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FEASIBILITY STUDY OF MILITARY VEHICLES IN SHORT MODE

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Abstract

The paper presents the methodology prepared by the author. During the process of acquiring new vehicles for the armed forces, time is of the essence in practice of conducting a wide range of structure changes in previously implemented undercarriages. It has to be pointed out that with a high individuality and the very nature of the units, difficulties in scope of comprehensive testing with regard to matters of transport safety. What is more, two determinants are essential in the process of acquiring equipment – time and cost. The process does not allow for improvement and perfecting of the structure, and the research in scope of wheel vehicle movement safety may be limited. The procedure of implementation and verification of equipment stresses the structure optimization as early as on the designing and prototype preparation stages. The procedure of acquiring new wheel vehicles for the military is one of the main premises for preparing the methodology with use of simulation research. Conducting research on the basis of the prepared methodology allows for avoiding possible traffic risks. The methodology enables an effective support for the current process of wheel vehicle acquisition for the armed forces. In this work the research procedure consisting of the necessary range of prepared, experimentally verified models, accepted by the methodology, have been verified. In order to do that two simulation models have been built, both of various levels of complexity.

Keywords*: road safety, simulation, military vehicles*

1. Introduction

Constructing different versions of vehicles, not only military ones, on the basis chassis is a common practice. Developing new constructions of wheel vehicles by manufacturers is related with the need to carry out research on the road safety. In order to avoid the research, both costly and dangerous to people, the research is carried out on prototypes. The development of new vehicle constructions should not be related with the safety deterioration. For crew the rollover of the vehicle is particularly dangerous. Vehicles of untypical construction, with highly placed centre of mass, are especially prone to such accidents. While constructing versions different than the basic ones or while vehicle improvement, the construction and operation changes are introduced which influence steering behaviour as well as stability. Unfortunately, the needs of the military operational activities demand the construction of vehicle under time pressure. At that point, there is not enough time to polish up the construction elements, which influence the road safety. Therefore, it seems necessary to take up steps leading to limiting threats and improving the crew safety in the vehicles under construction.

Taking care of the safety only during the implementation phase seems to be insufficient. It can result in vehicle rollover or its skidding, especially in case of armoured vehicles of different categories, first of all in case of OSP and MRAP. However, this problem has been recognized as in 2002 an alarming number of accidents were noted and the safety of crewmembers in combat vehicles has been officially stated insufficient [1]. These vehicles are modified frequently. Special equipment selected for the needs of special mission is mounted, often without paying enough attention to the safety level. In the study quoted [1] mentions 83 road accidents involving HMMWV, which took place in 2002. The straight majority of them were head-on collisions – 39 incidents and rollovers – 44 incidents.

2. Road safety of military vehicles

While considering the problem of military vehicles safety the military wheel vehicles need to be looked at in more details. Although majority of them can be described as special vehicles, then the part of them is specific and distinguishes itself with technical solutions untypical for commercial vehicles. Light armoured vehicles, mine resistant vehicles, combat vehicles, infantry transporters, road combinations for the transport of heavy combat equipment or technical evacuation vehicles should be mentioned in the groups of wheel vehicles. The uniqueness of these objects can be spotted while analysing their technical characteristics. Even having a brief look, depending on the vehicle type, unique dimensions, huge total mass and great inertia moments can be spotted. The driver work conditions are also special – often with significantly limited visibility and anti-mine protection systems as well as specific seats or safety belts.

Based on the information presented [5] on the threats for military vehicles in road traffic and on safety improvement measures a certain procedure seems to come in mind. The solution for the safety improvement of military vehicles in road traffic should be based on the assessment of implemented construction modifications on the movement safety. First of all, the assessment of the results from simulation research for distinctive manoeuvres and modifications to the vehicle constructions implemented on that basis should constitute the safety prerogative. Therefore, carrying out simulation tests (with experimentally verified mathematical models and developed software) seems to be of purpose. These tests determine the influence of selected construction and operation modifications on the steering behaviour as well as stability of military wheel vehicle and thus on the improvement of crew safety. The basis for such simulation tests can be own or commercial software developed on the basis of prepared and experimentally verified mathematical models of movement and dynamics of two- or multi-axis vehicles.

3. Procedure for gaining constructions of military wheel vehicles

Project implementation time from the vehicle concept to its implementation can be one of the factors negatively influencing the movement safety, which, in case of military wheel vehicles, gets shortened due to urgent operational needs [2]. In the recent years, the research and development process has been significantly shortened. Of example can be here the research programme for MRAP vehicles [3] divided into 3 phases of 9 months total.

The development of automotive technique related to the needs of national armed forces is carried out in a planned way. Purchases, research and implementation works are carried out pursuant to relevant procedures [2]. The procedure of their implementation has important influence on the safety level of military wheel vehicles. It is based on such documents as decisions of the ministry of national defence no. 57/2008 and 13/2010. At present, as part of implementation procedure, the following should be indicated: institution, which generates the need for vehicle implementation – the user, the coordination and decisive body – the General Staff, the implementing institution – IU (Armament Inspectorate). The implementing institution, if needed, develops tactical and technical requirements as well as test programme. It must be stated that, given a great uniqueness and specificity of the objects, difficulties may arise in exhaustive approach to the problem of movement safety as part of these tests. Additionally, the two determinants appear in the equipment acquisition process: time and money. Within this process, there is no time for construction improvement or polishing up and the research on movement safety of wheel vehicles can be limited. The procedure for implementation and verification focuses on construction optimizing at the stage of prototype designing and construction. That procedure is one of the issues that stress the need to develop a methodology using the simulation tests.

4. Methodology for determining the influence of selected construction changes on the movement safety of military wheel vehicles

One of the main factors stressing the need to develop the presented methodology is the procedure of acquiring equipment, including vehicles, valid in the army. The scope of tests needed prior to the vehicle implementation is diverse. With frequent time and financial restraints, the scope of tests as optimum is difficult to implement. At that moment, the need arose to develop strict framework - a methodology - of research, which should be applied to military vehicles. Due to already mentioned determinants, the methodology uses and allows for the use of the simulation methods, totally disregarded in those kinds of implementation processes. The developed methodology, having at its disposal experimental and simulation methods, determines the way they should be used in practice to determine the movement safety level expressed by vehicle stability and steering behaviour.

The pattern of the methodology is related to the implementation behaviour in the army where the main rule is to compare the test results with criteria and requirements stated by future users. Since the requirements for the stability and steering behaviour are very scarce and the standards often lack their quantitative definition, what partially results from the object characteristics, I have assumed that the best practice would be to refer to the results received for vehicles before modification.

Single stages present in the methodology result from the existing experience in modelling the vehicle dynamics and implementation tests. Therefore, the stage of collecting data for the model was stressed here. As the same time the role of construction, documentation was underlined as well as simulation parameters important from the launching point of view. The choice of relevant model does not impose any tool but it assumes that models of similar complexity will be used. This methodology takes into account the stage related to experimental method, which is carried out an independent and parallel way to the simulation stage. A test programme has been developed which seems to be the most representative in relation to the change influence on the vehicle movement safety.

Launching the simulation process requires collecting relevant necessary amount of data. If the simulation tests are to be used for experimental verification, in order to collect them, there is the need to carry out “a package” of several experiments and a detailed analysis of construction documentation. It requires carrying out several, independent research experiments. What should be stressed is that at every stage of collecting data for the model the access to the construction documentation is indispensable, since it limits the number of necessary experiments and can constitute a control element and source of information. The process of collecting data for the model should include the measurements of linear and mass dimensions, with the determination of inertia moments (important possibility to use CAD/CAE software). Moreover, the key factor is to determine the characteristics of elastic and suppressing elements in the chassis system and parameters for tired wheel. The data package for the model should be supplemented with the characteristics of steering and changing systems. The determination of vehicle movement resistance is an important element used in simulation models for vehicle movement dynamics.

The selection of simulation model. At that stage, the simulation model should be selected and the universal model should be modified, as applicable to the characteristics of test object. The selection of a model relevant for the test object should be carried out based on its structure: the bodywork shape, wheels and steering system, suspension system and number of tired wheels. For different armoured vehicles, the use of simulation models with similar complexity level is assumed.

The stage of experimental tests can be carried out independently (parallel) from the implementation of simulation test programme. Moreover, they can be carried out at the stage of tests, which condition the vehicle introduction to the armed forces. Taking into account the above-

mentioned determinants of introducing new armament, i.e. time and money, as well as verification of technical considerations, simulation tests and the assessment accounting for stated criteria, the experimental test programme should include the following tests:

– straight line braking,
– acceleration intensity,
– maximum speed,
– double change of lane,
– taking typical terrain obstacles with determined parameters.

The next stage is to develop a simulation test programme. The use of verified simulation models allows for significantly shortening the test time and carrying out tests, which are difficult to implement by experiment due to threat to crew as well as necessary intervention to the vehicle construction in order to install measurement equipment. The programme of simulation tests should be determined in relation to the scope of construction changes or user requirements introduced to basis chassis. Basically, they should be carried out based on the standardized, open or closed tests. The selection of tests strictly to the needs to determine specific construction changes is not excluded, e.g. running over obstacle in order to determine qualitative changes in the suspension system. However, the scope of tests should be as wide as possible. In simulation tests, if necessary, the characteristics of year's seasons should be taken into account in relation to pavement and movement obstacles (rolling, air). It is recommended to include the scope of construction changes for selected parameters in order to define their influence on safety (non-linear influence) in a broader sense in comparison with its real value.

Simulation tests. This stage consists in implementing the assumed test programme as well as in configuration and collection of input data. At that stage, the test results can be presented in form of numbers, sheets, charts or animations.

The results of simulation results should be compared with the relevant results obtained for the non-modified (basis) vehicle. In both cases, they should be related to the existing international standards (ISO, AVTP, etc.). The other criteria can be requirements determined by the future user - tactical and technical requirements.

Figure 1 below presents the conduct scheme during the methodology implementation.

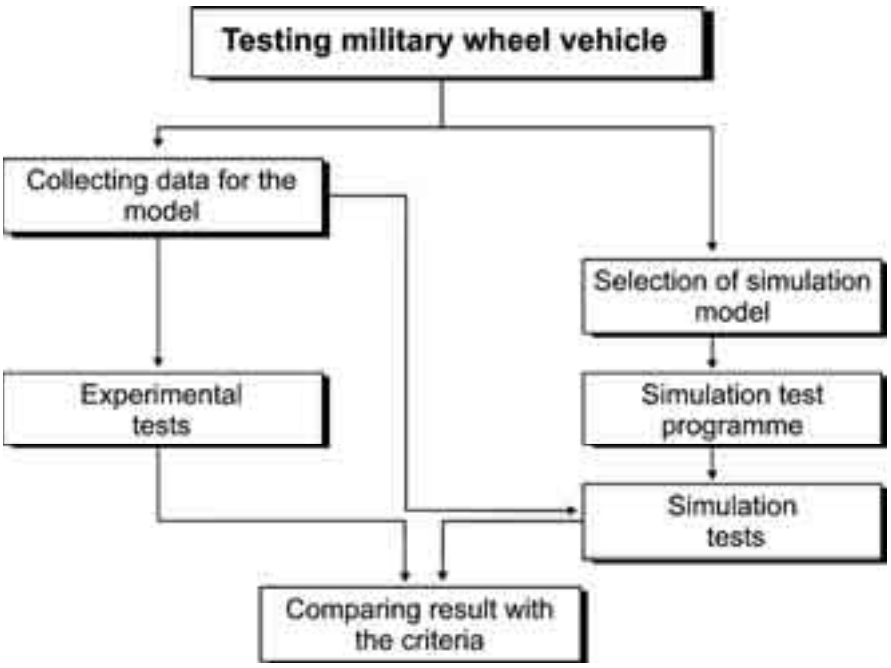

Fig. 1. Conduct scheme in methodology for determining the influence of selected construction changes on the movement safety of military wheel vehicles [5]

5. Verification of test capabilities in the accelerated mode

During the further conduct, the possibility to carry out experimental tests in relation to the accelerated mode of implementing vehicles for the military for different objects and different models constructed by means of own or commercial software was verified in order to indicate their usability. For this purpose the following were constructed - a model of double axis armoured vehicle - own software used [4], a model of four axis medium armoured vehicle - commercial software MBS DADS was used, a model of four axis medium armoured vehicle with hydropneumatic suspension - own software. The terminology used for the description is the effect of developed vehicle classification [5]. All models have been experimentally verified with a satisfactory result.

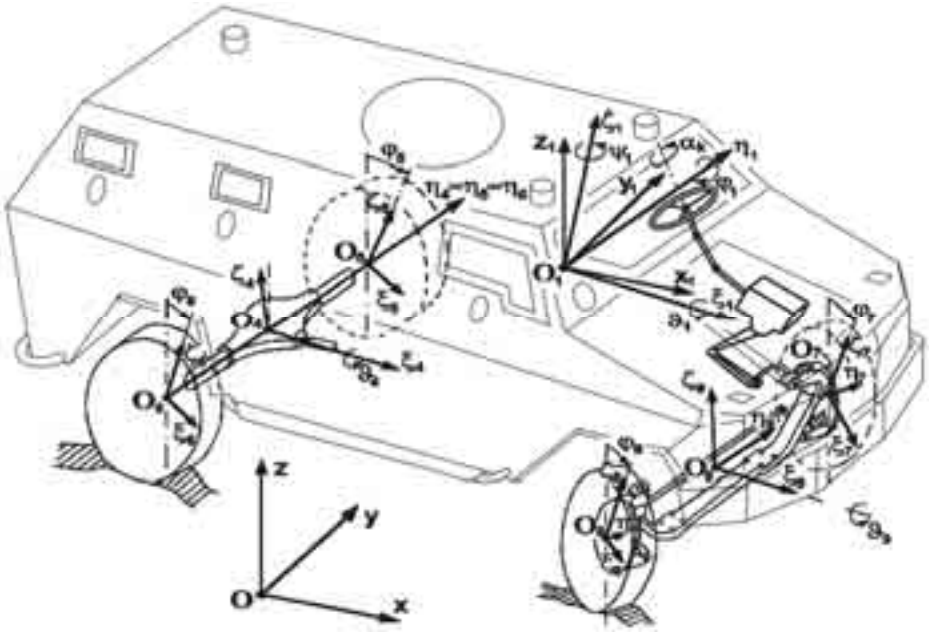

Fig. 2. A physical model of double axis light armoured vehicle and assumed coordinate systems [4]

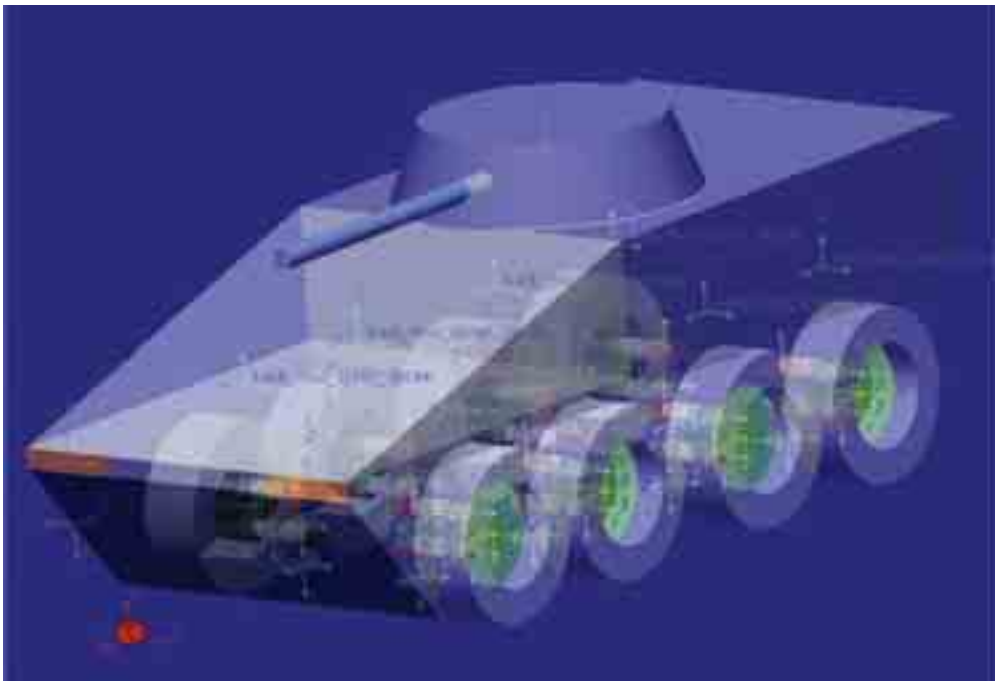

Fig. 3. A physical model of four axis medium armoured vehicle and assumed coordinate systems

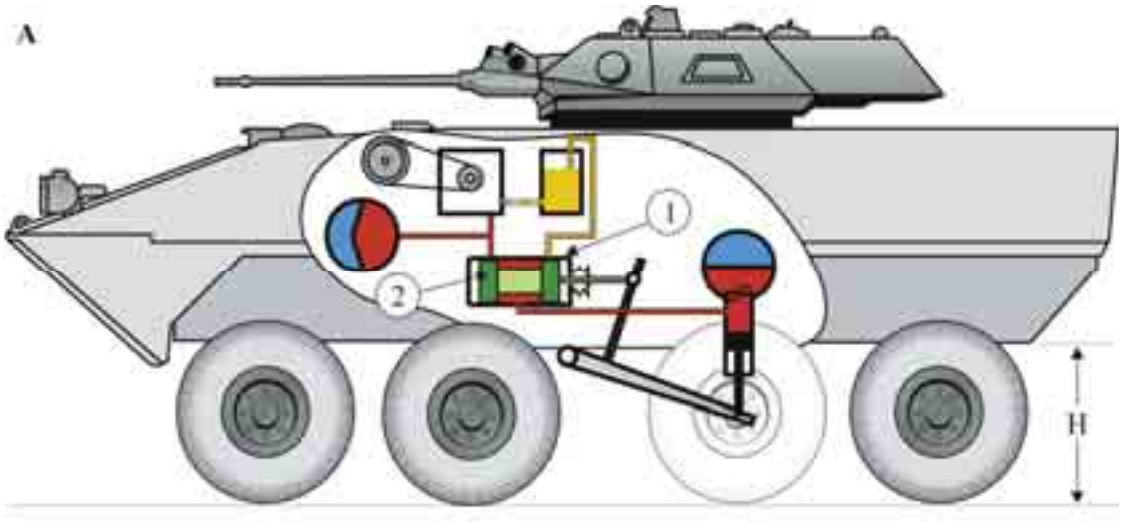

Fig. 4. General scheme of hydropneumatic suspension system on the four axis medium armoured vehicle

According to the assumed methodology, the constructed models were used to implement simulation research for tests: steady motion on circle (ISO 4138), step function on steering wheel (ISO 7401), single and double change of lane. The following model parameters were variable: vehicle mass and inertia moment, location of vehicle mass centre, tire parameters, suspension parameters. The end result was numerous test results in form of characteristics, which allowed analysing the influence of construction changes made on the vehicle movement dynamics. The results received can be compared with requirements presented or with vehicle results prior to its modification.

6. Summary

The methodology for determining the influence of selected construction changes on the movement safety of military wheel vehicles has been developed. The methodology has been verified in research process, which included experimental, and simulation tests, different models and test objects. The methodology has been verified in research process, which included experimental, and simulation tests, different models and test objects. The developed research methodology allows assessing the influence of different construction changes in a more efficient way than only by means of experimental tests.

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