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# APPROACHES TO MOTOR VEHICLE SCRAPPAGE WITH CONSIDERATION FOR TECHNICAL MAINTENANCE SYSTEM

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**ABSTRACT**

This article discusses the influence of vehicle technical maintenance (VTM) on vehicle efficient operation period (VEOP), hence, on vehicle scrappage time. Procedures have been developed for arrangement of schedule of maintenance operations (MO) and current repair (CR) of road vehicles which determines capacities of production and technical facilities (PTF) and operates in real time, that is, enables adaptation of capacities of motor transport enterprise (MTE) to vehicle number in limited period of time. It has been revealed that PTF operating structures, procedures applied for its generation, influence directly on qualitative determination of VEOP and then on generation of structure of scrappage and reprocessing of decommissioned vehicles. VEOP should rapidly and reliably reflect regularities of variation of CR performances upon commissioning of new road vehicles (RV), increase in operation periods and depreciation of operating RV.

## INTRODUCTION

Vehicle efficient operation period (VEOP) should be determined on the basis of vehicle design features and with consideration for vehicle technical maintenance (VTM) applied for its operation. Vehicle design features are selected and determined by vehicle manufactures and VTM system is determined by geographical region where motor vehicles (MV) operate. The influence of this system on VEOP is an important determining factor. In its turn, VEOP is an important performance influencing on capacity of vehicle scrappage and recycling facilities. Under the conditions of saturated market of MV consumers the capacity of vehicle scrappage facilities is a determining factor for scope of new delivery (demand), that is, for vehicle commissioning. It can be stated that VEOP plays the role of feedback in vehicle operation system.

The VTM system under current market conditions undergoes cardinal changes. Recently the amount of vehicle enterprises increased more than by 100 times. Vertical interrelations in the industry were weakened. Existed procedures of control and management of vehicle technical conditions did not comply with current macroeconomic situation. As a consequence of the changes in VTM system the activities of most enterprises in this industry do not meet current requirements, which leads to decrease in operational reliability of vehicles and operation efficiency, increase in motor trucking charges in production prime cost. Obviously, the vehicle operational reliability is a complex issue and assumes application of modern design procedures, engineering support, economic and organizational management, scheduling, supervising and other measures. Thus, in the scope of one work it is impossible to cover all aspects influencing on VEOP.

The aim of this work is to prove that solution of the issue of VTM system should be oriented not at maximum vehicle operation lifetime but at achievement of preset level of vehicle reliability in preset operation period (VEOP), and after reaching

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this level a vehicle should be decommissioned even if its resources are not exceed (Belyaev, *et al*., 2016; Fedos'kina, 2013; Katsuba, *et al*., 2014; Kokorev, *et al*., 2016; Menukhova, *et al*., 2014; Menukhova, *et al*., 2014; Kokorev, *et al*., 2016; Menukhova, *et al*., 2014; Platko, *et al*., 2013; Tarasov, *et al*., 2016; Terent'ev, 2008; Terent'ev, 2011; Terent'ev, 2013a; Terent'ev, 2013b; Terent'ev, 2014a; Terent'ev, 2014b; Terent'ev, *et al*., 2014; Terent'ev, *et al*., 2014a).

## EXPERIMENTAL

Engineering solution of the problem is based on determination of allowable parameters of VTM system which determine operability of vehicles, it requires for procedures which would omclude the following:

1. Random variations of vehicle parameters upon operation;
2. Multicriteriality;
3. Uncertainty upon selection of parameter values in vehicle operation;
4. Limited resources upon management of technical condition of vehicle, assemblies and systems in operation.

Currently increasingly larger role is played by development of motor vehicle operation, capabilities of engineering services to efficiently perform maintenance operations (MO) and current repair (CR) of purchased machinery, that is, to maintain working order of vehicles. The content of targeted object of VTM system also varies:

1) Improved design of vehicles, assemblies and units requires for modernization of production sites and stations, their provision with new engineering equipment.
2) Significant increase in resource of modern vehicles, time between overhauls and at the same time relative decrease in operation lifetime lead to impracticality of a set of sites in PTF (for instance, battery repair site, rooms for storage of acetylene bottles, timber processing and decoration sites and others).
3) Complex design of modern vehicles and at the same time increased reliability lead to impossibility or economic impracticality of keeping complicated and expensive equipment for repair and maintenance of numerous systems and assemblies by MTE. In particular, such items include modern power supply systems with electron control, automated transmissions and others. In some cases, it is more reasonable to forward vehicles for repair by official dealer or by third party.
4) Some restrictions of possible repair of various vehicles and their systems are imposed by purchasing terms of new vehicles related with manufacture warranties, leasing and credit terms.

## RESULTS

Vehicle efficient operation depends on subsystem of maintenance of motor vehicles (MV) in technical working condition, which significantly depends of development level and operation conditions of production and technical facilities (PTF) supporting its operation. Contribution of PTF into efficiency of vehicle operation is sufficiently high and estimated as 18% to 19%. The information about VEOP should originate and be adjusted by two main sources (Fig. 1):

1. Manufacturing companies, which provides to the customers recommendations on operation time of their products, either directly or indirectly in the form of warranty period.
2. VTM systems, namely, by the company maintaining vehicle technically working condition.

Some variants exist which can be illustrated by the flowchart in Fig. 1.

Such differentiation of companies operating motor vehicles is stipulated by the fact that the VTM system, supporting MV in technically working condition in Russian Federation, is cardinally different from the VTM system existing in advanced Western countries.

The system of maintenance operation and repair (hereinafter referred to as MO and CR) is embodied in production and technical facilities (PTF) of RV operating companies. Thus, at present the technical maintenance systems intended for Russian and foreign vehicles are different, we should distinguish between them.

Numerous projects applied for erection of MTE for cargo vehicles are intended mainly for Russian vehicles with capacity of 5 t to 8 t, the fraction of road trains in total fleet is 25% to 30%. Nowadays cargo traffic is performed by vehicles with capacity of 30 t and higher, this parameter is higher for towing trucks applied in trains with trailers of various purpose. The number of special purpose vehicles increases. Dimensions of up-to-date vehicles increased significantly. It is obvious that the sizes if production areas and sites, their purposes, location in buildings and premises cannot meet the requirements of new motor vehicles. Modification of structure of road

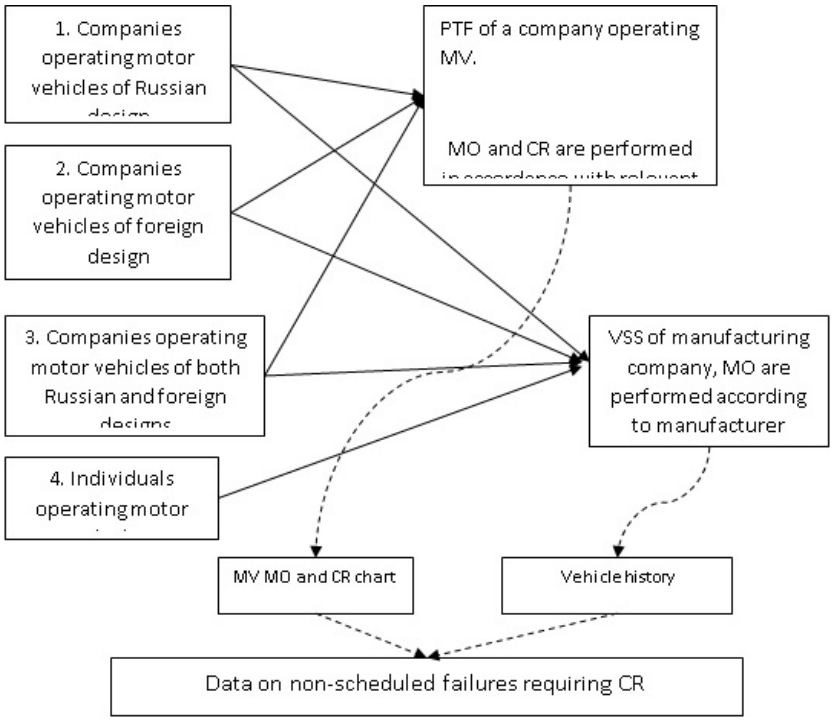


**Fig. 1** Differentiation flowchart of vehicle operating companies.

vehicle fleet is mainly related with projects devoted to company modernization. As a rule, in this case decisions are adopted on conversion to import machinery. Gradually the Russian machinery is decommissioned. The import fleet of numerous automotive companies is 70% to 85%.

Suppliers of these vehicles operate their vehicle service stations (VSS), they have complete range of spare parts. However, the capacities for servicing of all potential customers are obviously insufficient. Thus, waiting for vehicle repair and the costs of repair and maintenance do not satisfy requirements and financial capabilities of motor vehicle companies.

Unavailability of adequate procedure for development of schedule of MO and CR of RV leads to decrease in quality of diagnostics. Upon planning of PTF diagnostics it impossible to apply the calculated results of companies perfuming vehicle MO and repair.

It should be taken into account that in up-to-date market environment companies should rely only on their own money or on credits from financial enterprises which request for duly repayment of loans with significant per cents. Under such situation companies should explore the available production assets (production sites, engineering equipment and communications) with maximum economic efficiency.

It can be stated that peculiar features of vehicle MO and CR abroad are as follows:

1. Vehicle repair on the basis of assembly/unit servicing, namely: vehicle repair on the basis of ready assemblies (new or repaired); assembly repair on the basis of ready units and parts; repair of parts in specialized workshops, often in cooperation with workshops performing certain procedures (boring, polishing, galvanic coating and so on)
2. Execution of MO and CR by companies manufacturing new vehicles, as well as by large vehicle operating enterprises
3. Existence of wide-spread network of specialized repair providers owned by independent entrepreneurs
4. Existence of various forms and methods of MO and CR arrangement, which is the basis of competitiveness in the market of such services determining high quality of company activity, their good technical equipment, personnel skills, well designed planning and, finally, sufficient number of vehicle repairing facilities.

## DISCUSSION

The main aspects of existing procedures of scheduling RV MO and CR.

The key steps of engineering scheduling of VTM

system are selection of initial data and arrangement of schedule of MO and CR of running vehicles. As already mentioned, the companies operating Western vehicles face certain bottlenecks upon arrangement of PTF, namely: scheduling of MO and CR.

Autonomous MTE as the best representatives

of PTF structures of vehicle operating companies are characterized by the following sequence of engineering scheduling steps (Fig. 2). It should be mentioned that exactly this performance of CR performed at request are influenced by occasional factors to higher extent than performances of all other engineering actions. Thus, forecasting of labor intensity and CR, delay period is the most difficult issue. VEOP, acting as feedback of PTF subsystem in VTM system, should rapidly and reliably reflect regularities of variation of CR performances upon commissioning of new road vehicles (RV), increase in operation periods and depreciation of operating RV.

In addition to uncertainty of CR performances the existing procedure of scheduling of MO and CR is characterized by another drawback.

Engineering scheduling is based on the so called cyclic calculations. Herewith, until recently a cycle was referred to as vehicle operation period before its major overhaul and its decommissioning, that is, its complete operation resource. In this case we face the following inconsistency with the existing condition of vehicle design and relevant level of PTF. Under planned economy major overhaul of vehicles was performed obligatory according to predefined schedule of motor workshops. Therefore, the engineering scheduling was based on the main cycle: vehicle mileage from commissioning to major overhaul or the period between major overhauls. After calculation of impacts per cycle, using the coefficient of conversion from cycle to year, their number per year, day was determined. Taking into consideration that major overhaul is not a mandatory technical impact and already is not performed by workshops, it would be reasonable to develop only engineering scheduling. However, it should be mentioned that development of only annual engineering scheduling significantly narrows capabilities of enterprises in strategic planning of PTF development.

Nowadays the cycle-based calculation of engineering scheduling for MO stipulates:

1. Selection and adjustment of periodicity of MO-1, MO-2 and operation resources for MTE vehicles;
2. Calculation of MO number per one vehicle (road train per cycle);
3. Calculation of coefficient of technical availability and, on its basis, calculation of annual operation of

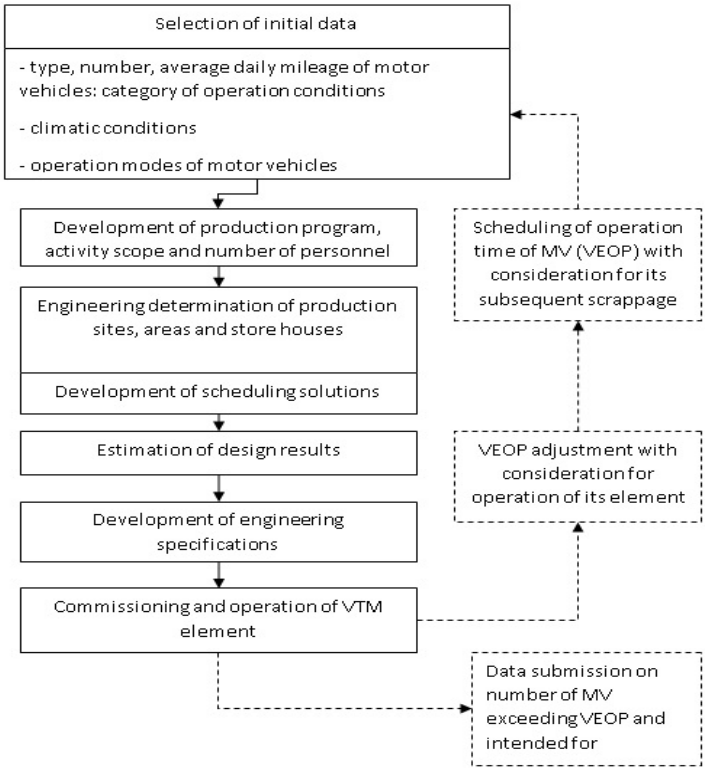


**Fig. 2** Main stages of engineering design and operation of VTM system.

vehicles and the number of MO per vehicle group (fleet).

It is possible to state that under the conditions of replacement of Russian vehicles with foreign ones the application of this procedure of scheduling of MO and CR for modern machinery becomes more difficult. This can be attributed to the following issues:

1. For instance, the operation resource of foreign lorries upon correct operation is 1.8…2.0 million kilometers. Thus, operation until decommissioning is not preset, operation period is set to 8…9 years irrespective of operation period. This is related with machinery obsolescence before the end of operation period.
2. Regulative periodicity of MO is determined according to service maintenance procedure developed by vehicle manufacturer, and the norms of labor intensity and of vehicle downtime during MO and CR are not stipulated in Russian regulations.
3. Concerning Russian vehicles, downtime duration MO and CR is regulated in the form of total specific downtime per 1000 km of operation, which is inconsistent with performance of MO and CR of foreign machinery.
4. In practice, due to variations in technical condition and operation periods of fleet not all vehicles of MTE, which performed operation norms before major overhaul, are decommissioned, which influences on total number of major overhauls, hence, on accurate determination of coefficient of technical availability.
5. Vehicle design in total and design of its separate units and systems in particular were changed significantly in recent years, thus necessitating qualitative and quantitative variation of scheduled activities concerning MO and CR.

Similar to the previous material of this section let us consider development of scheduling of technical impacts at technical maintenance stations when vehicles of foreign origin are serviced.

Sometimes it is difficult to apply Russian procedures for development of scheduling of MO and CR, when foreign vehicles operate in Russian Federation: in order to develop scheduling of MO and CR on the basis of domestic procedures it is required to know labor intensity of vehicle CR (h/1000 km). However, the required norms are not stipulated in the system of MO and CR of foreign manufacturers. Under the existing conditions (significant deterioration of MTE fleet, inconsistency between vehicle operation conditions and norms, and so on) it would be unreasonable to neglect CR.

An important advantage of such regulation is that the conditions of operation, climatic conditions are adjusted by preset labor intensity and activity type of MO individually for each vehicle type and model, that is, more thoroughly.

All activities performed with a vehicle are stored in the so-called vehicle history, both scheduled and unscheduled. Scheduled activities determine warranty maintenance period and are used for preliminary detection of VEOP. Final determination of VEOP should be determined on the availability of data on unscheduled activities, that is, on labor intensity of CR aimed at maintaining of vehicle in good working condition.

## CONCLUSION

The results of this work demonstrate that development of VTM system should be oriented not at maximum vehicle operation lifetime but at achievement of preset level of vehicle reliability in preset operation period (VEOP). After reaching this level a vehicle should be decommissioned even if its resources are not exceed.

VEOP, acting as feedback of PTF subsystem in VTM system, should rapidly and reliably reflect regularities of variation of CR performances upon commissioning of new road vehicles (RV), increase in operation periods and depreciation of operating RV.

Scheduled activities preset warranty maintenance periods and are used for preliminary detection of VEOP.

This work would facilitate application of the obtained data for determination of start time of vehicle scrappage with consideration for the influence of vehicle technical maintenance (VTM) on the vehicle efficient operation period (VEOP), hence, on vehicle scrappage time, as well as on economic estimation, optimization and increase in efficiency of vehicle operation system: manufacturing-operation-scrappage. This work is at its initial stage. Currently no reliable published data are available elsewhere concerning this subject, we will continue our efforts in these field.

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