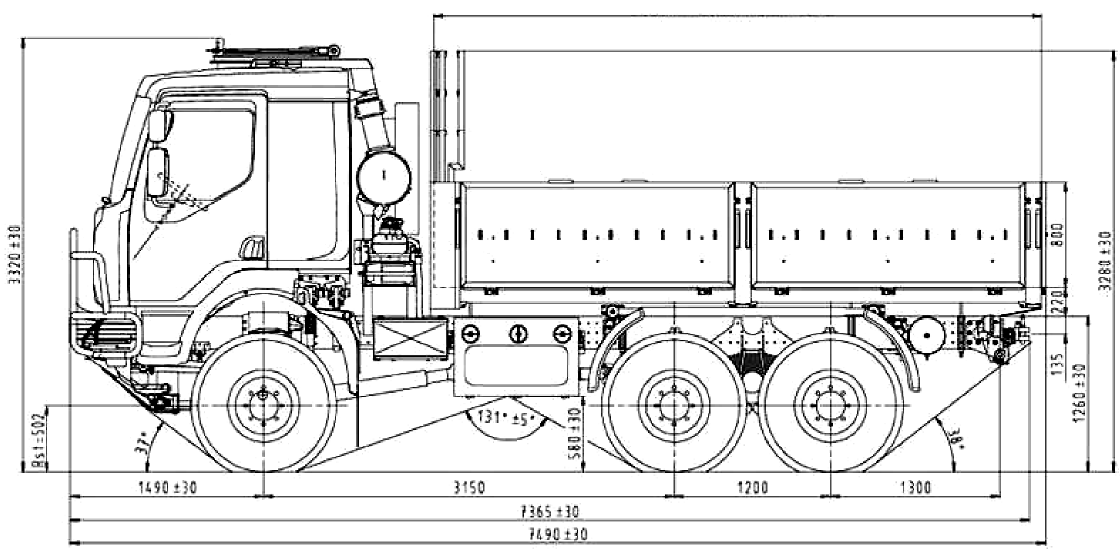


Fig. 2 Basic dimensions of the vehicle T-810

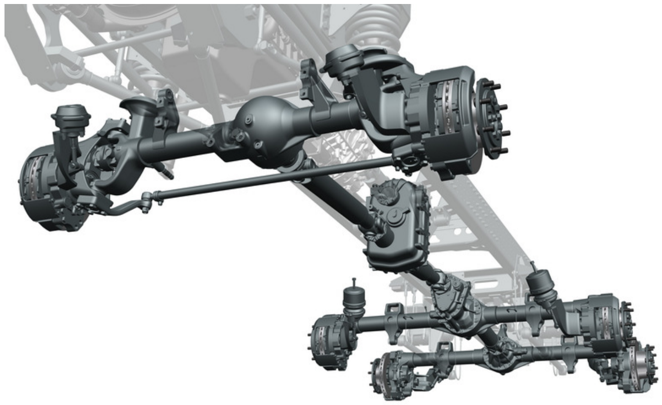


Fig. 3 Chassis of the vehicle T-810

I have set next model simplifications:

- all parts of model are solid bodies,
- wheel do not deflect from road, during whole simulation they are perpendicular to road,
- vehicle is going forward, turning or side slide is not taken into account,
- wheel slippage or slide is not taken into account,
- vehicle speed is constant, moving resistances are not taken into account,
- leak-spring of rear axles were replaced by wound springs,
- terrain is solid, without deformations.

Parts of the chassis (axles) were simplified, too. For example - axles of the vehicle can move vertically and can rotate around the centre of axles (Fig. 4) – it is not necessary to create all parts of the axle – leading bars were replaced by couplings.

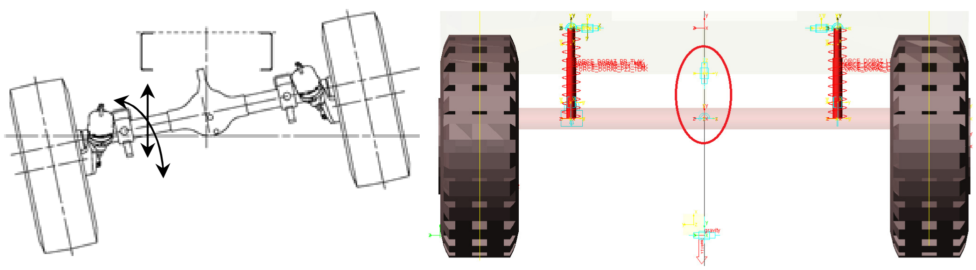


Fig. 4 Movement of the axles, axles in the model

Setting position of a centre of gravity according to the real vehicle is essential for "real" model behaviour. Example of centre of gravity measuring you can see in the Fig. 5. Model centre of gravity was set:

- in longitudinal direction (from 1st rear axle) 1876 mm,
- vehicle centre of gravity from a road 1220 mm.

Fig. 5 Example of centre of gravity measuring

Parameters of suspension system are presented in the Fig. 6. Basic dimensions of the created mathematic model you can see in the Fig. 7.

Created model of vehicle T-810 consists of 50 moving parts, 21 joint connections and 20 sliding connections.

Main parts of model are:

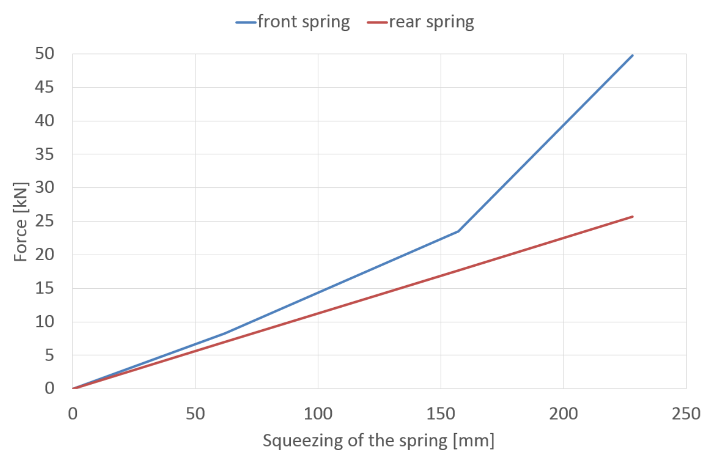
- chassis,
- axles with suspension,
- wheels,
- terrain.

Wheels – 365/80 R20

Weights of the main parts:

- overall vehicle weight 8500 kg,
- wheel 125 kg,
- front axles (wheels including) 860 kg,
- 1st rear axle (wheels including) 835 kg,
- 2nd rear axle (wheels including) 760 kg,
- driver 80 kg.

Terrain – in cooperation with Department of Military Geography and Meteorology was measured and scanned the real terrain. Outcomes of these measuring were transformed and inserted into the model. Examples you can see in the Fig. 8.



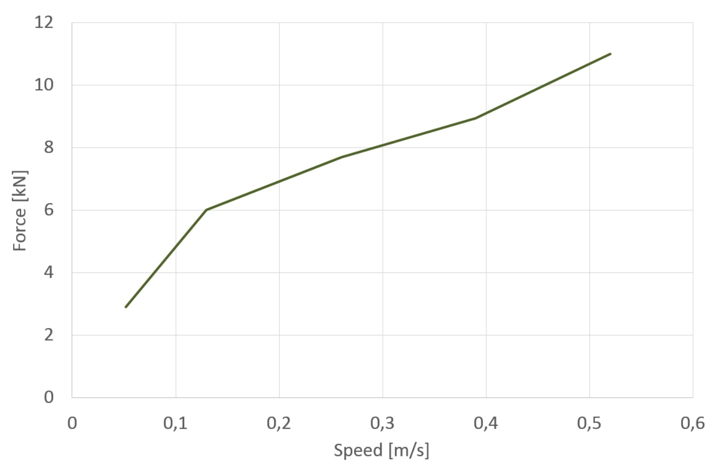


Fig. 6 Parameters of springs (left), parameters of dampers (right)

Model verification is the last step of process of the mathematic model development. Measuring of real vehicle data and their comparison with simulations outcomes is essential. This step was not proceeded in this example of mathematic model development. Presented outcomes demonstrate possibility of utilization of simulating technology manner.

3 SIMULATIONS

Created mathematic model enables simulation of movement of the vehicle on defined terrain – traces of the left and the right side are different. Passedsimulations enable study of main physical values (e.g. position, speed, acceleration and load) of selected vehicle parts.

Created vehicle model was tested on the defined terrain (Fig. 8). Simulation were focused on driver stress during the vehicle movement. Vertical and horizontal driver speed and vertical and horizontal driver acceleration were monitored.

I have proceeded next various modifications of the vehicle state –vehicle speed from 5 km/h to 80 km/h on the each terrain of:

- loaded vehicle (form light load (2000 kg) to full load (4500 kg),
- unloaded vehicle without one rear wheel,
- unloaded vehicle without two rear wheels,
- loaded vehicle without one rear wheel,
  loaded vehicle without two rear wheel.

Outcomes of simulations with vehicle (model) speed 40 km/h and 80 km/h are presented in this paper. The length of the simulations were 12 s (for speed 40 km/h) and 6 s (for speed 80 km/h).

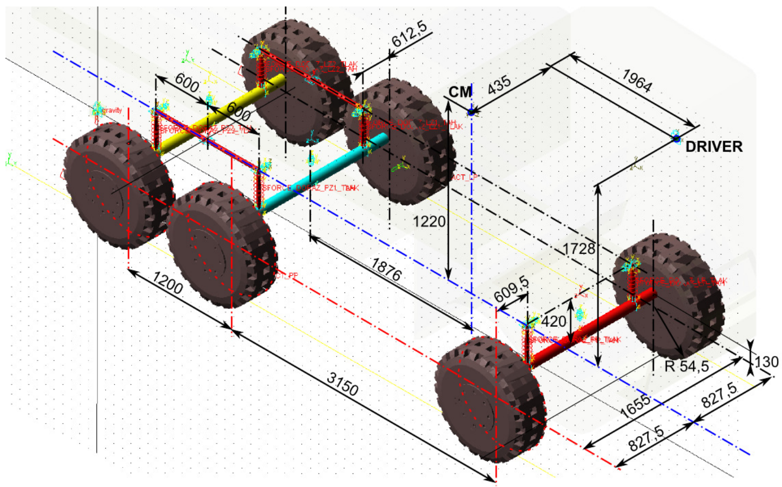


Fig. 7 Basic dimensions of the model

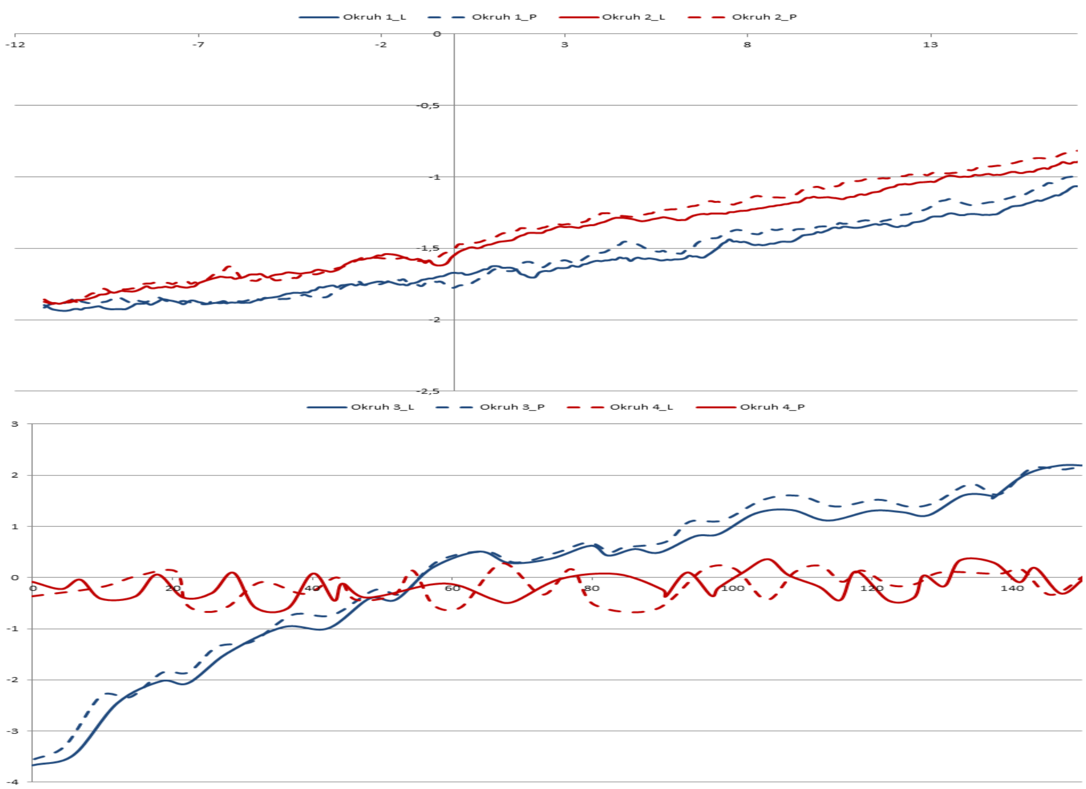


Fig. 8 Examples of terrain profiles

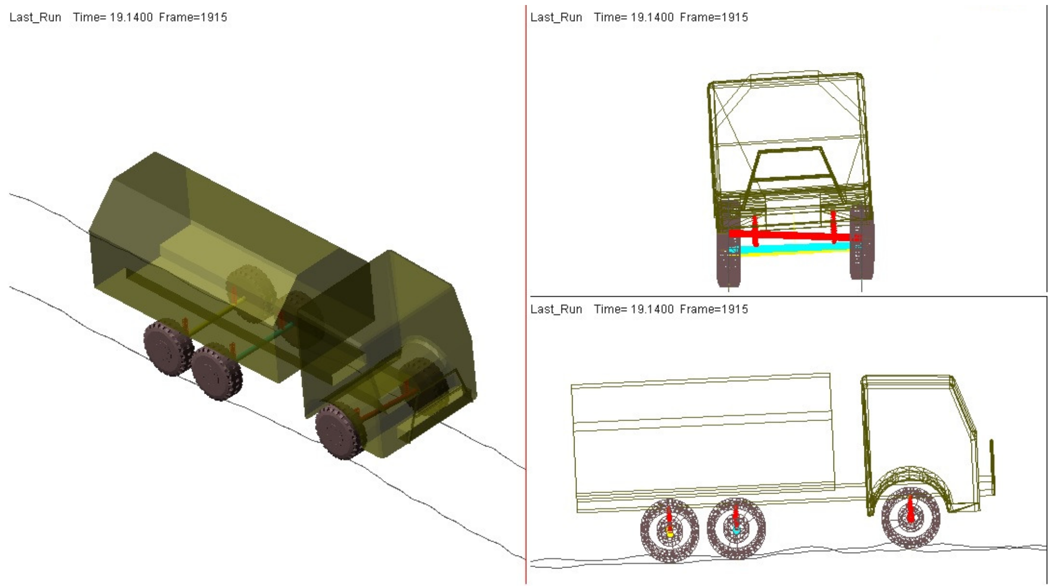


Fig. 9 Created mathematic model of vehicle T-810

4 OUTCOMES

Graphs of the driver vertical (vy) and horizontal (vz) speed and driver vertical (ay) and horizontal (az) acceleration are the outcomes of the proceeded simulations (Fig. 10 – 13).

In the Fig. 10 (speed 40 km/h) you can find that vibrations of driver of the unload vehicle are higher than vibrations of the loaded vehicle. Construction of the suspension system causes this result, because suspension system of trucks is developed on the stress of the loaded vehicle. Differences between loaded and unloaded vehicle are not so evident during overcoming the terrain with speed 80 km/h (Fig. 12). Vehicle wheels do not follow the terrain surface, yet “fly” on the tops of the terrain. Lower driver stress is the result of this state. On the other side, the wheels are losing contact with ground. This state is not acceptable for the front wheels, because driver can lose control over the vehicle.

Magnitude of the contact force can be used for analysis of possibility of losing control over the vehicle (Fig. 14 and 15). For better transparency was magnitude of the left wheel contact force inverted. We can find situations when wheel(s) rebound from the terrain. We can find situations when both front wheel lose contact with terrain – dangerous state.

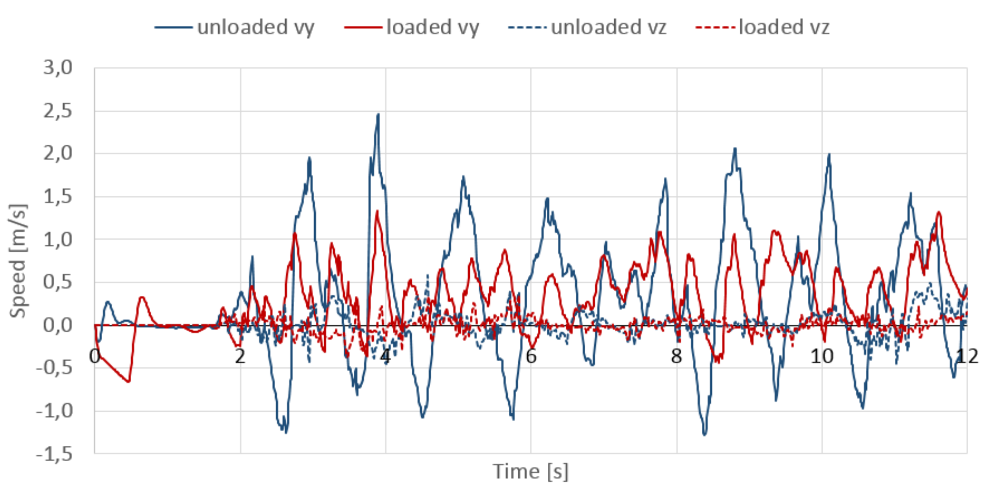


Fig. 10 Speed 40 km/h, driver vertical (vy) and horizontal (vz) speed

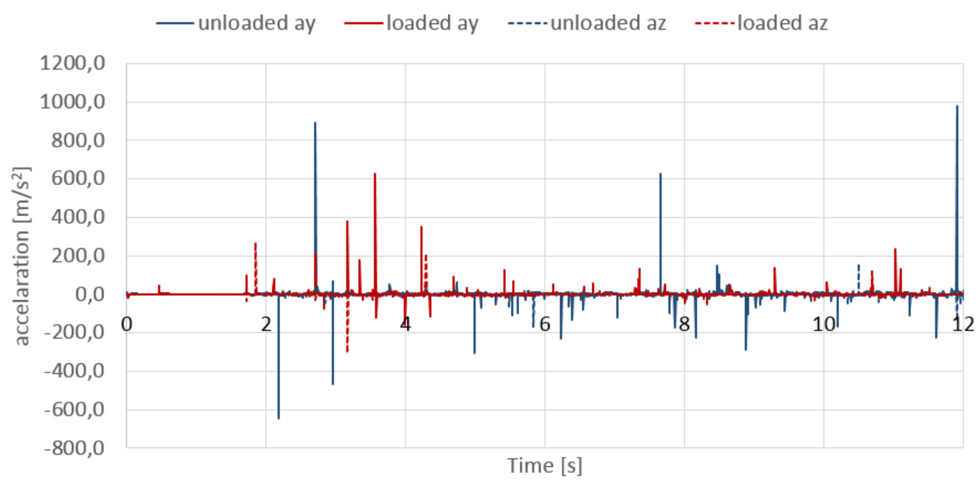


Fig. 11 Speed 40 km/h, driver vertical (ay) and horizontal (az) acceleration

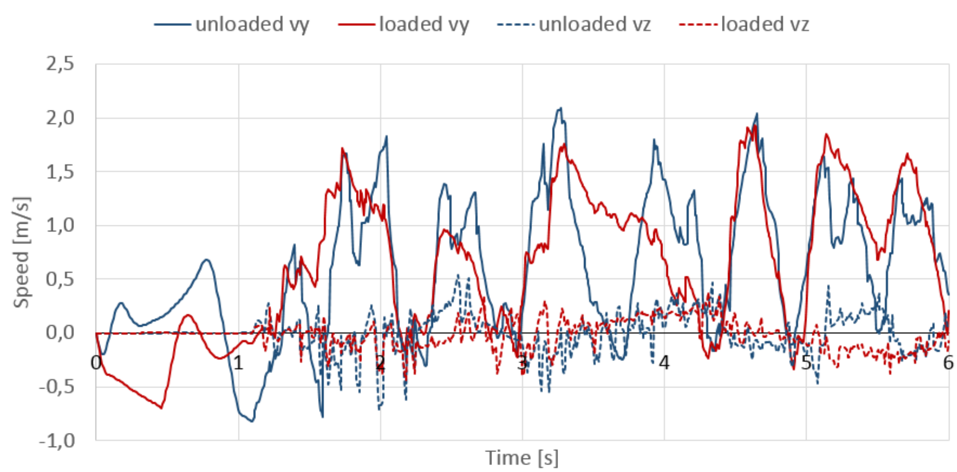


Fig. 12 Speed 80 km/h, driver vertical (vy) and horizontal (vz) speed

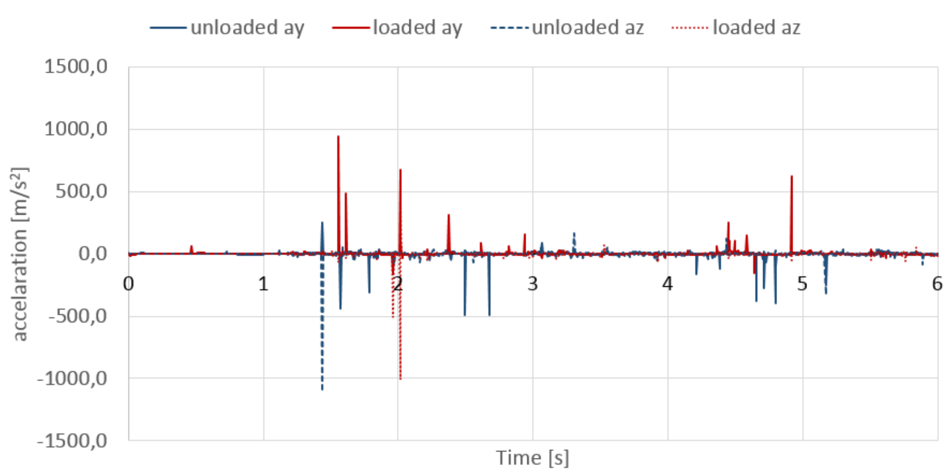


Fig. 13 Speed 80 km/h, driver vertical (ay) and horizontal (az) accelaration

The peaks of the driver acceleration (Fig. 11 and 12) represents contacts of the axles with the chassis (maximal wheel elevation). This state represents impacts which highly load parts of the vehicle and driver, too.

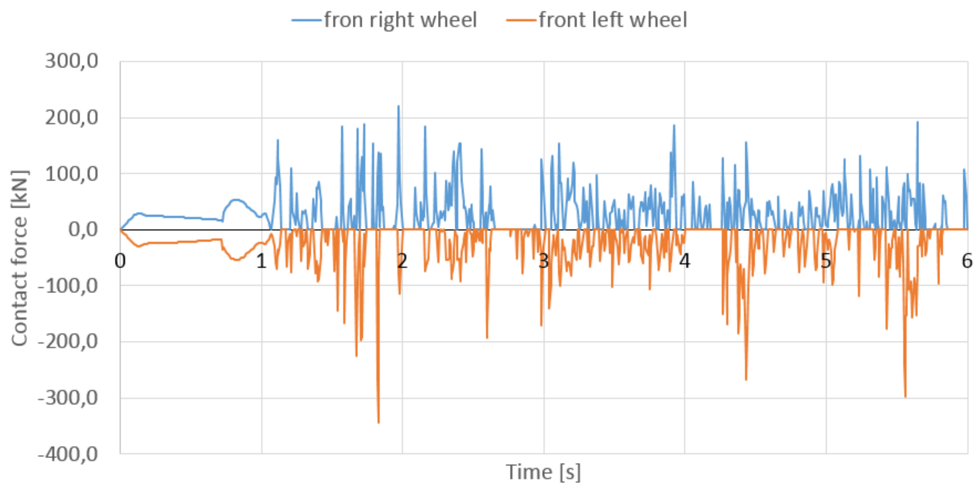


Fig. 14 Speed 80 km/h, unloaded vehicle, contact force

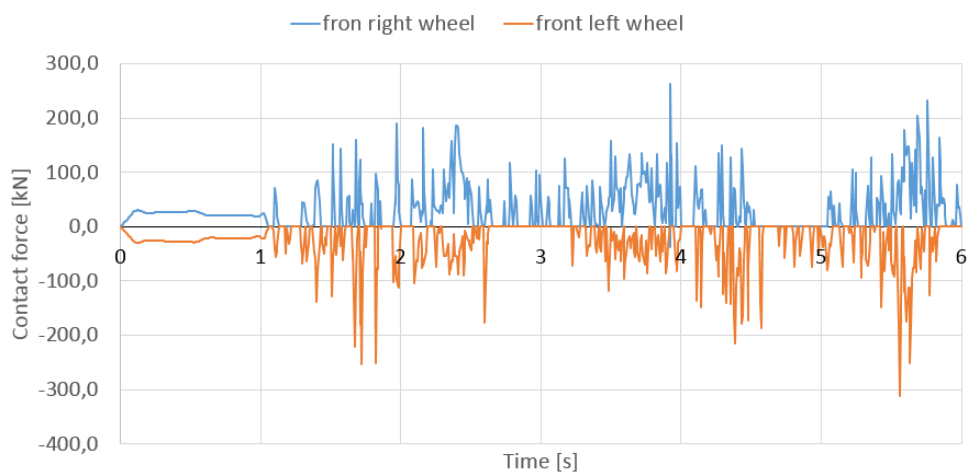


Fig. 15 Speed 80 km/h, loaded vehicle (4500 kg), contact force

5 CONCLUSION

Demonstration of development and utilization of the mathematic model of the truck is the purpose of this paper, because simulating technologies offer a lot of advantages – e.g. evaluation of various vehicle modifications and simulation of various critical operational states of vehicle. On the other side, input data or lack of them is general disadvantage of this manner. Ideal situation for mathematic model creating is development of a new vehicle. We know all vehicle (model) data in this case and simulation technologies are very efficient in process of vehicle optimization.

Purpose and target of the mathematic modelling must be determined before starting of the modelling process. This is really very important step because this decision has an effect on the model construction and its simplification. Creation of "full real" model is very complicated and simulations time consuming can be disproportional to the expected outcomes. More efficient is to specify general simplifications of the developed model.

Knowing of all input data (dimension and weight of the main parts, kinematics of the system, coupling between the main parts, parameters of contact etc.) is essential for mathematic model development.

Model verification should be inseparable part of process of the mathematic model development.

Comparison between simulations outcomes and the real vehicle values is necessary. This step can be the core of the problem, because it is very difficult (sometimes almost impossible) to get input data of the vehicles. This step was not proceeded in this example of mathematic model creating. Measuring of the real data of the vehicle T-810 and comparison with simulations are the aims of the next work.

Presented outcomes were focus on driver vibrations. Outcomes of proceeded simulations correspond with the real behaviour of the vehicle. Driver (vehicle) vibrations of the loaded vehicle are lower than vibrations of the unloaded vehicle, because suspension system of trucks is developed on the stress of the loaded vehicle. Similar outcomes we can find in dependency of the vehicle vibrations and vehicle speed. Vehicle does not follow the terrain surface, yet “flies” on the tops of the terrain during the increasing of vehicle speed, but the wheels are losing contact with terrain and driver can lose control over the vehicle.

By these simulations was proved that utilization of the simulating technologies can be suitable for vehicle evaluation. On the other side, this manner is sensitive to input data (their insufficient or lack of them). It is essential to focus on methodology development and its implementation to the current NATO documents related to area of evaluation, testing and reliability of the vehicles.

Acknowledgment

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DIFFERENTIAL RATIONING OF LINEAR FUEL CONSUMPTION OF BUSES AND TRUCKS UNDER DIFFERENT TRAFFIC CONDITIONS

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Abstract: In this paper there is proposed method of differential rationing of linear fuel consumption for trucks and buses that depends on prevailing traffic conditions. For trucks – upon the terms of quantitative assessment – based on road type and condition, average speed and load, for buses – based on typical driving tests for urban, suburban and long-distance tours.

Keywords: Multifactor experiment planning. Rationing of linear fuel consumption. Trucks. Buses. Traffic conditions.

1 INTRODUCTION

The rapid growth of prices for oil products and the domination of relevant expenses in the cost structure of transportations determine the importance of quantitative assessment of the interrelation of linear fuel consumption with specific traffic conditions.

This determines the need to improve the assessment of linear fuel consumption of vehicles in use, and can be divided into two stages - at the first stag the definition of linear fuel consumption Q_S in L/100km during driving at a constant (in the range of 60-80 km/h) speed on asphalt concrete road of I category with introduction of various empirical adjustment factors according to the type of road surface, urban or non-urban traffic conditions, the cold season, etc.[1–4], which was typical for the era of the Soviet Union almost to late 1980.

However, the fuel crisis of the 1970s led to the emergence of a more complicated (and obviously closer to reality) evaluation procedures - by the example of the dominant category in the total vehicle fleet - cars in Europe - as an integrated indicator mediated of 3 values of linear fuel consumption during driving at clear fixed speed of 90 and 120 km, and also during driving in the so-called typical city driving test - cycle (UN/ECER15) approximate to the typical city traffic conditions [5–6].

It is clear that a variety of types and conditions of road resurfaces, average speed on the territory of CIS (former USSR) led to the development in 1990 of a new assessment standard of fuel frugality - GOST 20306 - 90 [6], where there were introduced the typical driving tests (cycles) of movement of a number of other categories of cars and buses. However, in general for trucks has remained the basic principle of fixation of linear fuel consumption during driving at a constant speed on the road of I category with the introduction of certain adjustment factors. Introduced typical driving cycles, especially for city traffic conditions, are not deprived of serious shortcomings [7].

2 MAIN MATERIAL

Under actual operating conditions the linear fuel consumption of trucks and buses vary quite significantly, depending on the determining traffic conditions of fuel frugality - the type and condition of the road surface, average speed, vehicle load (filling inside the bus).

Eventually in the modern regulatory framework [4, 5] there are so-called base linear standards (whose method of measurement, incidentally, is not clearly defined and reflected in regulatory framework of branch) which involve more than 6 corrections and 15 increments of standards that:

- on the one hand confirm that the problem is multifactorial, and it hardly could be reduced to some value, universal for all specific cases,
- on the other hand introduce significant complexity and subjectivity in the quantification of standards because of the quite wide range of correction factors and their subjective fixation.

Figure 1 shows a generalized calculation structure of standard fuel consumption $Q_н$ for basic categories of vehicles (M1 - cars, M2, M3 - minibuses and buses, N - trucks).

Summarizing abovementioned analysis of works on research and rationing of fuel efficiency of the car can be stated that:

- existing methodology for rationing of operating fuel consumption of vehicles is oriented on the so-called basic costs on asphalt concrete roads of I category and practically ignores the real speed and the type and condition of the road surface,
- correction of fuel consumption rates, depending on the load (2.0 l/100 ton for petrol trucks and 1.3 l/100 ton for diesel) is approximate, generalized and does not take into account features of the particular models, fundamental change that occurred in engine technology for the last 20 years (transition from carburetor to injector petrol engines, reduction of working capacity of diesel engines with traditional retrofit by systems of turbocharging and intercooling in connection with the transition to environmental demands "Euro-2" - "Euro-4", significant

intensification of thermodynamics engines). In principle, such correction cannot be sufficiently accurate for all types of trucks, including new generation of models, which appeared during the last decade, there are no studies that confirm the adequacy of such correction,

- especially relevant is the correct rationing of linear costs for all-wheel drive vehicles used in force structures, especially military vehicles and trucks in the agricultural sector with a significantly lower specific proportion of total kilometrage on asphalt concrete roads of I and II categories.

Graphic illustration of the range of real change Q_s for studied traffic conditions by the example of the truck KAMAZ-4310 and determined for the exploitation of linear norm Q_s is shown in Figure 2 that indicates an apparent need to introduce differential rationing Q_s depending on traffic conditions [8].

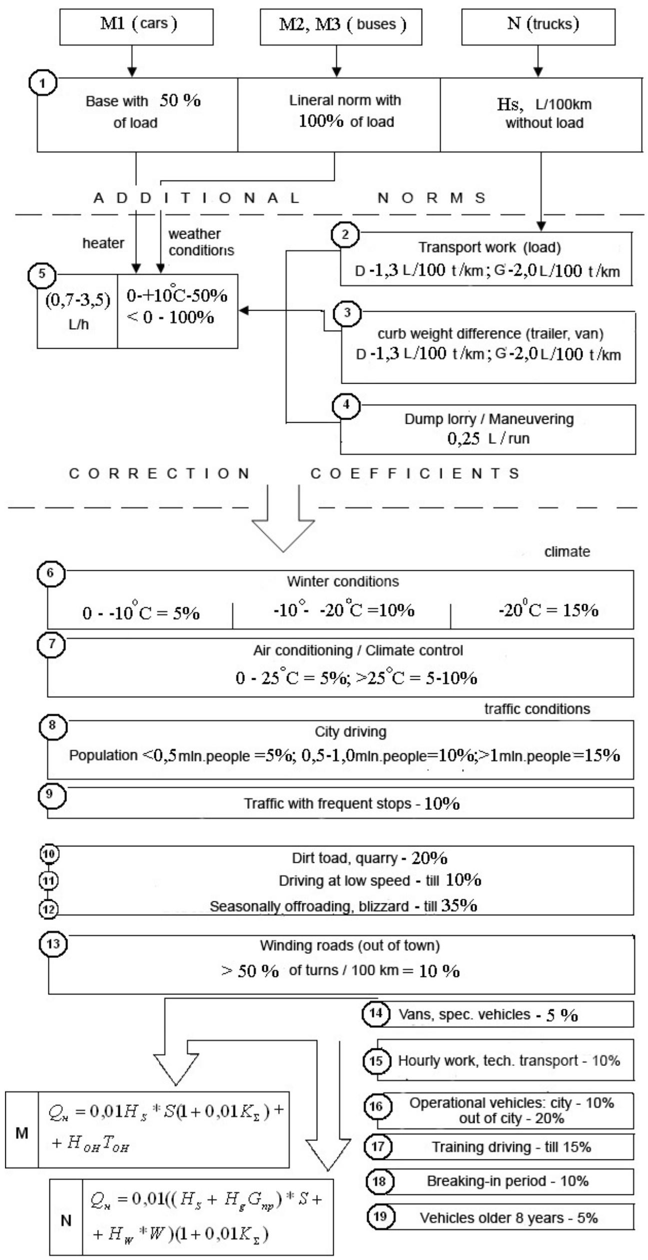

Fig. 1 Calculation structure of standard fuel consumption [7]

H_s - basic linear norm; S - kilometrage; K_{Σ} - total useful coefficient; H_{OH} - norm of autonomous heater; T_{OH} - working time of heater; H_W - norm of transport work; W - transport work.

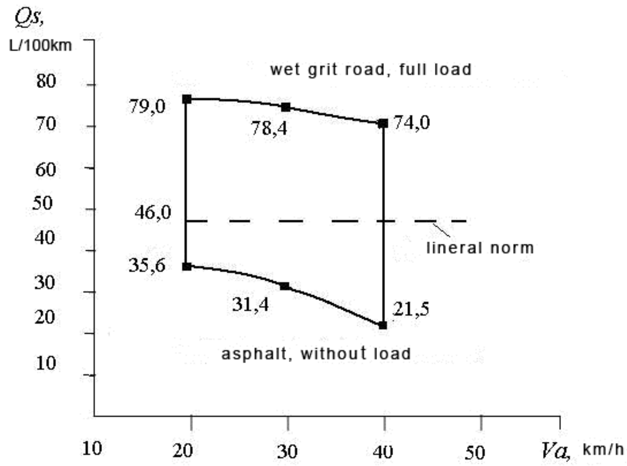

Fig. 2 Fuel-speed characteristic of the constant movement of KAMAZ-4310 on different types of roads

Comparative evaluation of ranges of linear fuel consumption of the truck KAMAZ-4310 on different types of roads is graphically represented in Fig. 3.

Analysis of Fig. 3 shows that the transition of vehicle movement to the roads with deformed surface due to substantial nonlinear growth of the resistance movement - for the deformation of soil, roughness, wheel slip (despite the proportional increase in the so-called base value of the coefficient of rolling resistance of tires - hysteretic internal energy loss in the tire Ψ_0) causes substantial practical nonlinear increase in fuel consumption Q_s. No doubt that to generalize the rationing of linear consumption Qs by any certain universal value for different traffic conditions is almost unreal.

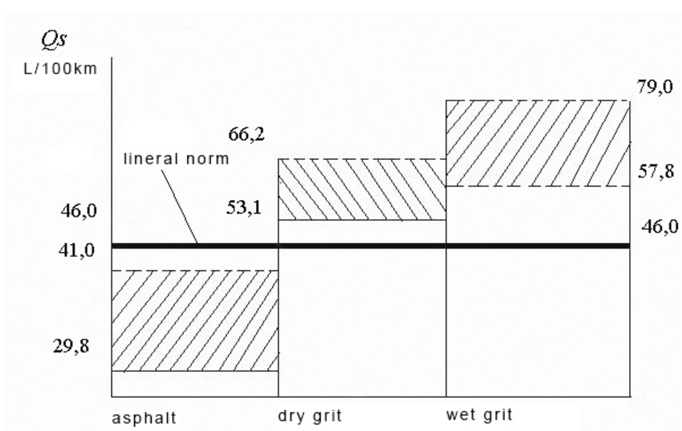

Fig. 3 Comparative evaluation of the range of linear fuel consumption of KAMAZ-4310 on different types of roads

It should be noted that the same qualitative characteristic of change of the above factors - traffic conditions is typical for other truck models that confirm the results of road tests still widespread in Ukraine trucks GAZ and ZIL.

Qualitatively new stage of the calculation of linear fuel consumption rates for trucks operated on the roads of different categories, with variable loading and respectively different average speed is the differentiated assessment of norm depending on these three determining factors, based on the methods of multivariate experiment planning [7-8]. In this case it is about three factorial simple matrices of research that allow to gain regressive change dependencies Q_s on the specific values of average speed $V_a(x_1)$, total resistance coefficient of movement $\Psi(x_2)$ and mass change (loading) of the car $G_a(x_3)$ - from the equipped weight up to the maximum permissible value (full nominal load).

Accordingly, there are given values of abovementioned factors that correspond to the range of their possible change in real exploitation - to simplify the processing results of road tests, or adequate computer simulation of movement respectively in coded form - X from -1 (lower limitof the change range of the studied factor) to +1 (the upper limit of the change range).

In the linear approximation the equation of the relationship of fuel consumption Q_s and determining factors - traffic conditions V_a, Ψ and G_a respectively X_1, X_2, X_3 for truck KAMAZ-4310 has the form:

$$Q_s = 49{,}83 - 5{,}1x_1 + 13{,}9x_2 + 8{,}0x_3 - 2{,}73x_1x_2 + 2{,}93x_1x_2 + 4{,}78x_2x_3 \quad (1)$$

where the transition between coded and natural values:

$$x_1 = \frac{V_a - 30}{10}; \; x_2 = \frac{\Psi - 0.035}{0.020}; \; x_3 = \frac{G_a - 11500}{3500} \quad (2)$$

Considering mostly nonlinear factor Q_s of dependence on traffic conditions we get more accurate nonlinear model:

$$Q_s = 54{,}3 - 3{,}84x_1 + 15{,}04x_2 + 5{,}59x_3 - 1{,}34x_1x_2 + 1{,}73x_1x_3 + 4{,}08x_2x_3 - 0{,}49x_1^2 - 1{,}15x_2^2 + 1{,}47x_3^2 . \quad (3)$$

For other truck models is the same qualitative situation.In practical work and during the formation of linear fuel consumption rates appropriate is their presentation in the form of tables or nomograms [7, 8].

As an example for the truck KAMAZ-4310 is presented Table 1 and graphic nomogram Figure 4 for determining Q_s under specific traffic conditions.

Table 1 Differential correction of fuel consumption rates of KAMAZ-4310 (6 × 6), depending on traffic conditions

Base Q, for average conditions	**Correction by V_a**		**Correction by G_a**		**Correction by type of the road ΔQ, L/100km**	
	ΔQ, L/100km	**V_a, km/h**	**ΔQ, L/100km**	**G_a, t**		
54,3	**-6,0** **-4,3**	**60** **40**	**+16,1** **+7,3**	**14 (trailer)** **7,0**	**38,1**	**Grass field**
					26,8	**Wet grit**
					15,2	**Wet soil**
	0	**45**	**0**	**2,5**	**0**	**Dry profiled road**
	+14,0	**30**	**-9,1**	**0**	**-8,2**	**Bound gravel**
					-16,12	**1-st cat. asphalt**

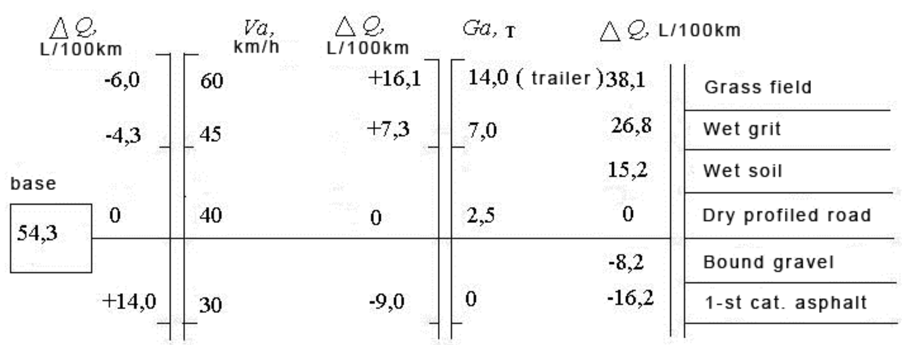

Fig. 4 Graphic nomogram of the formation of linear fuel consumption of KAMAZ-4310 (6 × 6), depending on traffic conditions

Traffic conditions of buses due to specific target spheres of their use - city (urban), local (suburban) or intercity (long-distance) transportation differ significantly in terms of typicality in comparison with trucks. Type and condition of roads, average speed (technical or operational) which are regulated by the typical routes that form the weighted average (indirect) of interior loading, and therefore the average value of the bus mass during the shift is fundamentally various.

The fundamental difference primarily of urban bus routes, as, after all, and suburban (with a much longer traffic cycle) is separate parts of the route, which buses run at similar speed values. At the same time, as shown research, each of the main route types is characterized by certain constant values of average speed on the route, which are different for each type. Considering this, and the cyclicity of movement phases can be formed a typical driving cycle (more correctly a test, which, in fact, is formed by the combination of several cycles) that will reflect the average movement values (speed, acceleration, race lengths) on the route.

Actually the historical precondition of the formation of typical driving cycles (test) was the need for typing of traffic conditions as a necessary condition for research the fuel efficiency and toxicity of vehicles. Finally the same typical driving cycles (tests) are used for parametric optimization of power drive out of the fuel efficiency conditions (under certain dynamic characteristics of motion).

Driving tests are regulated by standards. Current functional standard in Ukraine GOST 20306-90 has a range of disadvantages [9], which leads to a significant overstatement of fuel consumption rates in comparison with data of under-control exploitation (more than 6 l/100 km for urban bus Bogdan A091, 4,6 l/100 km for bus Bogdan A141 according to data of municipal enterprise "Kyivpastrans" [10]). Proposed typical driving cycle (tests) to evaluate the fuel efficiency of urban and suburban buses are deprived of these disadvantages and allow to provide a better rationing of fuel consumption of of urban and suburban buses, that is confirmed by the data of exploitation and experimental road tests [11, 12].

Figure 5 shows a typical driving test to assess the fuel efficiency of buses exploited on city routes.

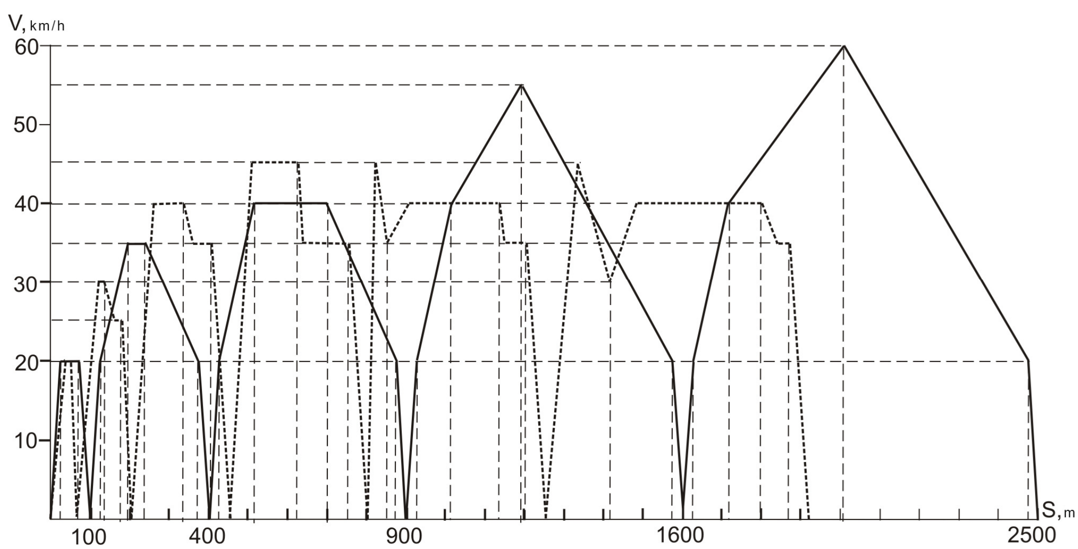

Fig. 5 A typical driving cycle for city buses: ······ according to GOST 20306-90; —— proposed city driving cycle

In GOST 20306-90 there is missed the cycle for suburban (local) routes, length of 50 km. Instead, there is a recommendation to determine the linear rates of fuel consumption by the combination of data of passing city and intercity cycles at a ratio of 40 % to 60 %, which does not meet the realities of suburban traffic. Thus was formed the driving test for assessing fuel consumption of suburban buses [12].

Intercity bus routes slightly differ under the terms of traffic. To assess the fuel efficiency of intercity and tourist buses are also used typical driving cycles. However it is necessary to make remark that the name "driving cycle" in this case is absolutely wrong, because this cycle is a fragment which displays the characteristic speed operating modes of the bus during the whole route. Thus it is more correct this fragment to be called a test.

Can be distinguished two types of intercity bus routes that slightly differ according to the speed criteria. This is actually intercity routes, and long-distance routes that are characterized by slightly higher average speed. Figures 6 and 7 respectively show the typical tests for testing fuel efficiency of buses III class (intercity and tourist buses).

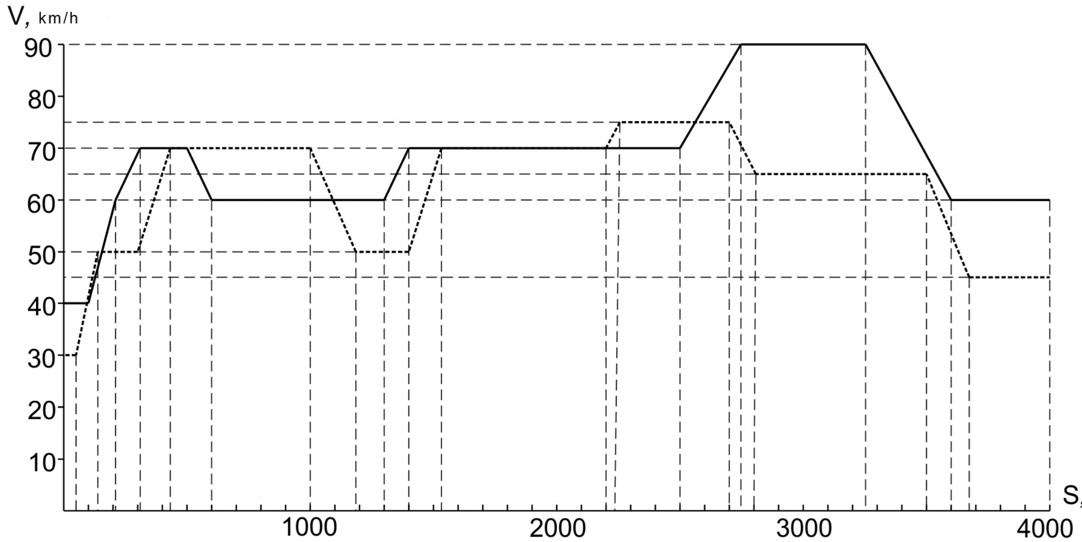

Fig. 6 A typical driving cycle for intercity buses: ...... according to GOST 20306-90; ——— proposed intercity driving cycle

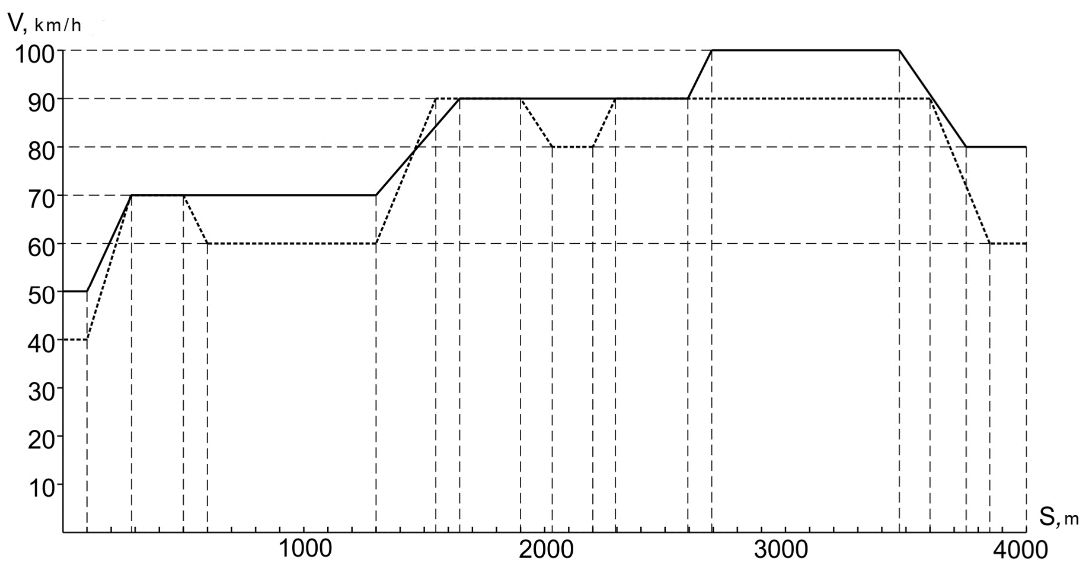

Fig. 7 A typical driving cycle for long-distance buses: ...... according to GOST 20306-90; ——— proposed driving cycle for long-distance buses

Formed driving cycles are the basis for rationing of fuel consumption of urban, suburban and intercity buses, they reflect the speed modes of traffic on the routes and allow to conduct a comparative analysis of different models or versions of buses to operate in typical traffic conditions.

3 CONCLUSIONS

Consequently there is obtained more qualitative methodology of rationing of fuel consumption of trucks and buses. In particular for trucks is received the opportunity of differential rationing of linear fuel consumption depending on the traffic conditions, and for buses is proposed typical driving tests that more accurately (in comparison with the current GOST 20306-90 of regulatory framework) reproduce traffic conditions on certain routes. As a result, the tests on the fuel efficiency of trucks and buses have yielded results sufficiently correlated with the data in a real exploitation, and the designed and improved methods of rationing of fuel consumption can be the basis for updating the national regulatory framework.

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POSSIBILITIES OF TEMPORARY REPAIRS IN THE ARMY

Jan FURCH, Josef GLOS

Abstract: The article deals with temporary repairs. Applying a different technology, using a reproduction part, or performing a repair by a serviceman without the competence is typical features of temporary repairs. Temporary repair makes possible for an object to fulfil its function for a limited time, until regular repairs can be made. The complexity perplex modern vehicles their reparability. It is necessary to look for the new procedures of the implementation so-called temporary repairs. There is an analysis of temporary repairs in selected countries in NATO. The authors suggested procedure battle damage assessment and repair, which they expressed in the form of diagrams. The kit for battle damage for vehicles IVECO is described in the final part of the article.

Keywords: Battle damage assessment and repair. Battle damage repair. Kit for battle damage repair. Temporary repair.

1 INTRODUCTION

In present Czech Army units carry out duties, which are connected with those carried out by NATO alliance. These missions are on first place connected with deployment in peacekeeping operations in abroad. The main objective which is required is that units composed of few vehicles have to departure for long distances from bases; it can be tens of kilometres. This fact lay stress on crew self-sufficiency for example in situations of self-recovery, but also in cases of technical faults and lighter failures solution. Those failures can cause vehicle immobility.

Another motivation to permanent introduction and improvement of means used for temporary repairs is the fact, that activity of enemy causes just about 40 percents damages of vehicles. To this number can be counted damages caused by IED explosion or hit by anti-armour weapons. The majority of cases it is a direct result of improper use of technology (i.e. raid on uneven terrain or obstacle at high speed, or due to accident) or random failure of components. Big part of those failures could be easily restored without necessity of excessive efforts and without usage of special NATO Stock Number (NSN) or represented spare parts [1].

High-risk battle damage repairs (involving possible danger to personnel or further damage to equipment) are only permitted in emergencies, normally in a battlefield environment, and only when authorized by the unit commander or his designated representative. The goal is to return a combat system to the battlefield in the least amount of time, while minimizing danger to personnel and equipment.

Battle Damage Assessment and Repair (BDAR) techniques are not limited to simply restoring minimal functional combat capability. If full mission capability can be restored expediently with a limited expenditure of time and assets, it should be restored.

Some BDAR techniques, if applied, may result in shortened lifespan or further damage to components. The commander must decide whether the risk of having one less piece of equipment outweighs the risk of applying a potentially destructive field-expedient repair. Each technique provides appropriate warnings and cautions, which list the system's limitations caused by the action. Personnel must use ground guides and extreme caution when operating recovery assets.

2 THE SIGNIFICANCE OF TEMPORARY REPAIRS

In past, temporary repair evolution was carried out spontaneously, according circumstances which were needed to deal with. Temporary repair depended on crew experience, on the level of vehicle complexity, on technical contingency and also on skill of individuals. Typical attribute of temporary repairs is another technology, not original part application or repair executing out of repairer competence.

Battle Damage Assessment (BDA) is the process used to quickly identify primary and secondary damage. Battle damage repair is accomplished by bypassing components or safety devices, cannibalizing or controlled Exchange of parts from like or lower priority equipment, fabricating repair parts, jury-rigging, taking shortcuts to standard maintenance, and using substitute fluids, materials or components.

During the BDA process, it is important to perform an "equipment triage." Triage is a process used to determine which systems are mission critical and the priority of repairs to restore function and return to service.

The battlefield is a chaotic environment with many unexpected circumstances. After performing triage, repair only what is needed, spending time on non-essential repairs is a waste of resources. Specific repair procedures may not be listed in technical or field manuals, and repair parts, tools, and skilled personnel may not be available. Flexibility and ingenuity are crucial to successful performance of BDAR.

The main principles of temporary repair are [2]:

- visually inspect interior and exterior for damaged parts and systems,

- visually determine if vehicle main systems appear to be operable,
- perform equipment self-test function–using a built-in test, built-in test equipment, and a function test,
- find out if the repair need to be executed immediately or can be postponed to arrival to unit post,
- determine technical state of vehicles parts, which have to be repaired,
- decide about the availability of means needed for repair execution,
- consideration of the economic performance of the repair (temporary and regular),
- consideration of the risk of the situation towards saving lives and vehicles,
- estimate required experience and skill of vehicle crew to execute repair,
- estimate time needed to carry out the repair,
- determine what materials are required,
- repair only what is necessary to regain combat capability,
- analyse the real state and decide about calling in supporting forces including specialists,
- determine what the vehicle limitations will be after repairing using BDAR or standard repair.

From mentioned facts arise that temporary repair system should be projected for each type of vehicle separately. Executions of temporary repair suppose also carrying out repairs training in battlefield conditions.

3 ANALYSIS OF TEMPORARY REPAIRS IN NATO

3.1 Army of the U.S.A.

Army of the U.S.A. makes use one of the best developed systems for solution of temporary repairs in NATO. Every vehicle acquired by this army is tested from point of view of possible application of means for temporary repair. Methodical procedures for (performance) accomplishment of temporary repair by means of the BDAR assembly are integral part of vehicles documentation. The BDAR was developed by the SURVIAC company. The SURVIAC Company collects data concerning performed repairs and it shares perpetual innovation and testing of new components of the assembly [1].

The assembly contains the means for following works:

- repairs of coolers and radiators,
- repairs of rubber joints and hoses,
- replacement of wedge-shaped and groove belts for propulsion of aggregates,
- repairs of metallic casings and blocks,
- repairs of smaller perforations of tyres,
- repairs of electric conductors.

American method also considers use of components yielded from equipment with lower priority of applicability under the given situation (so called cannibalism).

3.2 Army of the German Federal Republic

The system of situation of temporary repairs in the Army of the German Federal Republic does not assume use of the assembly which is similar to American one. In case of impossibility to bring out the vehicle in operable state by the crew of the vehicle using means of basic vehicle equipment, the means for carrying out of temporary repairs including specialists are called to vehicles location.

The mean is built on the light armoured wheeled vehicle Dingo 2 chassis with special superstructure carrying needed material for accomplishment of temporary repair. In this way equipped vehicle can ensure wider range of works than it is possible to accomplish using means of the assembly for temporary repairs. However temporal delays arises. These delays could have fatal consequences on enemy territory. Likewise it is impossible to ensure temporary repars of tracked vehicles as for example the IFV Marder II. or the Leopard II. tank in very rugged terrain where the vehicles usually operate [1].

3.3 Norwegian Army

Norwegian Army uses three levels system of temporary repair which combines of systems described above. The vehicles are equipped with similar assemblies as in case of the U.S. Army but the army also uses special vehicle based on the heavy truck Scania 6x6 chassis which is exclusively determined for executing of temporary repair in combat conditions. The third level is mobile post installed in the ISO 1C container. This workplace contains equal equipment as the Scania vehicle described above. Moreover own electricity generator, compressor and also welding and cutting units are installed. Workplace use to be developed in repairmen unit post near the gathering place of inoperable equipment. The stand solves repairs in cases when the temporary repair is sufficient [1].

3.4 Czech Army

Even the issue of temporary repairs have been solved yet in conditions of Czech Army, results were never implicated into practice. This fact can be caused of financial situation in which is Czech Army or in which was in recent history. Recently acquired vehicles were not tested to possibility of temporary repairs.

In present times temporary repairs are solved exclusively using basic vehicle equipment, in cases in which is not this method sufficient to restore vehicle operability, vehicles have to be transported to gathering place and repaired using conventional repairing methods of corrective maintenance. These methods have to be used also in cases when restoration could be easily processed by means of above mentioned temporary repair systems. This solution causes excessive delays in possible vehicles operations.

4 PRINCIPLES OF TEMPORARY REPAIRS

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

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

a) Temporary repairs in peace time

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

Operating costs are not expected to be increased due to the temporary repair, therefore, when deciding whether to perform it, mainly an economical factor will be the main criterion. The economical factor can be expressed by the following formula [2].

$$N_O + N_{DO} + N_{ZtDO} \leq N_O + N_{ZtO} \tag{1}$$

where N_O - costs of performing the repair, N_{DO} – temporary repair costs, N_{ZtDO} – loss incurred by the time the temporary repair is performed, and N_{ZtO} – loss incurred by the time the repair is performed.

The loss can include the costs of the settlement of a possible breakdown, the devaluation of a transported material, penalty payments, repair assistance, the costs of reloading material, the recovery and evacuation of a vehicle, or the increased costs of the repair due to the wear-out caused by performing the temporary repair.

After modifying the equation (1), we get

$$N_{DO} \leq N_{ZtO} - N_{ZtDO} \tag{2}$$

which is an economical requirement for performing the temporary repair. However, even much higher costs of performing the temporary repair as compared with the repair costs might be justified this way, therefore the following formula must apply simultaneously:

$$N_{DO} \leq N_O \tag{3}$$

and then it holds

$$(N_{DO} \leq N_{ZtO} - N_{ZtDO}) \bigcap (N_{DO} \leq N_O) \tag{4}$$

When deciding whether to perform the temporary repair, we should take in to account not only the costs, but also the fact to what extent a vehicle or a workshop vehicle is equipped with tools and material, to what degree a vehicle can be adapted to temporary repair performance, and the level of operating personnel skills.

Another important factor used when we are to agree on performing the temporary repair is time t_{min}, during which it is necessary to assure the main function of a temporarily repaired part until a regular repair is performed. The information stated above is followed by a requirement limiting the costs of temporary repair performance

$$N_{DO} \leq t_{\min} \frac{N_{ZtO} - N_{ZtDO}}{dt} \tag{5}$$

Therefore, when deciding whether to perform the temporary repair in peace time, it holds [2]

$$(N_{DO} \leq N_O) \bigcap (N_{DO} \leq t_{\min} \frac{N_{ZtO} - N_{ZtDO}}{dt}) \tag{6}$$

b) Temporary repairs in field conditions

The difference between the temporary repairs of combat vehicles performed in peace time and in field conditions is that we follow not only economical factors which are the most important in peace time, but also the provision of combat vehicle main functions, e.g. a weapon system, vehicle mobility and connection. The survival time of a vehicle (a crew) in a battlefield is crucial for deciding whether to perform the temporary repair. To put it simply, the recovery process of combat vehicle fighting power might be viewed as a geometric sequence [2]:

$$n_t = n_0 \cdot q^{t-1} \tag{7}$$

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

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

$$q = 1 - z + \psi \varepsilon z \quad (8)$$

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

$$n_x = n_0 \cdot q^{t_x - 1} \quad (9)$$

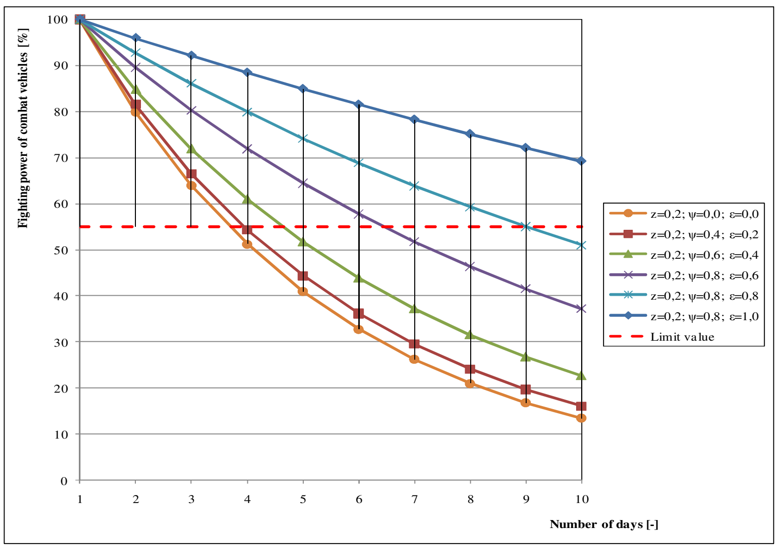
and therefore

$$t_x = \frac{\log n_x - \log n_0}{\log q} + 1 \quad (10)$$

when reaching the time t_x a unit must be replaced or supplied by another combat vehicle [2].

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

Graph 1 shows the courses of the decrease in fighting power with average 20 % daily losses z, the limit of 55 % fighting power and different magnitudes ψ and ε.



Graph 1 Fighting power of combat vehicles with 20 % daily losses

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

5 PROCEDURE BATTLE DAMAGE ASSESSMENT AND REPAIR

This chapter gives procedures for BDAR. Use these guidelines to rapidly assess battle-damaged equipment and systematically determine which subsystems are affected, to include the time, personnel, and materials required for repair.

These guidelines will also assist in performing “equipment triage.” Equipment triage is the process used to decide the order that battle damaged equipment will receive repairs. This determination is based on combat or combat support equipment, time, urgency, materials, and personnel required to do the required repairs [3], [4].

System assessment summary

a) Determine vehicle status:
   - Can the vehicle shoot, move, and communicate?
   - Can the vehicle be repaired to shoot, move, and communicate?
   - Can the vehicle be self-recovered, towed, or transported?
b) Check engine, transmission, fuel system, electrical system, wheels and suspension, hydraulic system, armour/ammunition storage, armament/fire control, and communications to see if they can be repaired or recovered and identify any limitations.
c) Identify expendables, parts, and tools and National Stock Number (NSN) if applicable.
d) Estimate the time and personnel needed [3], [4].

Hull damage assessment and repair

a) Record applicable NSN for exchanged and cannibalized parts.
b) Check engine system - for example, starter, oil tank, air induction system, air cleaner, oil filter, drain valve, accessory drive, shaft, low oil pressure.
c) Check transmission and final drive systems for faults, for example, transmission will not shift, broken linkage, vehicle will not steer, final drive locked, transmission leaks, parking and service brake serviceability, and oil cooler.
d) Check fuel systems - for example, fuel tanks, fuel lines, fuel filters, fuel pumps.
e) Check electrical systems - for example, wiring harness, slip ring, batteries, circuit breakers, and power distribution box.
f) Check track and suspension systems for example, compensating idlers, track adjusting link, road wheel arms, road wheels, support rollers, sprockets, shock absorbers, torsion bars, and track assembly.
g) Check hydraulic systems lines and fluids, driver controls, and instruments [3], [4].

Communications damage assessment and repair

a) Record applicable NSN for exchanged and cannibalized parts.
b) Check serviceability of intercommunications, receiver, transmitter, antennas, cables, and security.

Turret damage assessment and repair

a) Record applicable NSN for exchanged and cannibalized parts.
b) Check electrical system - for example, turret power, slip ring, circuit breaker, and wiring harness.
c) Check armament - for example, bore evacuator, gun tube, breech group, and main gun mount.
d) Check fire control system - for example, commander control handle and weapon sight, gunner primary and auxiliary sight, range finder, crosswind sensor, wiring system, gunner control handle, stabilization system, manual traverse and elevation, and loader's panel.
e) Check hydraulic system - for example, auxiliary hydraulic pump, hydraulic fluid, and hydraulic reservoir [3], [4].

6 THE PROPOSAL KIT FOR A BATTLE DAMAGE REPAIR VEHICLE IVECO

We proposed a battle damage repair (BDR) kit (Fig. 1) for the temporary repairs implementation in the Czech Army. Dimensions of BDR kit bag are 50 x 32 x 15 cm and weight is 7.7 kg. The bag is divided in to three separate boxes, in which the material for the temporary repairs of the land vehicles is placed.

First box contains adhesives and cements. There are tubes, adapters, connectors and plugs in the second box. In the third box there is material for repairs of the land vehicles electrical systems, for instance shielding, wire, crimping pliers, tin solder etc.

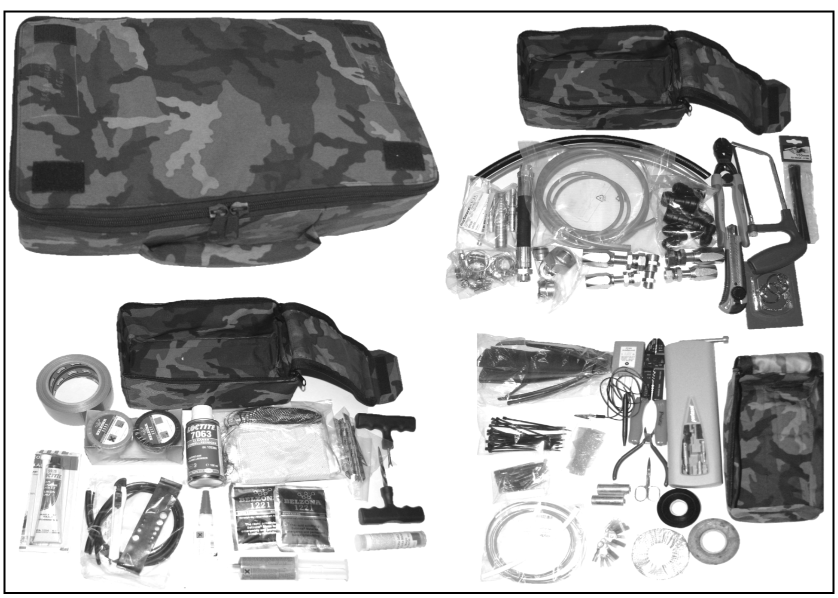


Fig. 1 Battle damage repair kit for repair of land vehicle IVECO [own source]
a) Overall view of the kit, b) Tubes, adapters, connectors and plugs, c) Adhesives and cements, d) Electrical material.

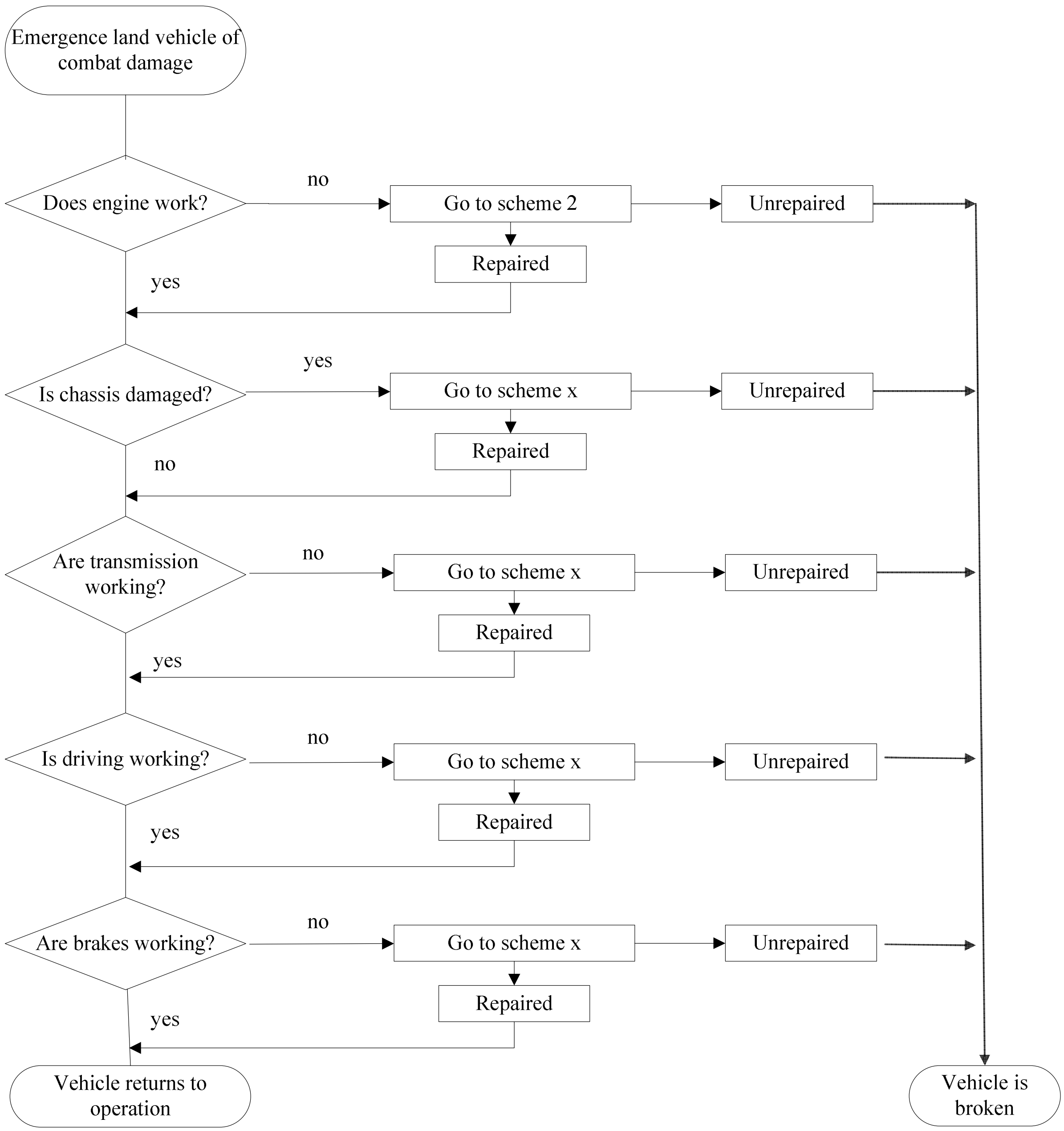


Fig. 2 Design of battle damage assessment procedures of land vehicle [own source]

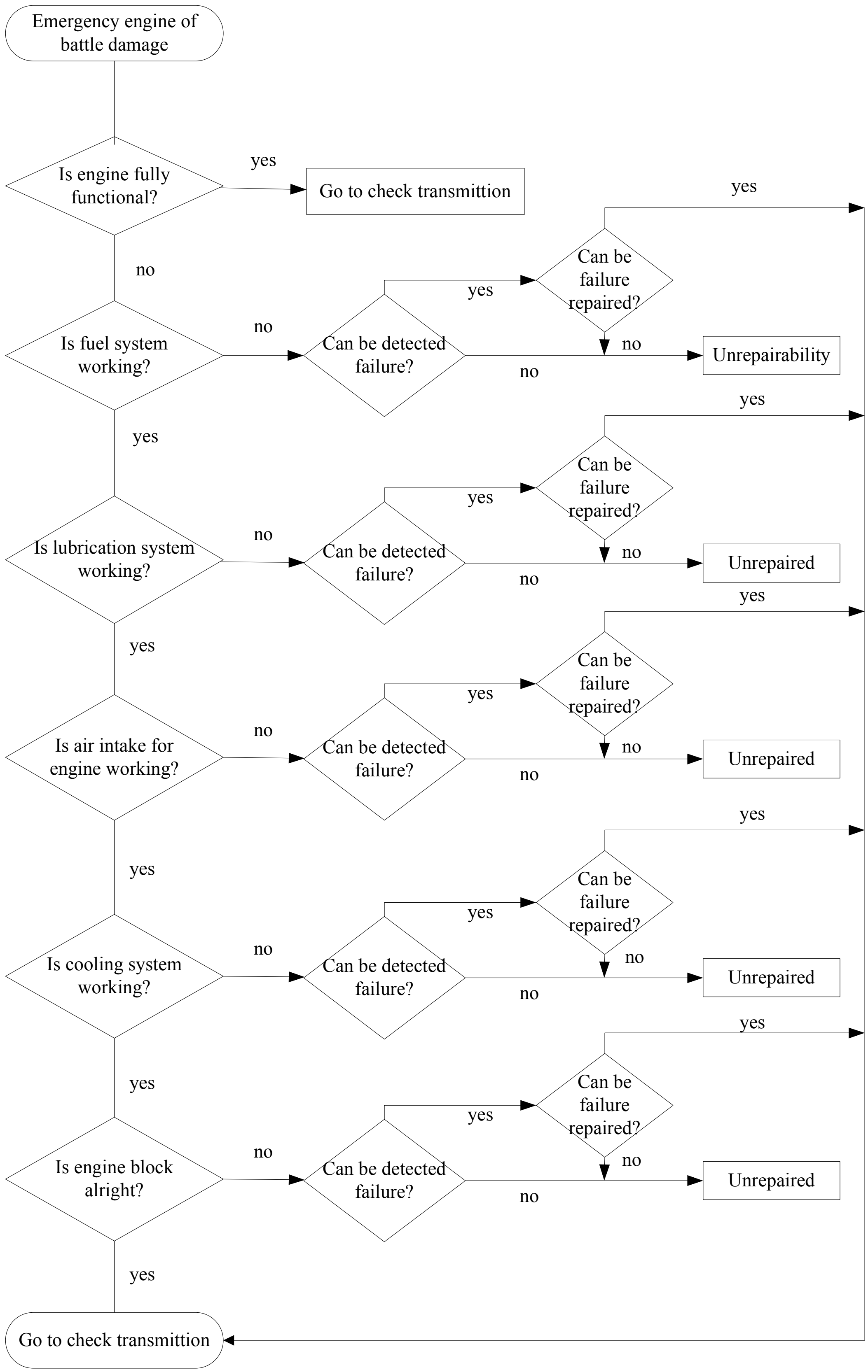


Fig. 3 Design of battle damage assessment procedures of engine [own source]

7 CONCLUSION

The main purpose of temporary repair execution is to restore vehicle operability in relatively brief time interval (time needed up to 4,5 hours) using means carried by vehicle. There exist also prerequisite, that the repair will be executed by vehicles crew (usually the driver) directly in combat conditions and the vehicle displacement will not be needed. In certain cases the temporary repair can be carried out by specially trained personnel, using means from special vehicles equipment, which are designed especially for this purpose, for example recovery and workshop vehicles. Main disadvantage of this method is prolongation of time needed for repair.

On the other hand one of the advantage of temporary repair is very fast return of vehicle to operational state, although is not necessary to transport vehicle to repairer units post. Temporary repairs are favourable especially in cases of easy viable repairs which have fundamental influence to vehicles operability.

Acknowledgement

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MODELLING LIFE CYCLE COST IVECO VEHICLES AND TATRA 810

Zbyšek KORECKI, Monika CABICAROVÁ, Filip BALHAR

Abstract: In general it can be said that there is currently no fully to track the life cycle cost. NATO members use two approaches – the life cycle of materials and the cost structure of projects. The paper will address the LCC with a focus on direct and indirect costs for selected military equipment of the Army of the Czech Republic.

Keywords: LCC. Modeling. OmegaPS Analyzer.

1 THE THEORETICAL PART

LCC consists of all direct costs plus indirect costs, variable associated with the procurement, operation and support, and disposal. Indirect costs may also include the costs linked to other common support equipment, administrative staff and unlinked costs associated with recruiting additional staff. It can be said that they are all indirect costs associated with the activities or resources that are not affected by the introduction of the system or are not part of the LCC.

LCC also contains marginal cost, marginal cost of direct and indirect marginal costs for the introduction of new equipment or facilities. LCC usually serves as a decision support in the selection of optimal variants of the product in order to achieve savings in the use and support. The actual value is the result of LCC, which aims to evaluate the different options and give them the order. The resulting values of LCC generally serve to promote financial planning. The main reason why perform LCC is that, all multinational programs must implement a program of life-cycle cost estimate because the life cycle is very well used as a metric for measuring the value of which was taken for finance defenses.

1.1 Product Life Cycle

Each stage of the product life cycle means a period of time the life cycle of the system. The allocation system life cycle stage is to focus on effective implementation work in smaller, more distinct, time-bound steps. Among the various stages of the life cycle of the decision gates and entry/exit criteria, which provide a mechanism to manage the transition between stages and control mechanisms of the processes according to ISO 15288 System Engineering - System Life Cycle Process, which are also defined in the CSO 051655th life cycle consists of phases concept, development, production, use, and retirement.

Typically, it is a general breakdown of the life cycle costs of weapon systems in NATO conditions in the range of 2 % to determine the concept, 8 % D, 30 % to 60 % of the production and the operation. [Technical Report TR-SAS-076 source 64].

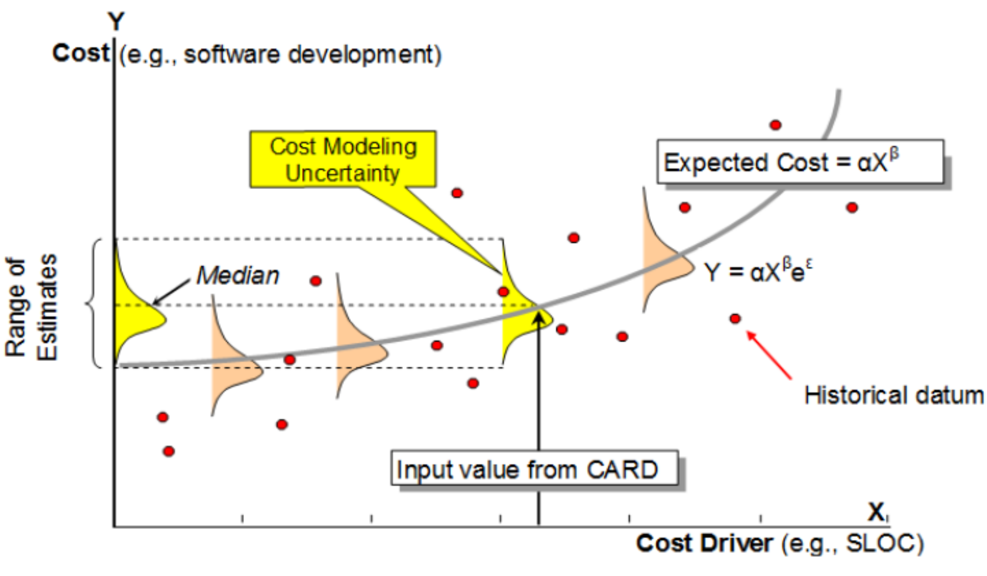

Fig. 1 Estimating the cost for software development (example)
Source: NATO Initiatives to Improve Life Cycle Costing, p. 8.

1.2 Structure of the life cycle costs of military systems

The costs are divided by the time factor into two main groups. In the first case, the costs already incurred and costs, which are still in place and these costs are derived from predictions based on estimates and computational models with more or less deviation from reality.

LCC analysis uses eight basic mathematical models.

Summation of the total cost model only summarizes the various cost elements of the acquired data and does not include the time value of money and does not use any mathematical prediction models.

A general model of life cycle costs when including time value of money includes the discount rate, inflation and uses the basic relation

$$LCC = \sum_{k-(m-1)}^{n} \frac{C_k}{(1+i)^k} \quad (1)$$

where "m" represents the length of the development or acquisition phase in years, "n" indicates the length of the life cycle in years, "i" represents the discount rate and 'Ck' cost k-th year.

Model minimum life cycle cost consists only of two main cost items. The cost of the life cycle of the vehicle is equal to the cost and cost of ownership.

Model equivalent annual operating costs, the time value of money, which is calculated using a discount rate. The model is expressed by the formula:

$$EAUC = A_k + \frac{\sum_{i=0}^{n}[PV_{cost}]}{\left(\frac{1}{(1+r)^n}\right)} \quad (2)$$

where "Ak" is annual recurring costs for regular maintenance, "r" represents the discount rate, "n" is the length of the life cycle in years and "PVcost" represents the present value of the cost of repairs.

Model relative savings is the savings ratio to additional investments incorporating the time value of money through the discount rate. The relative saving is defined as the basic relationship:

$$SIR = \frac{\sum_{i=0}^{N}\frac{S_t}{(1+d)^t}}{\sum_{i=0}^{N}\frac{I_t}{(1+d)^t}} \quad (3)$$

where "St" is achieved savings in year t, "It" is additional investment in the "d" represents the discount rate.

Model of the energy cost savings are the total life cycle costs at the possibility of detailed costing for each energy source. Cost savings is expressed by the formula:

$$L = I_0 + \sum_{t=1\ldots T} \frac{(p_t^1 \cdot q_t^1 + p_t^2 \cdot q_t^2 \cdot \ldots \cdot p_t^N \cdot q_t^N) + M_t + Q_t}{(1+i)^t} + \frac{R}{(1+i)^T} \quad (4)$$

where "I_0" are the initial investment, "p_t" is the price of energy in t per kW, "q_t" expresses the amount of energy consumed in kW tv, "Mt" maintenance costs "O_t" formulates other costs, "R" the residual value of ai expresses the discount rate.

Model probability of failure is based on determining the frequency of failures and is based on the Weibull distribution.

Wielbull distribution is defined by the formula:

$$H = 1 - e^{-\left(\frac{t}{T}\right)^b} \quad (5)$$

where "e" is the base of natural algorithms "t" the operating time of the product group "T" stands for the operation of the product group, which just broke down last product a "b" parameter Weibull distribution sets.

Model risk analysis, which is an integral part of the analysis of life cycle costs method, uses Monte Carlo.

1.3 Program analysis LCC

Program OmegaPS Analyzer is probably the most comprehensive software for modeling the life cycle cost.

The decisive factors for the calculation of LCC are mean time between failures, the prices of spare parts, hourly maintenance work. As part of the application is the ability to generate reports arranged appeals costs, including graphs of comparison with other products.

2 THE PRACTICAL PART

2.1 The vehicle Iveco LMV M65E19WM

LCC analysis was carried out on vehicles Iveco LMV M65E19WM, the total is in the Army as recorded in the register of ISL 113 units Iveco LMV vehicles in 8 modifications. Modeling was performed on randomly selected 12 pieces of vehicles where the selected at least once each of the eight above-mentioned modifications. Data correspond to the time interval from 1st January 2010 till 17th April 2014.

In the modeling life-cycle cost for using the software Excel created four tables that together simulate and calculate the Cost lifecycle of a vehicle Iveco LMV. Calculated values of operating costs are estimated costs for one year operation of a vehicle, the estimated cost of one year of operation of 113 vehicles, the estimated cost of 20 years of operation of all 113 vehicles and the time decay of the total cost of the 20 years of operation of 13 vehicles Iveco LMV with the acquisition due to profile.

Table 1 Data for modeling

Type of vehicle	Military license plate	Total km	Consumption liters	Average consumption per 100 km	Km per year	Service [CZK]	Material [CZK]
IVECO 4X4, S VEZ	025-61-60	5,151	1,420	27.567	1,199.818	0.00	29,995.00
IVECO 4X4, S LAF	515-01-08	14,015	4,418	31.523	3,264.502	0.00	2,362.00
IVECO 50B VR	411-34-58	1,188	386	32.492	276.720	0.00	0.00
IVECO 50B4 RVS	309-57-68	3,828	1,226	32.027	891.653	0.00	2,256.00
IVECO 50B4 RVS	307-36-49	2,696	974	36.128	627.977	1,308,354.00	2,945.00
IVECO 50B5	408-55-20	5,650	1,811	32.053	1,316.05	0.00	0.00
IVECO 50B5	409-44-49	1,465	427	29.147	341.241	0.00	0.00
IVECO 50B5	419-76-47	2,706	836	30.894	630.306	103,334.00	38.0
IVECO 50B5 M2	325-93-57	8,593	2,435	28.337	2,001.560	0.00	0.00
IVECO 50B5 RVS	312-85-52	1,808	495	27.378	421.136	0.00	0.00
IVECO 7,62B5	422-75-88	513	163	31.773	119.493	0.00	0.00
Ambulance	025-12-73	1,540	526	34.156	358.711	0.00	7,792.00
	Total	49,153	15,117		11,449.167	1,411,688.00	45,388.00
	Average	4,096	1,260	31.123	954.097	705,844.00	3,782.33

The Table 2 shows the estimated cost per year of operation of a vehicle Iveco LMV. Price of the vehicle was calculated by dividing the total sum by the number of vehicles on order.

The total predicted cost of operation 113 vehicles Iveco LMV were 190,135,857 CZK

Due to the expected duration of use in the Army of the Czech Republic for 20 years are predicted costs in the amount of 3,802,717,132 CZK.

Previous calculations were used as the basis for calculating the cost of living for 113 vehicles Iveco LMV with the acquisition due to the profile.

Table 2 Estimated costs for one year operation of a vehicle Iveco LMV

	The values for the calculation of the annual cost							
Cost item	**Basic**				**Derived**			**Annual costs [thous. CZK]**
					Unit	**Number of units**	**Costs unit [CZK]**	
1. Fuel (moving vehicle) Pr-annual mileage [km],Mj-average fuel consumption [l/100km]	Pr	Mj	-	-				
	954	31	-	-	l	295.74	30	8.872
2. Fuel (stationary vehicle) Mr-annual standard [Mh], Ms-fuel consumption [l/Mh]	Mr	Ms	-	-				
	190	2	-	-	l	380	30	11.4
3. Batteries Pa-number of batteries in the vehicle, Za-battery life	Pa	Ža	-	-				
	2	4	-	-	unit	0.4	13,000	5.2
4. Tires Pp-number of tires on a vehicle e, Pr-annual mileage km,, Zp-tire life	Pp [item]	Pr [km/year]	Žp [km]	-				
	4	4,000	25,000	-	unit	0.6	33,500	20.1
5. Supplies of low life	-	-	-	-	-	-	-	2
6. Smoke grenades Pg-number of grenades for one vehicle [units/year]	Pg	-	-	-				
	6	-	-	-	unit	6	10,000	60
7. Ammunition Pn-number of rounds for one vehicle [units/year]	Pn	-	-	-				
	2,000	-	-	-	unit	2,000	300	600
8. Maintenance Nsú-cost of service u, Nsmu-costs of consumables, Pú-labor intensive maintenance, Nhu-obligatory costs per worker	Nsú [CZK/year]	Nsmú [CZK/year]	Pú [Nh/year	Nhú [CZK/Nh]				
	58,879	945	50	550	-	-	-	87.324
9. Corrections (except overhaul) Nso-cost of service, Nsmo- material costs, Po-labor intensive repairs, Nho-obligatory costs per worker	Nso [CZK/year]	Nsmo [CZK/year]	Po [Nh/year]	Nho [CZK/Nh]				
	29,410	29,410	70	550	-	-	-	82.722
10. Overhaul Xo-share of the cost of the GO price of the vehicle, Cv-price of the vehicle	Xo [%]	Cv [thousand CZK]	-	-				
	40	40,000	-	-	-	-	-	800
11. Disposals Xv-share of the decommissioning costs from the price of the vehicle, Cv-price of the vehicle	Xv [%]	Cv [thousand CZK]	-	-				
	0.25	40,000	-	-	-	-	-	5
TOTAL							**1 682.618**	

Table 3 Time decomposition total cost of 20 years of operation 113 vehicles Iveco LMV – with the acquisition profile

Year	The annual cost to the vehicle group by acquisition profile [thous. CZK]			The total annual cost [thousand]
	19 pieces in year 2008	90 pieces in year 2009	3 pieces in year 2010	
2008	15,103.028	0	0	15,103.028
2009	15,103.028	71,540.658	0	86,643.686
2010	16,952.108	71,540.658	2,384.689	90,877.454
2011	16,952.108	80,299.458	2,384.689	99,636.254
2012	16,952.108	80,299.458	2,676.649	99,928.214
2013	16,952.108	80,299.458	2,676.649	99,928.214
2014	16,952.108	80,299.458	2,676.649	99,928.214
2015	16,952.108	80,299.458	2,676.649	99,928.214
2016	16,952.108	80,299.458	2,676.649	99,928.214
2017	16,952.108	80,299.458	2,676.649	99,928.214
2018	319,103.028	80,299.458	2,676.649	402,079.134
2019	16,952.108	1,511,540.658	2,676.649	1,531,169.414
2020	16,952.108	80,299.458	50,384.689	147,636.254
2021	16,952.108	80,299.458	2,676.649	99,928.2144
2022	16,952.108	80,299.458	2,676.649	99,928.2144
2023	16952.108	80,299.458	2,676.649	99,928.2144
2024	16,952.108	80,299.458	2,676.649	99,928.2144
2025	16,952.108	80,299.458	2,676.649	99,928.214
2026	16,952.108	80,299.458	2,676.649	99,928.214
2027	18,852.108	80,299.458	2,676.649	101,828.214
2028	0	89,299.458	2,676.649	91,976.107
2029	0	0	2,976.6486	2,976.649
TOTAL				**3,769,064.768**

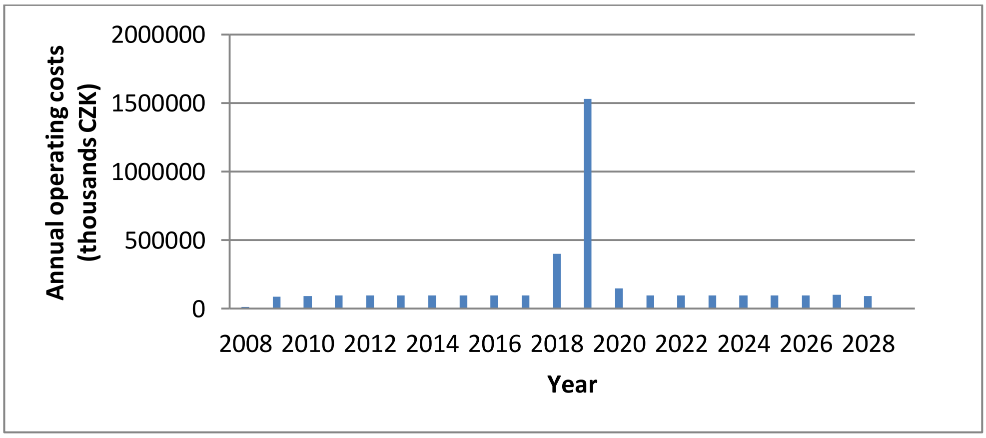

Fig. 2 Time decay annual operating costs 113 vehicles Iveco LMV

2.2 Truck middle categories Tatra 810

The vehicles were purchased by the ACR in 2008–2009 and consisted of 588 custom cars in several modifications.

In total, 10 vehicles were analyzed in four modifications in the period from 1.1.2010 – 17.4.2014 using MoD Logistics Information System and ACR.

Table 4 Characteristics of the analyzed vehicles

Type of vehicle	Military license plate	Total km	Total liters	Consumption [l/100km]	Km per year	Service [CZK]
T810 6X6.1R	026-27-70	10,968	3,774	34.41	2,554.77	4,219.00
T810 6X6.1R	026-27-25	12,242	4,025	32.88	2,851.52	4,219.00
T810 6X6.1R	026-28-64	14,078	4,975	35.34	3,279.18	4,219.00
T810 6X6.1R	026-12-10	22,957	7,187	31.31	5,347.35	4,219.00
AT810 6X6 D.OVL	025-82-05	26,118	10,831	41.47	6,083.64	4,219.00
T810 6X6 D.OVL	025-80-27	15,426	4,907	31.81	3,593.17	4,219.00
T810 6X6 D.OVL	025-80-03	12,282	4,293	34.95	2,860.84	4,219.00
T810 6X6 Z.Č	023-63-88	27,336	8,512	31.14	6,367.35	4,219.00
T810 6X6 Z.Č	023-63-95	24,984	7,704	30.84	5,819.50	4,219.00
T810 6X6 PRAM	023-55-01	23,911	8,408	35.16	5,569.57	4,219.00
Total		190,302	64,616		44,326.89	42,190.00
Average		19030.2	6,461.6	33.93	4,432.69	4,219.00

Table 5 Estimated costs for one year operation of a vehicle Tatra

Item	The values for the calculation of the annual cost							Annual cost (thous. CZK)
	Basic				Derived			
					Unit	Number of units	Costs unit (CZK)	
1. Fuel Pr- annual mileage [km], Ms- average fuel consumption [l/100km]	Pr [km/year]	Ms [l/100km]	-	-				
	19,300	33.93	-	-	l	6548.49	25	163.712
2. Battery Pa- number on a vehicle , Ža-annual mileage,	Pa [units]	Ža [year]	-	-				
	2	4	-	-	ks	0.4	2,000	0.8
3. Tires Pp- number of tires on a vehicle, Pr-annual mileage km, Žp- tire life	Pp [units]	Pr [km/year]	Žp [km]	-				
	6	19,300	25,000	-	ks	4.6	6,000	27.6
4. Supplies of low life	-	-	-	-	-	-	-	0.5
5. Maintenance Pr-annual mileage km, Iú-maintenance interval, Nsú-average maintenance costs	Pr [km/year]	Iú [km]	Nsú [CZK]	- -				
	19,300	19,300	1,407	-	-	-	-	1.337
6. Corrections Pr-annual mileage km, Io-interval correction, Nso-the average repair costs	Pr [km/year]	Io [km]	Nso [CZK]	- -				
	19,300	20,000	10,000	-	-	-	-	9.168
7. Revision after 10 years	-	-	-	-	-	-	-	10
8. Disposals Xv-share of the decommissioning costs from the price of the vehicle, Cv-price of the vehicle	Xv [%]	Cv [thous. CZK]	- -	- -				
	0.5	4,592	-	-	-	-	-	1.148
TOTAL								**214.264**

Subsequently, the calculated total costs to 20 years operation of vehicles, disintegration time of 20 years, the cost of operation due to all vehicles with the acquisition profile.

The total cost for one year of operation of one vehicle was estimated at 2,142,644 CZK and for 588 vehicles is the amount of 1,259,874,672 CZK.

The time decay of the total cost of the 20 years of operation of vehicle given with the acquisition profile is expressed in the following table.

Table 6 Time decomposition total cost of 20 years of operation vehicles Tatra – with the acquisition profile

Year	The annual cost to the vehicle group by acquisition profile [thousand CZK]			The total annual costs [thous. CZK]
	20 pieces in 2007	538 pieces in 2008	30 pieces in 2009	
2007	3,880.39	0	0	3,880.39
2008	4,073.39	104,382.36	0	108,455.74
2009	4,073.39	109,574.06	5,820.58	119,468.02
2010	4,073.39	109,574.06	6,110.08	119,757.52
2011	4,073.39	109,574.06	6,110.08	119,757.52
2012	4,073.39	109,574.06	6,110.08	119,757.52
2013	4,073.39	109,574.06	6,110.08	119,757.52
2014	4,073.39	109,574.06	6,110.08	119,757.52
2015	4,073.39	109,574.06	6,110.08	119,757.52
2016	4,073.39	109,574.06	6,110.08	119,757.52
2017	8,045.25	109,574.06	6,110.08	123,729.38
2018	4,073.39	216,417.09	6,110.08	226,600.55
2019	4,073.39	109,574.06	12,067.87	125,715.31
2020	4,073.39	109,574.06	6,110.08	119,757.52
2021	4,073.39	109,574.06	6,110.08	119,757.52
2022	4,073.39	109,574.06	6,110.08	119,757.52
2023	4,073.39	109,574.06	6,110.08	119,757.52
2024	4,073.39	109,574.06	6,110.08	119,757.52
2025	4,073.39	109,574.06	6,110.08	119,757.52
2026	4,258.39	109,574.06	6,110.08	119,942.52
2027	0	114,550.56	6,110.08	120,660.63
2028	0	0	6,387.58	6,387,58
TOTAL				**2 511 687,88**

3 CONCLUSION

This article assesses the cost of vehicle life cycle M65E19WM Iveco LMV and Tatra 810 for 20 years of operation for all vehicles operated in the records of the ACR. In the following years it is possible to see how the actual costs consistent with the expected calculated costs.

The greatest drawbacks LCC analysis can indicate a linear relationship, which is associated with disorders of vehicles. It is biased to assume that in a given year to break down all the cars in a particular group. This problem can be solved by better amenities and sophistication of software for calculating LCC.

Another major drawback is the already mentioned veracity of the information embedded in the ISL.

This problem has been addressed through the use of wireless modules that would dispatched to the vehicle information separately, independently of the human factor.

Life cycle cost modeling is a topic that is very current, the future and will continue to evolve. Can be predicted that in the near future will be a necessary indicator, without which you cannot do the evaluation and procurement by the fact he will be fragmentation of weight.

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DEVELOPMENT OF NUCLEAR EDUCATION STANDARDS

Sergij V. BEGUN, Vasilij V. BEGUN

Abstract: If we analyze the causes of severe accidents in the world nuclear industry, we find in most cases common root causes: project deficiency, human error. The fundamental remedy of these root causes is only possible through improvement of nuclear education. Development of the nuclear education standards for the nuclear industry staff and the certification system for teaching staff are proposed. Recommendations with mandatory for the nuclear industry staff disciplines, appropriate knowledge and skills were developed. Propositions for the principles and structure of the certification system for teaching staff are formulated. The risk of emergency situations and accidents in nuclear industry will be significantly reduced.

Keywords: Nuclear Education. Education Standard. Training, Certification.

1 INTRODUCTION

Nuclear power can provide the essential part of humanity energy needs for thousands of years as pointed out in [1].

But if one more accident of the scale like Three-Mile Island (1979), Chernobyl (1986) or Fukushima (2011) will occur, the consequences may lead to the rejection of nuclear energy in many countries and even in the whole world. This assumption is confirmed by the decisions of some countries to provide the moratorium on the development or complete phase out of nuclear energy, especially after the Chernobyl accident in 1986, and after the accident at the Fukushima Daiichi Nuclear Power Plant in 2011.

Therefore, taken in account the global consequences of severe accidents on all nuclear energy in the world, there is a time to develop the international standards in the field of nuclear energy, which should be mandatory for all the countries with nuclear energy.

If we analyze the causes of above mentioned severe accidents, we find common root causes: project deficiency, human error. These confirmed by the results of post accident analysis of Three Mile Island accident [2, 3], of Chernobyl accident [4, 5], as well as in the case of Fukushima accident [6, 7, 8]. The fundamental remedy of these root causes is only possible through improvement of nuclear education. The corresponding qualification enhancement of designers will lead to the elimination of design deficiencies at the design stage or during the operation of the existing nuclear facilities. The personnel qualification enhancement will lead to the identification of design deficiencies, which were missed at the design phase and to the reduction of errors during the operation of nuclear facilities.

The analysis of nuclear education curricula at various universities shows a significant difference in training in the same specialty. Often, this situation is related to the actual circumstances at the universities for different reasons. Sometimes this is due to the direction of scientific activity of the teaching staff at the departments. This creates a precedent of different education level of professionals in the industry.

There are a lot of good practice (mainly in old universities), where the teaching staff are the best industry experts with great experience of work in the industry. But, there are some negative effects associated with the lack of qualified teaching staff in the field of special education at some universities. The later described situation is particularly due to the much lower teacher salaries compared to industry experts. This phenomenon is especially evident in the teaching of special subjects. In such cases, it is often not taught what is needed, but what they can teach. As a result, trained specialists have significant gaps in knowledge, and with this incomplete knowledge they come to the nuclear industry.

Therefore, at this paper we propose to define a set of mandatory fundamental disciplines for the study, which correspond to the set of knowledge and skills of nuclear energy specialists, covering all the main stages of the nuclear fuel cycle.

Obviously, this point of view, first of all, should be implemented to the teaching of special disciplines related to nuclear and radiation safety. Unfortunately, there is a reality, when these disciplines are taught by assistants, who do not have any experience in the industry. Such teachers have only theoretical knowledge about equipment and processes. In our opinion, such situation can cause a lack of training both for Bachelor`s degree students and for Master`s degree students. Therefore, from our point of view, the special requirements to higher education teachers in the field of nuclear energy should be developed similar to the current requirements in the industry: periodical certification, the requirements for initial education and work experience in the industry. In this connection it is necessary to develop the system of certification of special disciplines teachers. The universities, that do not have own teachers with proper skills, will need to provide teaching by inviting certified professionals, until they train local specialists.

The main purpose of this paper is to define the problem of *common* mandatory basis of knowledge and competence determination, which should be obligatory for the operational personnel, technical experts of the operating organization and the regulatory body, decision makers in the industry. As a result, in our opinion, the people with a certain defined set of competences should be at all levels in the industry. The existence of a common basis of knowledge and competences provides the following benefits:

1. Increase in the efficiency and speed of information exchange at all levels in the industry while reducing the probability of incorrect perception of information through a common language and a common understanding of processes.
2. Consistent knowledge of what to do in standard situations.
3. Clear consistent understanding at all levels of the industry of possible ways to solve arising safety problems due to sufficient knowledge of the basic processes and opportunities to influence on the sequence of events.
4. Increasing of the probability of timely decision-making as a result of clear understanding of the time limits for each type of decision-making by all specialists and managers.
5. Improving consistency in the divisions of industry, including consistency in emergency situations.

The most important processes should be identified to determine the list and content of mandatory for study disciplines. Such processes are:

a) most strongly influence to the production data of industry,
b) have the greatest impact on safety.

Improvement of knowledge about the first type (a) of processes would lead to more efficient use of facilities and their stable work. Improvement of knowledge about the second type (b) of processes will reduce the probability of accidents and lead to more effective emergency response.

2 DESCRIPTION OF EXISTING EDUCATIONAL AND TRAINING SYSTEM

At present the structure of education and training of industry specialists in all countries has approximately the same form shown schematically in Fig. 1.

After graduation from universities and the professional selection, young specialists are trained at the Training Center (TC). Every nuclear power plant (NPP) usually has its own TC as a subdivision of NPP. The retraining for the new position is also performed at TC.

The training at NPPs has a systematic and planned nature. This training is based on the developed teaching and methodological materials in accordance with the standard training programs for certain positions of NPP operational personnel and technical managers. The Full-Scale Training Simulators of NPP (FSTS of NPP), Local and Analytical Simulators are designed and built for these purposes in TCs.

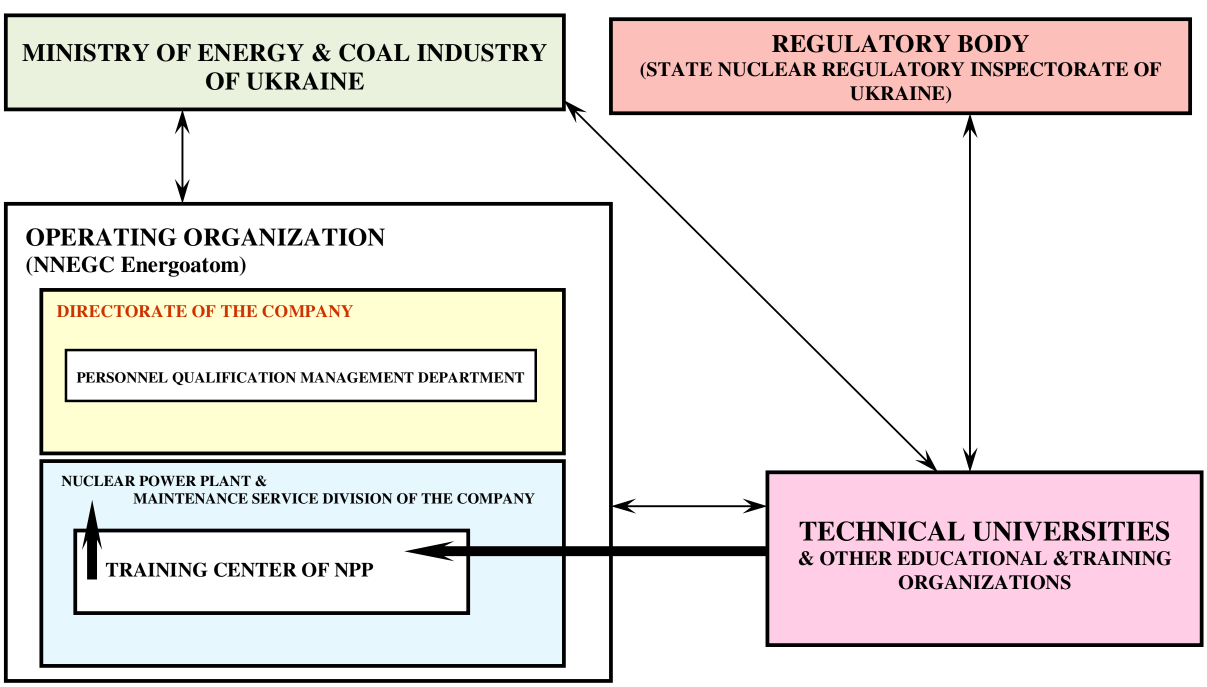

Fig. 1 Scheme of personnel education and training for the nuclear industry of Ukraine

The powerful computer systems are used in these simulators, which allow to perform the real-time simulation of processes in nuclear power reactor, turbines, other equipment of NPP and the NPP as a whole with actuation of protection and blocking systems. Thus, for all trained specialists of all categories and levels there is the opportunity of gradual improvement of knowledge and skills concerning all technological operations at the NPP under the guidance of experienced instructors.

The tough psychophysiological selection is mandatory before subsequent training for the ones, who will work on the operational positions (licensed personnel). The subsequent education and training is long enough, you can see some related information for the selected positions in Table 1.

Table 1 Education and training of license personnel at NNEGC Energoatom.

Position	Time of education under interruption of work (months)	Time of training at the FSTS of NPP (hours)	Total work experience after retraining (months)
Principal Engineer of Reactor Control	9-11	220	33-35
Shift Supervisor of Reactor Department	5-6	220	49-53
Principal Engineer of NPP Unit Control	11-12	116	50-58
Shift Supervisor of NPP Unit / Shift supervisor of NPP Units	Reactor Department - 14-16; Turbine Department - 21-24; Electricity Department / Department of Heat Automatics and Measurements - 24-27.	255	55-69

Let us note that the "Safety culture" discipline is an integral mandatory part of education and training programs for all the categories of license personnel, and includes the following topics:

- Fundamentals and characteristics of safety culture.
- The role of the human factor in ensuring the safety culture.
- The role of the trainee specialist in ensuring the safety.
- Self-assessment of the personnel.
- Quality assurance.

As a result, the operational personnel and the technical management of the NPP unit become the well trained professionals, what is confirmed by international missions. But in this scheme, shown in Fig. 1 and Table 1, there are significant drawbacks:

1. Different basic level of education after graduation from technical universities.
2. Fairly high cost of license personnel training.

Indeed, education under interruption of work is being performed during 1-2 years. It is clear that this condition is strongly correlated with the first one, which is the subject of our paper. Today technical university graduate need to finish learning at the TC of NPP or even to learn again. Let us note that the described above educational and training system exists for training mainly of operational personnel for nuclear industry. Directorate and management of NPP, operating organization staff, technical experts have, at best, the following simplified scheme of education and training, see Fig. 2.

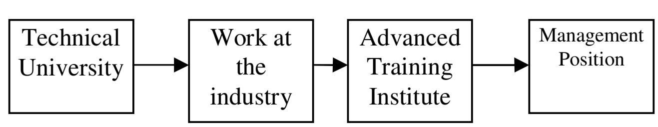

Fig. 2 Scheme of non-operational staff education and training

As we can see from Fig. 1 and Table 1, that in the case of operational personnel training and education, the gaps in knowledge and skills after technical university could be corrected with high probability during the process of education and training at the TC of NPP (1-2 years). But in the case of non-operational staff training and education (Fig. 2), the chance to correct the gaps in knowledge and skills after technical university is minimal - these gaps in basic knowledge and skills can not be corrected during the short-term retraining courses at the Advanced Training Institute. Therefore, the education at the technical universities should be standardized to make impossible the gaps in critical knowledge and skills, which are most strongly influence to the production data of industry and have the greatest impact on safety.

3 LIST OF OBLIGATORY KNOWLEDGE AND SKILLS

Nuclear energy - the largest source of low carbon electricity after hydropower in the world [9], but nuclear power plants are complex technological objects and dangerous objects. Severe accidents at nuclear facilities can have global consequences outside the national boundaries of separate country. Therefore, the safe operation of nuclear facilities is associated with high demands on staff and managers at all levels.

Let us consider a common basis of knowledge, which should be mandatory for the *industry staff*: the operational personnel, technical experts of the operating organization and the regulatory body, decision makers in the industry. It is known that the solution of that problem starts with the requirements analysis to the volume of knowledge on the position (profession). Based on the requirements to the professions of the nuclear industry and personal experience, we consider it necessary the regulation (standardization) of a minimum amount of industry staff knowledge, including general educational disciplines. At the next part of paper, we note, first of all, on the validity of proposed requirements by the reasons of their application to industry specialists.

1. Mathematics. Mathematical knowledge needed to understand the laws of physics and chemistry that are associated with the processes of the nuclear fuel cycle and with the emergency processes. Knowledge in this case should be divided into the list of general mandatory knowledge for all of the categories of persons and the list of additional knowledge for executives. Therefore, from our point of view, nuclear industry staff`s general mandatory knowledge in mathematics should be in accordance with relevant generally recognized curricula of technical universities, including mathematical modeling.

Additional knowledge for executives (technical experts of the operating organization and the regulatory body, decision makers in the industry) should include elements of the theory of management, including control algorithms for stochastic processes (risk management), the mathematical basis of modern computer codes for the nuclear industry and other specific knowledge. This list of additional knowledge may be included both in the curricula for Master's degree and in the retraining curricula for the nuclear industry specialists.

2. Programming. Every modern control and management systems of complex objects, which are the nuclear facilities, include computer codes. Basic knowledge of programming is required to use these computer codes. It is much more difficult (impossible) without programming to create designs of nuclear facilities, to offer new solutions and perform the technical evaluation of such projects and solutions. Therefore, nuclear industry staff`s general mandatory knowledge in programming should be in accordance with relevant generally recognized curricula of technical universities.

The technical experts of the operating organization and the regulatory body should have additional knowledge of relevant computer codes algorithms and skills of their use for the evaluation of new projects and solutions.

3. Descriptive Geometry. Knowledge of descriptive geometry is necessary to all of the above categories: the operational personnel, technical experts of the operating organization and the regulatory body, decision makers in the industry - all of them should be able to read drawings, schemes and diagrams, which are the parts of technical documentation. There is impossible to understand the text (and formulas) of technical documentation without a proper understanding of the graphical part of the technical documentation.

4. Probability Theory. Knowledge of probability theory and basics of probabilistic safety analysis are required for operating personnel to understand the fundamentals of modern safety concept and assess their contribution to the enhancing of the general level of safety culture at a particular facility and at the industry as a whole. These knowledge define operating personnel`s ability to evaluate their contribution to reducing the risk of accidents. Knowledge of probability theory is required for technical experts of the operating organization and the regulatory body, the decision makers in the industry for the ability to calculate risks using methods of probabilistic safety analysis. International practice has shown that the implementation of risk-based approach is one of the most effective ways to reduce the probability of accidents in all types of dangerous objects.

5. *Physics.* All of listed above categories - industry staff - should, as a minimum, have knowledge of the following topics:

1. General Physics;
2. Mechanics;
3. Properties of Materials;
4. Thermodynamics;
5. Thermal Hydraulics;
6. Electricity and Magnetism;
7. Atomic Physics;
8. The Fundamentals of Quantum Mechanics;
9. Nuclear and Neutron Physics;
10. Dosimetry;
11. Fundamentals of radiometry and spectrometry.

It is impossible to understand fully the processes that occur in nuclear facilities, to evaluate the project and the technical solutions, to organize proper planning of nuclear facilities operation without this knowledge and competences in physics.

6. Chemistry. Knowledge of chemistry basics should be mandatory for all of listed above categories (both Bachelor`s degree, Master`s degree). Knowledge of chemistry is necessary for the ability to organize in a proper manner the nuclear facility chemistry both in normal operation and under the emergency conditions. Knowledge of chemical processes is an important element in reducing the probability of accidents at nuclear facilities. Knowledge of chemical processes in emergency situations can have a decisive impact on the prevention of accidents by making timely decisions. The technical experts of the operating organization and the regulatory body, decision makers in the industry (Master`s degree) must have the deep knowledge of chemical processes at the nuclear facilities both in normal operation and under the emergency conditions.

7. The Special Knowledge and Competences in the nuclear industry should include, first of all, the issues of the nuclear reactors theory, the descriptions of nuclear facilities designs, descriptions of primary and secondary equipment of nuclear facilities, operation issues, safety culture, safety analysis. All of listed above categories - industry staff (both Bachelor`s degree, Master`s degree) should have knowledge of:

1. Types of Nuclear Facilities;
2. Nuclear and Heat Power Plants;
3. Heat and Mechanical Equipment of Nuclear Facilities;
4. Nuclear Power Reactors;
5. Theory of Nuclear Reactors;
6. Non-stationary Processes in Nuclear Facilities;
7. Pumps;
8. Steam Generators;
9. Turbines and Electricity Generators;
10. Operation of Nuclear Facilities;
11. Emergency Processes at Nuclear Facilities;
12. Construction, Decommissioning and Decontamination of Nuclear Power Plants.

The technical experts of the operating organization and the regulatory body, decision makers in the industry (Master`s degree) as a result of studying of the listed above special knowledge should be able to carry out the engineering design calculations for nuclear facilities with the specified parameters using advanced computer codes. Operating personnel (Bachelor`s degree) must be able to carry out similar calculations on a simplified level.

Listed above special skills and knowledge will give to the one the ability to identify the design deficiencies under the operation of nuclear facility, which have been missed in the design phase of the nuclear facility project. It also improves the speed and the probability of making the right decisions in unusual (non-standard) situations.

8. The Law. Knowledge of law basics should be mandatory for all of listed above categories (both Bachelor`s degree, Master`s degree). At the laws and regulatory documents the rules, procedures and instructions both for normal operation and for emergency situations usually are established. The regulatory documents include the safety limits that should not be exceeded. The knowledge of law is necessary to understand the level of responsibility for the abnormal operation of nuclear facility and for the emergency situations and accidents. The technical experts of the operating organization and the regulatory body, decision makers in the industry (Master`s degree) should have the deep knowledge of law.

9. Safety Culture. Safety culture should be studied as a generalization, systematization discipline at the end of the course.

All of listed above categories - industry staff - should have knowledge of:

1. The structure of the nuclear industry and the general information on nuclear facilities;
2. Safety management techniques based on risk assessments;
3. The basic concepts of socionics and sociometry;
4. Procedures for the analysis of violations at nuclear power plants (nuclear facilities);
5. Methods of human factor impact assessment on safety;
6. Psychology of security;
7. Best practices in the management of the nuclear energy industry;
8. Components of safety culture at various levels;
9. The documentary basis of the safety culture;
10. Methods of safety culture level assessment.

All of these categories - industry staff - must have the skills in:

1. Estimations of equipment reliability based on operation results and risk assessments;
2. The organization of sociological surveys in the team;
3. The analysis of violations;
4. Assessments human factor impact on safety;
5. Analysis of the psychological causes of violations;
6. Self-assessment of safety culture level;
7. Assessment of safety culture level at the department.

The inclusion "safety culture" discipline in the Bachelor`s degree curriculum for the nuclear industry specialists allows creation competences:

- the ability to detect hidden failures and unresolved safety issues,
- the ability to identify the significance of events, problems in safety ensuring and adequately respond to these problems,
- the ability to learn from experience and solve problems in safety.

Safety culture is a modern concept of safety ensuring at dangerous objects and, as already mentioned, is also studied in retraining courses at the TC of NPP. The inclusion of this discipline in the Bachelor`s degree curriculum, in our opinion, is necessary for special (safe) behavior motives formation of future professionals from the student`s bench.

10. Probabilistic safety analysis. From safety analysis disciplines we consider it necessary to study the probabilistic safety analysis (PSA) with the implementation of this method at the computer code SAPHIRE. This course, in our opinion, should be included only to Master`s degree curriculum. The study of PSA with SAPHIRE code course is useful not only for the formation of NPP systems analysis skills and safety of the NPP unit, but also develops logical thinking, helps to understand the cause-effect relationship of operation and failures of the equipment.

4 DEVELOPMENT OF STANDARDS. TRAINING AND CERTIFICATION OF SPECIALISTS

4.1 Teaching staff certification

As shown above, the specific requirements for the teaching staff are necessary at the technical universities that provide nuclear knowledge. The scope of their competence must meet the above requirements and the state of knowledge in the industry. The appropriate procedures for admission to work and certification should be ensured. As a result, certified teachers should be not only in TC of NPP, but also in technical universities - all of them are the teachers of the nuclear industry. Both, the teachers at technical universities and the TC of NPP teachers should have a salary at the level of directorate of NPP and have the same responsibility for the training results. The education at the industry under such conditions will have a structure of continuous process, which will facilitate the progress in safety enhancement.

4.2 International standards development

The coordination center of the international standards of education development, in our opinion, should be the International Atomic Energy Agency (IAEA) and the World Association of Nuclear Operators (WANO). This activity will be most effective under conditions of mandatory implementation of the developed standards by all the operators of nuclear facilities in the world. The first steps towards this direction are described in [10] and in [11]. For the training and certification of technical experts and teachers, from our point of view, as a first step, the working group should be created. In addition to IAEA and WANO experts and divisions, it is possible and necessary to use The World Nuclear University (WNU), Asian Network for Education in Nuclear Technology (ANENT) and leading technical universities of the world.

5 POSSIBILITIES OF PROLIFERATION SENSITIVE KNOWLEDGE RESTRICTION

In establishing restrictions to the distribution of knowledge in the industry, we should remember that only through openness of nuclear knowledge, which are necessary for the development of peaceful nuclear energy uses, is possible to achieve a significant increase in the global level of safety in the world.

There are great difficulties in the direction of distribution control of proliferation sensitive knowledge, due to objective reasons.

The main difficulty in this case is that one does not need very much to know for primitive small capacity nuclear bombs and for "dirty" bombs creation, which can cause no less harmful consequences than advanced high capacity nuclear bombs. All these knowledge are the part of basics mandatory knowledge necessary for peaceful nuclear energy.

Moreover, one of the reasons is the presence of part or all of corresponding knowledge in the open type scientific publications on the nuclear and related topics, as well as existence of all or a substantial part of the relevant information at the Internet.

It is impossible to carry out the development of science with the global exchange of information and thus hope that this information will not fall into the wrong hands - on the contrary - this information will be in the wrong hands shortly after the appearance in any form, as the potential nuclear or radiological terrorists are focused their search on such information using all available methods and tools.

In addition, history has proved ineffectiveness of so-called "secret" developments, the reason for that is the presence of global competition and struggle for spheres of influence. Therefore, all those, who wanted or wants to learn this information - received the necessary knowledge sources sooner or later. And for the realization of their plans, they will need only nuclear materials, because everything else they can get legally. They can train the appropriate specialists, paying for their education at the leading universities of the world, this is not a problem. Therefore, getting of proliferation sensitive knowledge in the wrong hands and the development by them of missing links of knowledge - it is only a matter of time - how long after the appearance they will own a complete set of knowledge and technology. As a conclusion, while investigating nuclear technology, developers should understand that most or all of this knowledge will be available to the potential nuclear or radiological terrorists after a time more or less in each case.

A significant problem in this area is that the nuclear reactors on thermal neutrons with an open nuclear fuel cycle have limits on the amount of fuel at the relatively low price range as shown in [12] and [1]. Known fact is that the average content of U-235 in natural uranium is 0.72% [13]. There is a need to create an additional neutron source in the case of thorium for energy production use to activate the fissile nuclei U-233 from the stable nuclei of Th-232. Therefore, both in the case of thorium and uranium the most efficient use of natural resources will be implementation of nuclear reactors on fast neutrons with a closed nuclear fuel cycle as shown by [14, 15] and in the IAEA reports [16, 17].

Transition to the use of fast neutron reactors with reprocessing of spent nuclear fuel to extract fissile material from it, which should be realized in the case of a closed fuel cycle, will significantly increase of proliferation risks.

From our point of view, most likely, it will be impossible to restrict the distribution of proliferation sensitive technologies as the depletion of oil and gas resources in the world and concentration of remaining resources of oil and gas in limited number of countries (potential monopolists). Such processes will start, in our opinion, from developing countries with poor natural resources. Therefore, when making decisions about the future of nuclear energy development and distribution of relevant knowledge, it is necessary to compare the risks of proliferation in the variant of centralized enrichment and reprocessing with transportation on long distances with proliferation risks in the variant of construction of licensed controlled enrichment and reprocessing plants in the expanded list of countries, that have operational nuclear reactors and closed nuclear fuel cycle, with transportation inside of these countries on short distances.

The enhancement of the global development of nuclear power in the world is mainly tied with the global need to reconsider the attitude towards nuclear materials as to a source of peaceful power, but not as to the nuclear weapons. The tough control over the movement and use of nuclear materials should be implemented. To all violators of the nuclear nonproliferation regime the use of economic sanctions should be mandatory.

6 CONCLUSIONS

The international regulation and standardization of the set of mandatory educational disciplines for the study, a list of relevant knowledge and skills of nuclear energy specialists, covering all the main stages of the nuclear fuel cycle is proposed to perform. The obligatory certification of technical universities teachers at the international level is offered.

The IAEA and WANO should be the coordination centers of the international standards of education development. In addition to IAEA and WANO experts and divisions, it is possible and necessary to use WNU, ANENT and leading technical universities of the world.

The combined efforts to create mandatory standards for nuclear education will lead to significant reduction of risk or even to the impossibility of severe accidents. This is an opportunity and need for further development of nuclear energy.

All of these efforts will be useless without transparency of nuclear knowledge necessary for the development of peaceful nuclear energy. Obviously, non-proliferation of nuclear weapons, technology and corresponding knowledge should be taken into account.

For the successful implementation of such standards the joint efforts of countries using nuclear energy with appropriate mechanisms of influence on the countries, that do not want to implement these standards, will be needed. For these purposes the role and the authorities of the IAEA and WANO should be reconsidered and fixed in the form of international treaties.

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DEVELOPMENT OF THE POTENTIAL OF THE POLISH ARMY IN THE SECOND DECADE OF THE 21st CENTURY

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Abstract: The subject of this paper is analysis of a few armament initiatives for Polish Army that are significant for national security and engaging the Polish economy on a large scale. Poland is a country that is large and significant enough to be expected to not only protect its own territory but also to actively participate in international missions. Polish Army will become a very important creator of security at a supra-regional scale.

Keywords: Security. Military forces. Modernisation. International missions. Professionalization.

1 INTRODUCTION

The first wave of large purchases for our army took place at the beginning of the 21st century. Between 2000 and 2002, the Polish Navy received Oliver Hazard Perry type of frigates (no 272-273) as a gift from the USA: "General K. Pułaski" and "General T. Kościuszko". At the end of 2002, a tender for multipurpose aircraft was completed - 48 F-16 "Jastrząb" machines were purchased for $3.5 million. At the end of 2003, 690 (the target is 900) wheeled armoured vehicles (WAV) were bought for around PLN 3 billion from the Finish company Patria, which along with the turrets from the Italian company OTO, became the basic "Rosomak" WAV in the Polish army. Finally, in the years 2002-2003 we received 128 Leopard-2 tanks from the Bundeswehr (for the symbolic 1 Euro).

This development of the Polish defensive potential and replacement of post-Soviet equipment with Western one coincided with increased engagement of our armed forces in missions around the world. While in the second half of the 1990s our expeditionary capability did not exceed the limit of 1000 soldiers (in 1996 and in 1999 we sent one battalion to Bosnia and Kosovo respectively as part of a UN mission), the war on terror led from September 11, 2001 became a serious challenge for our army. In 2003, Poland - without the obligation to do so and operating as part of an ad hoc USA organised "coalition of the willing and capable" - sent a 2500-strong brigade to Iraq, constituting the core of an international 8500-strong division. Polish military engagement in Afghanistan was at first lesser, but since the middle of the decade it also began to increase, and between 2010 and 2011 there were 2600 soldiers in our contingent in this country.

Despite the increase in our military activity abroad, the divisions that participated in missions and gained experience, equipment and capacity to act comparable with that of western armies constituted only a small part of our armed forces. This meant that our armed forces were in danger of "cracking". On the one hand, expeditionary forces of several thousand soldiers would be formed – fully capable of conducting complicated operations and the first in the line to be supplemented and supplied with the most modern equipment. On the other hand, the fundamental part of our army supposed to defend their own territory would be "the second" in line for being modernised.

In this situation, the decision about full professionalization of The Polish Army was justified, although it was taken too hastily, shortening thus the process that was started earlier and planned to be completed over a few years. The professionalization of our armed forces has been taking place since the beginning of the century. As a result of gradual changes, the numerical strength of the army decreased from over 200 thousand in 2000 to around 150 thousand in 2003. Since 2004, the number of professional soldiers has been increased, while the number of officers' positions has been decreased, and the number of non-commissioned officers' positions has been increased. A new corpus has been created: regular privates. In mid-2008, the Polish Army (with around 150 thousand soldiers) was divided into two fundamental groups: professional soldiers and soldiers of the compulsory military service whose number in 2008 was around 38 thousand. In December 2008, conscripts were for the last time conscripted into the compulsory military service, and on 30th of August 2009 the last soldiers were discharged from this service. Full professionalization was achieved on the 1st of January 2010, and the plan was to reduce the army to 115.5 thousand soldiers (up to 95.5 thousand active soldiers and up to 20 thousand soldiers in the National Reserve Forces) and to 4.5 thousand positions for candidates - cadets, non-commissioned officers - by 2012.

2 RATIONALISATION OF PURCHASES AND EXPENDITURE

Since the 1st of January 2011, a new body is responsible for acquisition of equipment and arms - the Armaments Inspectorate (AI), which replaced the Department for Armed Forces Supplies of the National Defence Ministry. Among the 250 employees, there are less uniforms than civilians and more employees with factual knowledge than administrative ones. The AI head can set up task teams composed of specialists from various fields in order to increase the efficiency of purchases.[1]

The Inspectorate for Armed Forces Support (IAFS) is responsible (as previously) for the use of the equipment acquired by the AI, and the Agency for Military Property - for disposing of decommissioned property. In the new arrangement, it is possible to comprehensively develop a cycle of the use of the different types of weapons and equipment, and in particular - accurately calculate the life cycle cost. Moreover, it should generate an anti-corruption "inhibitor" - the three institutions can control one another.[2]

During 2011, another important financial and organisational issue was also simplified: principles of financing NATO investments in Poland.[3] The new rules allow the head of the National Defence Ministry to finance Poland's participation in NATO Security Investment Programme (NSIP) in accordance with the Public Finance Act in force since 2009. The aim of these investments is to develop infrastructure in Poland that will allow the allied forces to arrive and act in the event of a conflict (airport elements, telecommunications infrastructure, propellants and lubricant depots, fuel lines, port installations and other similar projects).

In 2012, the Agency for Military Property (AMP) underwent restructuring: "The AMP became an organisation specialising in disposing of property and utilising unnecessary military equipment. The Inspectorate for Armed Forces Support deals with purchasing material resources, equipment of common use and services" - declared Deputy Minister of Defence, Marcin Idzik on the 15th of February 2012.[4] Since the 1st of January 2012, the agency has been operating in a new format, with a new status.

The activity of the Agency for Military Property has visibly increased: in 2011, it organised over 800 tenders for the development of 1250 items (movable and immovable property), whereas one year earlier these figures were 730 tenders for 1043 items. Revenues of the AMP for 2011 were over PLN 235 million (initial profit - PLN 128 million), which means that the target was achieved with a surplus – 112 %.

Table 1 Sale of concession movable property in 2011

Armoured vehicles	65 items
Artillery of 23-152 millimetre calibre	272 items
Weapon of 4.5-14.5 millimetre calibre	24,691 items
Ammunition	3,324,110 items
Aircraft	1 item
Warships	1 item
Aircraft engines	3 items
Communications and radio determination equipment	3,820 items
Miscellaneous	73,143 items

Source: ZARZYCKI, P.: Rekordowa sprzedaż. In „*PZ*' issue no 9 (26 February) 2012, p. 25.

A specific example of rationalisation of military expenditure is the growing share of private entities (Specialist Armed Protection Forces) in securing military bases and areas. This has been possible since 1997, when private companies were statutorily allowed to provide security services. Also the army more and more often resorted to the outsourcing of security guards. The full professionalization of the armed forces sped up this trend.[5] The Polish Army has around 350 protected facilities, over half (52.5%) of which were secured in 2011 by the Specialist Armed Protection Forces (SAPF); 44.5% of the facilities were protected by the Civil Watch Forces, and only 3 % - by soldiers. Over 3200 employees of the Specialist Armed Protection Forces employed in over 130 private companies provide services to the army (for comparison: there are over 4500 people in the Civil Watch Forces, and the number of full-time soldier guards is 700). In 2011, the National Defence Ministry spent PLN 275 million on services provided by the Specialist Armed Protection Forces. Monthly costs of maintaining one SAPF station amounted to PLN 19.2 thousand in 2011, and in the case of the Civil Watch Forces, the cost is PLN 26.5 thousand, whereas a military station of a security sub-unit - trained to do guard duty - cost nearly PLN 29 thousand. The cheapest was the guard duty by soldiers from the sub-units of the line - only PLN 14.3 thousand per one station. The tendency to outsource the "non-military service" of the army is widespread around the world - there is however a concern of crossing a point where the functioning of the army would be impossible without cooperation with commercial entities - this would mean that it is in fact not the authorities of a democratic state but

[1] Nowy kupiec na rynku. In *Polska Zbrojna*, issue no 3 (16 January) 2011, p. 7.
[2] Ibidem.
[3] ZAKRZEWSKA, A.: Nowa forma ZIOTP. In *Polska Zbrojna,* issue no 6 (6 February) 2011, p. 21.
[4] ZARZYCKI, P.: Rekordowa sprzedaż. In *Polska Zbrojna,* issue no 9 (26 February) 2012, p. 25.
[5] KOWALCZYK, K.: Cenna ochrona. In *Polska Zbrojna,* issue no 3 (16 January) 2011, pp. 13-17.

commercial entities that create the Polish defence policy.

3 PLAN OF TECHNICAL MODERNISATION OF THE ARMED FORCES

In recent years, numerous projects for modernisation of the Polish armed forces have come up. They were connected with:

- Development chances of our defence industry: in particular Bumar Group and Huta Stalowa Wola (Stalowa Wola steel mill) and aviation companies in Mielec (Sikorsky Aircraft) and in Świdnik (Agusta Westland);
- Will to tighten political and defence relations with other countries (American offer of building elements of the Missile Defence Shield in Poland put forward in the years 2006-2009 and its continuation in the project by President B. Komorowski from August 2012);
- Expected forms of the Polish armed forces' activity in military operations: within the country and abroad, in cooperation with the EU and NATO.

For the purpose of coordination and prioritisation, on the 17th of September 2013 the government made a list of 14 priority programmes as part of the Plan for Technical Modernisation of the Armed Forces (PTMAF) for the years 2013-2022.[6] In total, these programmes will consume PLN 91 billion of PLN 139 billion earmarked for the implementation of the plan in this period and will be included in draft budget laws.[7]

The priorities include not only modernisation of the armed forces but also achieving this objective with possibly maximal participation of the domestic defence industry, co-participation in the solutions from abroad and optimal "Polonization" related with acquisition of modern technologies. Thus, it is envisaged in this programme that significant part of this financial envelope will go to the Polish industry, strengthening the defence and economic potential of the country.

The list of priorities according to the National Defence Ministry is as follows:

6 Resolution of the Council of Ministers no 164 from the 17th of September 2013 on establishing a long-term programme "Priority tasks of the Technical Modernisation of the Armed Forces of the Republic of Poland as part of operating programmes", Monitor Polski, Official Journal of the Republic of Poland, Warsaw, on the 4th of October 2013, item 796; Available at: http://www.defence24.pl/news_mon-priorytety-modernizacji-sil-zbrojnych (access: 10.19. 2013).

7 There were also much higher amounts, e.g. PLN 160 billion - see Waldemar Skrzypczak, *Punkty krytyczne* (interview), "Polska Zbrojna" issue no 3 (June 2012), pp. 26-31.

1. Air defence system

The programme envisages acquisition of, among other things: Air Defence Systems (MANPADS): WISŁA intermediate range; NAREW short-range; POPRAD self-propelled; GROM/PIORUN portable; PILICA short-range air defence and artillery systems; SOŁA/BYSTRA mobile radar stations.

2. Battle support, protection and VIP helicopters

As part of the programme the following helicopters will be purchased, among other things: multi-purpose transport helicopters, SAR search and rescue helicopters, anti-submarine warfare helicopters, assault helicopters, helicopters for carrying VIP passengers.

3. Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance systems. (C4ISR)

Purchases made as part of this programme will include: integrated systems of battle resource command and control which integrate reconnaissance, fire attack and logistic systems; Mobile Command Post Modules; command vehicles, command and combat vehicles, and a system for monitoring the location of own troops equipped with Rosomak combat vehicles; tactical systems of data transmission; anti-cyber attack systems.

4. Modernisation of Armoured and Mechanised Forces

5. Countering threats at sea

Purchases made as part of this programme will include: new type submarines, KORMORAN II minehunter, patrol ships: ŚLĄZAK in the basic version and CZAPLA with the mine hunting function, MIECZNIK coastal protection ships, DELFIN electronic intelligence ship, MARLIN combined operations support ship, RATOWNIK rescue ship, MAGNETO floating demagnetization station, coastal missile division of the Navy and missiles for it.

6. Imagery and satellite intelligence

Purchases made as part of this programme will include: short-range, intermediate-range and operating-range unmanned aircraft:[8]

7. Individual equipment and arms of a soldier

The basis in this programme is TYTAN project.

8. Modernisation of Missile and Artillery Forces

Purchases made as part of this programme will include: 155 mm KRAB howitzer with intelligent ammunition, HOMAR launch rocket systems, 120 mm RAK self-propelled mortars, TOPAZ Automated Fire Control System, artillery reconnaissance systems.

8 Unmanned Aerial Vehicle (UAV).

9. Simulators and flying trainers

10. Training helicopter

11. Transport helicopters

As part of the programme more C-295M and M-28 transport helicopters will be purchased.[9]

12. "ROSOMAK" Wheeled Armoured ehicles[10]

13. SPIKE anti-tank guided missiles

14. Reconnaissance.

This programme envisages acquisition, among other things, of light armoured reconnaissance troop carriers, reconnaissance vehicles for long-distance reconnaissance sub-units, mobile unmanned reconnaissance vehicles, information system for intelligence collection, analysis and distribution, automated system for collection, gathering, processing and distribution.

The plan is very wide-ranging - especially in the context of the funds that the National Defence Ministry has had at its disposal in recent years. This budget grew from PLN 25.5 billion in 2010 to PLN 31.2 billion in 2013, of which 5-6 billion could be earmarked for modernisation annually. The government department can spend around one billion of Polish zlotys annually on new material purchases for all types of the armed forces.[11]

Table 2 Budget of the National Defence Ministry

Year	2010	2011	2012	2013
Amount (in PLN million)	25,448	27,260	29,203	31,171

Own work.[12]

Naturally, these expenditures should be spread over time, and the purchases would cover the period 2030-2040. However, strategic decisions had to be made - e.g. about repairs and modernisation of the old post-Soviet equipment (Newa antiaircraft systems or T-72 tanks) which will go out of use in a few years. The funds earmarked for this purpose could be spent on new technologies meeting modern challenges. We can also ask whether there is any overriding conception in the above mentioned modernisation programmes that would enable focussing on fundamental goals. Unfortunately, the modernisation effort is distributed and the actions lack any sensible vision. There is no conception, neither for creating new capacity, nor for building new formations or units. One of the causes is certainly the fact that there are too many entities co-deciding in these matters: Management in the General Staff of the Polish Armed Forces, Inspectorate for Armed Forces Support, Armament Inspectorate, two departments, commanders of the different types of armed forces.[13]

4 HELICOPTERS AND UNMANNED MACHINES

One of the weaknesses of our army is insufficient number of modern helicopters, both for battlefield and support. At the beginning of 2011, Poland signed the first in over a decade significant contract for the delivery of military equipment from Russia, in a situation when it was important for us to quickly receive deliveries. In two tenders (in February and July 2010) we purchased from the Rosoboroneksport centre of armament export five Mi-17 transport and assault helicopters together with a logistics package. These machines were to be used by 25th Air Cavalry Brigade, and at the beginning of 2012 they were to be sent to Afghanistan. In Military Aviation Works No. 1 in Łódź, the machines were to be armoured and retrofitted to meet NATO standards.[14]

Another way to eliminate the shortages of the armed forces' helicopters was retrofitting of PZL W-3 Sokół helicopters with modern equipment (renamed to "Głuszec" after the modernisation). The Głuszec programme was implemented between 2003 and 2010 on order of the Department of Armaments Policy of the National Defence Ministry and financed in full from the ministry's budget. At the

[9] Already in 2012, an agreement was signed for the purchase of five more CASA C-295M machines worth around PLN 900 million (together with logistics and offset packages including the organisation of a service centre for these machines in Poland). After the delivery of this batch of aircraft, Poland has got 16 in total and is one of larger users in the world. They are standing in 8th Base of Transport Aviation i Cracow - "Polska Zbrojna" issue no 5 (August) 2012, p. 11.

[10] By 2018, Wojskowe Zakłady Mechaniczne in Siemianowice Śląskie will have manufactured 200 more "Rosomaks", and the overall number of machines handed over to our army will have increased to around 850.

[11] SKRZYPCZAK, W.: Punkty krytyczne (interview). In *Polska Zbrojna,* issue no 3 (June 2012), pp. 26-31.

[12] Own work based on: Budgetary decision for 2010 No 55/MON of National Defence Ministry from 16 February 2010. (Official Journal of National Defence Ministry No 2a, Warszawa, on 25 February 2010; Budgetary decision for 2011 No 31/MON of National Defence Ministry from 10 February 2011. (Official Journal of National Defence Ministry No 2a, Warszawa, on 23 February 2011; Budgetary decision for 2012 No 85/MON of National Defence Ministry from 29 March 2012. (Official Journal of National Defence Ministry, Warszawa, on 30 March 2012, item 110; Budgetary decision for 2013 No 42/MON of National Defence Ministry from 14 February 2013. (Official Journal of National Defence Ministry, Warszawa, on 14 February 2013, item 49.

[13] SKRZYPCZAK, W.: *Punkty…*.

[14] *Polska Zbrojna*, issue no 1-2/9 January 2011, p. 8.

development stage, a prototype of a modernised helicopter was made in WSK-PZL Świdnik (now AgustaWestland) and subjected to qualification tests in 2008. At the implementation stage, four machines were made and subjected to acceptance tests over a few months. The project involved not only modification of four machines but also training pilots and technicians, as well as developing new technical instructions. The main innovations in the helicopter include: integrated control and monitoring of avionic, communications and armament systems, a 12.7 mm machine gun, 23 mm canon, and systems for misguiding hostile missiles.

The first Głuszec helicopters were sent towards the end of 2010 to Inowrocław, to the 2nd Squadron of the 1st Brigade of Army Aviation. A V-formation was created from these helicopters that can be used for a Combat Search and Rescue (CSAR) mission.[15] The CSAR version of Głuszec has got medical equipment, including oxygen cylinders and a stretcher.

A real Eldorado for companies manufacturing helicopters will be a huge contract for 70 multi-purpose and transport machines worth around PLN 10 billion (the tender for the first batch of 26 helicopters was opened at the end of 2011). The competition was entered by enterprises with branches in Poland: Sikorsky Aircraft proposed to build Black Hawk S 70i helicopters in PZL Mielec, and Agusta Westland offered to construct NH-90 helicopters in PZL Świdnik.[16]

New purchases and rearmament of our army led to firm establishment of Polish private armaments companies. They turned out to be effective in the areas of high technologies, e.g. the company WB Electronics from Ożarów Mazowiecki. WB Electronics specialises in the area of electronic engineering and software, as well as military communications systems (C4IS systems, i.e. Command, Control, Communication, Computer and Intelligence Systems) and electronic equipment for military vehicles.[17]

WB Electronics is building UAVs - it is the only Polish enterprise that offers machines of its own construction. Its first product was observation UAV - SOFAR (built together with the Israeli company Top I Vision)[18] which was bought by the Hungarian army (6 vehicles and a navigation system for around Euro 0.5 million).[19] The machines came from Israel, and the Polish company was overseeing the equipping of them with systems of communications with operators and developed a station for flight navigation and control. The delivery was effected in 2007, but SOFAR did not pass technical acceptance tests.

A much more advanced construction is the FlyEye UAV, whose story began in 2006, and the project became a priority after Hungary had rejected SOFAR machines. The authorities of WB Electronics decided then to develop a UAV on their own, and in January 2008 its company daughter - Flytronic - prepared the first prototype of the vehicle, as well as developing an observation head. Tests of the prototypes lasted until December 2009, and on 14 June 2010 FlyEye from Ożarów was presented at the defence industry exhibition, Eurosatory, in Paris. In December 2010, the first two FlyEye systems were handed over to the Polish Army.[20] Another product of WB Electronics is a small Tarkus rotorcraft.

5 AIR DEFENCE

Another weakness of our security system is anti-aircraft and anti-missile defence. Capability of defence against an attack using ballistic missiles should be guaranteed by air forces. However, their current state and equipment significantly limit the effectiveness of this defence. Technologically outdated missile systems from the Soviet times give us no chances to defeat ballistic missiles, targets at high altitudes or those moving at great speed. Besides, possibilities of their use are ending:

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[15] GOŁAWSKI, A.: Zadziorne ptaszysko. In *Polska Zbrojna,* issue no 4 /2011 (23 January), pp. 35-37.

[16] LENTOWICZ, Z.: Sikorsky i Agusta Westland powalczą o miliard. In *Rzeczpospolita,* 30 October 2011.

[17] In 2009, revenues of WB Electronics were PLN 51 million, and profits - PLN 16 million, whereas those of Radmor - PLN 70 million and PLN 3 million respectively. See: Zbigniew Lentowicz, *Powstaje prywatny potentat zbrojeniówki*, "Rzeczpospolita" 29 Septemper 2010.

[18] Israeli name: Casper 250.

[19] HOŁDANOWICZ, G.: SOFAR wreszcie na Węgrzech. In *RAPORT – WTO.* (Wojsko, Technika, Obronność) issue no 9/2007. Available at: http://www.altair.com.pl/magazines/article?article_id=810 (access: 10.10.2013)

[20] They have been significantly upgraded: they have larger bearing surface, smaller observation head and an option of installing a photographic equipment. The observation head for FlyEye was also built by WB Electronics (it is equipped with cameras: a TV camera with a zoom and an infrared camera). The weight of the machine is 11 kg (observation head - 1 kg, batteries - 3 kg) and it can start without a launcher; it also has got an autopilot. The control link of the machine has got a range of 30 km, and with the use of a mobile station - 300 km. In the case of loss of communication, the machine ascends, and if it doesn't help it to resume communication - it returns to the last place where the communication worked, and if it still does not regain it there - it returns to the flight control station - see: Michał Nita, *Zawodowy podglądacz*, "Polska Zbrojna" issue no 1-2/9 January 2011, pp. 35-37.

currently possessed anti-aircraft missile systems of long and intermediate range will no longer be in good working order in a few years and will be decommissioned.[21]

In order to eliminate this problem, in summer 2012 President B. Komorowski proposed the building of national "anti-missile shield", i.e. an installation capable of defending our territory against hostile short-range missiles. Such an investment is urgent: modernisation of the systems that defend our sky will be of key importance for the defence of Poland. Apart from terrorism, it is a missile attack that is the most realistic threat to our country.

The planned system would be complementary to the elements of the "anti-missile shield" which Americans plan to deploy in our territory in 2018 (which would defend against strategic long-range missiles). The American project envisages "linking" the already existing domestic anti-missile systems into one whole. A huge hope is placed in the announcement of building of a common system of missile defence by NATO countries. However, Poland's contribution will be necessary in this project.

The Polish shield is to operate as part of NATO's air defence systems, but it will focus on ensuring security to the Polish territory.[22] The system that is to be an element of anti-aircraft defence has to be built from scratch by Poland by 2023. The aim is to create a modular, mobile, capable of strategic reaction structure which, depending on the needs, will be able to ensure protection to an operational military formation or several facilities of cities of strategic importance. "The shield" will be equipped with reconnaissance equipment and launchers, ensuring a fully autonomous operation under national command, and at the same time it should be able to successfully fight in the allied system and under NATO's full command.[23]

The orders for elements of the shield, whose building will consume around 14-16 billion of Polish zlotys, would be placed starting from 2014 by open tenders with annual values of 0.9-1.6 billion Polish zlotys. The operating programme for the Air Force envisages acquisition of new equipment and modernisation of the existing systems. It does not envisage any special preferences for domestic companies, since even the largest of them, i.e. the armaments group Bumar does not have technologies allowing it to build effective weapon, e.g. anti-missile weapon. Thus, a question arises: with which international company will we start cooperation: the European corporation MBDA, American Raytheon, Norwegian Kongsberg or Israeli Rafael (from which we bought "Spike" armour-piercing missiles).[24] Among the new, available anti-aircraft systems that would be useful for our army we should name: MEADS system, developed jointly by the USA, Germany and Italy, SAMP-T system, developed by France and Italy, or Israeli Barak-8 and Spader-MR systems.

In fact, there are enterprises in Poland that could play - if not the leading - at least an important supporting role in this project. Wojskowe Zakłady Uzbrojenia SA in Grudziądz, set up in 1960, has from the beginning specialised in maintenance of anti-aircraft missile systems. After 1990, WZU maintained its specialisation and focused on modernisation of the systems it maintained (of post-Soviet production). At the end of the 1990s and beginning of 2000 WZU enhanced the anti-aircraft missile systems: "KUB" and "KRUG", and in the early years of the 21st century it presented a new system - "OSA". It found a lot of buyers: in 2001, a contract was signed for modernisation of "KUB" systems for Hungary, and in 2005 - for Germany.[25]

WZU in Grudziądz chose a narrow specialisation and it was a good decision. Also the American concern Raytheon became interested in modifications of post-Soviet equipment: it offered WZU cooperation in modernising "KUB" systems. As a result, in 2007 a Polish launcher was created that can launch also Sea Sparrow missiles manufactured by Raytheon. Cooperation with Raytheon brought WZU an additional benefit: already in 2007, thanks to support of the co-operator, the Polish company obtained a certificate from the US Defence Department, confirming that the "friend-or-foe" identification systems installed by it in "OSA" and "KUB" missile systems are fully compatible with NATO's and USA armament This confirmation began to be used by the allies. The company sells upgraded missile systems to France, Germany, USA and Great Britain.

Experts claim that of fundamental importance are intermediate-range systems which enable combating ballistic missiles, among other things. The parameters of these systems enable protection of huge areas and facilities; they are expensive but effective. However, due to limited funds at the disposal of the National Defence Ministry, it won't be possible to buy even one intermediate-range system by 2018 without exceptional investment. The "Strzała" outdated, mobile short-range anti-aircraft missiles will be replaced with "Grom" missiles, and in the future with "Piorun".

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[21] PACEK, B.: Zanim coś spadnie na głowę. In *Polska Zbrojna*, issue no 8 (20 February) 2011.

[22] LENTOWICZ, Z.: Miliardy z powietrznej tarczy poza zasięgiem Bumaru? In *Rzeczpospolita*, 12 September 2012 .

[23] LENTOWICZ, Z.: Miliardy złotych na tarczę przeciwrakietową. In *Rzeczpospolita*, 15 October 2012.

[24] LENTOWICZ, Z.: Gromy, pioruny i błyskawice. In *Rzeczpospolita,* 26 November 2012.

[25] WILEWSKI, K.: Przeciwlotnicza nisza. In *Polska Zbrojna,* 4/23 January 2011, pp. 38-39.

6 WEAKNESSES OF THE NAVY

The future of the Polish Navy looks very bleak. While currently the Navy has got 43 battleships, of which 13 are attack vessels and the rest: minesweepers and transport and mine vessels (the average age of battleships is 28 years), by 2020 it will have lost practically all currently possessed striking vessels. Without intensive repair and purchase of new ships, we may end without a single larger vessel in a few years. At the end of 2010 and beginning of 2011, it was estimated that the effectiveness of the Navy would be drastically reduced from 2014, with no project in place to drastically increase funds for its development. The old Oliver Hazard Perry frigates received from Americans and Kobben submarines from Norwegians ("Kondor", "Sokół" and "Sęp") required investment and retrofitting, and from the start they were only temporary purchases. On a short-time basis, this solution made it possible to maintain any Polish armed forces at sea at all, but in around 2015 Kobbens, which will reach the age of 48-50 years (a phenomenon on a global scale), will have to be withdrawn from service, whereas the end of the usability of the frigates will be in around 2025 (already today they can be only revitalised, because their modernisation is unfeasible).[26] By 2022, we will also have decommissioned three minehunters and all five transport and mine vessels.

The only new weapon purchased by the Navy over the last 20 years was ORP "Kontradmirał X. Czernicki" (logistics and command vessel) which originally was intended for Russia but it resigned from accepting the vessel. A sad reminder may also be the fate of "Gawron" multitask corvette (so-called "project 621"): in 2001, a decision was made to build 7 battleships of this class at Polish Navy Shipyard in Gdynia. The ambitious plan was gradually reduced - finally they focused on building one battleship (although the shipyard has already bought equipment which was cost-effective only in serial production). The programme was closed in 2012, when a ship hull was built for PLN 400 million (later unsuccessful attempts were made to sell it abroad).[27] As a result, Minister T. Siemoniak had to deal with the "bankruptcy estate" from the programme during his appearance in the Sejm (the lower chamber of the Polish parliament): "We have proposals from two Polish shipyards to convert the corvette hull into a patrol ship for a hundred or a hundred and a few dozens of million zlotys"[28] Meanwhile, we could have drawn on e.g. designs of German frigates and corvettes that combine versatility and adaptation to today's threats. Germans built ships capable of participating in operations by naval and combined forces (multinational and national ones) combating asymmetric threats, and remaining on the high sea for a long time. Typical tasks of vessels of this class include: participation in stabilisation operations, operations other than a war (evacuation, peace enforcement and building, embargo supervision), blocking land from the sea, monitoring air and aquatic situation, protection of marine areas against asymmetric threats, combating coastal targets and transport of special forces.

Bleak is also the calculation indicating that in 15 years the most modern part of the equipment of the Navy will be... helicopters that have not been bought yet. The situation encouraged to formulate even radical repair postulates - e.g. Major General Anatol Wojtan, head of the Strategic Planning Directorate of the General Staff of the Polish Armed Forces said on 11 April 2012: "*... effective reconstruction of the Navy's combat potential requires resignation from modernising existing equipment and armament and introduction of new generation vessels (...) This is a conception of a generation leap - we are going in the direction of introducing modern battleships, equipped with unmanned submarine and air machines."*[29]

The crisis in the Navy also hit the shipbuilding industry, although the National Defence Ministry announced that it would earmark around PLN 250 million for modernisation and repairs of the Navy's vessels. Since 2009, Polish Navy Shipyard in Gdynia has been in reorganisation bankruptcy; in 2010, over 200 people were dismissed, and at the beginning of 2011 Polish Navy Shipyard employed little over 1000 employees (to whom further dismissals were announced). The restructuring programme implemented there involved sale of unnecessary property, increased contracting of orders and layoffs. Roman Kraiński, chairman of the board of directors of Polish Navy Shipyard, left no doubts: "We have got a small navy, little money, not many repairs are performed, so this situation forces us to reduce the number of employees and shift to the civilian market".[30]

According to the "Plan for the development of Armed Forces of the Republic of Poland for 2009-2018", one/two submarines are to be bought in 2018 at the latest, which seems to be too late: in order to rationally use the competences of the crews of Kobbens that are now being withdrawn from service, the purchase should be made by 2014. An alternative for classic vessels of this category could be purchase of several (4-6) miniature submarines,[31]

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26 GOS, T.: *Hipermarket a sprawa morska*, "Polska Zbrojna" issue no 5 (30 January) 2011, pp. 13-20.

27 MAJEWSKI, M., RESZKA, P.: Gawron – marzenie admirałów zatonęło, nim wypłynęło. In *Rzeczpospolita,*. 10 March 2012.

28 *Polska Zbrojna*, issue no 2 (May 2012), p. 8.

29 *Polska Zbrojna*, issue no 2 (May 2012), p. 8.

30 *Polska Zbrojna*, issue no 9 (27 February) 2011, p. 5.

31 Italian vessels of SX404, SX506 and SX756 types, Russian Pirania 865, Swedish Spiggen II or Sea

capable of performing operations in the coastal zone and near their own ports and bases, or approaching naval bases of potential opponent. For security of the nation, by 2030 the Navy should have three coastal defence vessels, three submarines, three patrol vessels, six helicopters for fighting submarines, and Coastal Missile Division. It should also have three mine countermeasures vessels together with unmanned systems for mine location and destruction, two anti-aircraft missile systems for protection of naval bases, two rescue vessels and seven helicopters of sea rescue, as well as logistic and operational support units, a ship for commanding naval mine battle, a survey ship and a floating demagnetization station. The Navy would also use two radio-electronic reconnaissance vessels with unmanned reconnaissance aeroplanes, as well as ten patrol and reconnaissance aeroplanes.[32]

According to the assumptions, on average around PLN 900 million would be spent annually in the years 2013–2022. This amount will be covered by defence budget assuming that it still will be 1.95 % of GDP, of which around a quarter will be earmarked for modernisation.

One option of increasing our capability to participate in allied forces missions is to offer specialist vessels - not corvettes or frigates, but e.g. supply vessels. The Navy has got a tanker of Bałtyk type, which is relatively modern (built between 1987 and 1991 in Polish Navy Shipyard) and after some alteration (installations for fuelling up helicopters, systems for protection against magnetic mines) it could significantly support NATO forces in expeditionary missions. The organisation has a shortage of supply vessels and a vessel of this class could constitute a more important contribution than vessels used strictly in battles.[33]

Another project was to build a versatile logistic carrier vessel for the Navy by 2022 which - as a vessel for operational support - would be able to redeploy troops and equipment to the areas covered by military actions. This vessel would have landing platforms and a hangar for two helicopters and place for transporting containers, and could be used for transporting various types of cargo (also as a tanker) as well as the injured and for providing medical first aid to them. Several variants of this vessel were developed; depending on the equipment and interoperable capabilities, the price would be between $30 and 50 million, and it would be built over 2-4 years.[34] A design for such a vessel designed for transporting military equipment and people was also developed. The vessel would be able to carry 600 troops.

Our Navy should be able to effectively perform operations both in the Baltic Sea and beyond this area as part of allied forces missions (such as Active Endeavour). In particular, it should be missions in which asymmetric threats are contained: terrorism, piracy or illegal immigration.

Lack of correlation between withdrawing old vessels from service and purchasing new ones raises serious concerns: because of the schedule of acquisition of new vessels it may turn out necessary to maintain crews without vessels or to find additional financing to maintain the existing vessels for a longer time. Minister T. Siemoniak tried to calm the situation: "*When new vessels appear, the Navy will have crews for them. Re-establishing them, once the sailors left the service, is practically impossible*".[35]

7 CONCLUSIONS

Only a broken army does not undergo modernisation, just like only a dead city is not rebuilt. However, the scale of delays and shortages in our armed forces requires quick action. Poland is a country that is large and significant enough to be expected to not only protect its own territory but also to actively participate in international missions and provide assistance to its neighbours (e.g. the Baltic countries whose airspace was already patrolled several times by Poland as a NATO ally). The 2013 PTMAF project is very ambitious and there can be doubts about whether it will be possible to implement it as planned, or whether special forms of support will be necessary (like in 2001 when a special law had to be passed about purchase of a multi-task aeroplane to be able to buy F-16 machines). If, however, Poland succeeds in implementing only a significant part of this plan, the Polish Army will become a very important creator of security at a supra-regional scale. It will also mean inflow of new technologies to our economy and profits from the cooperation between the military and civilian sectors.

Dagger SAS - Tomasz Gos, *Hipermarket a sprawa morska*, "Polska Zbrojna" issue no 5 (30 January) 2011, p. 13-20.

32 GOŁAWSKI, A.: Kurs na lobbing. In *Polska Zbrojna,* issue no 5 (30 January) 2011, pp. 16-17.

33 GOŁAWSKI, A.: *Kurs….*

34 GOS, T.: Odgrzewane projekty. In *Polska Zbrojna,* issue no 3 (June 2012), pp. 67-68.

35 Zmiany na horyzoncie In *Polska Zbrojna,* issue no 2 (May 2012), p. 8.

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