# The method of rational organization of maintenance of light commercial vehicles of foreign production using specialized diagnostic tools at the motor transport company in cooperation with the branded service stations

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**Abstract.** The article describes a method of rational organization of maintenance and repair of light commercial vehicles of foreign production using specialized diagnostic tools with the diagnosis in cooperation with branded service stations (BSS). The main purpose of using technical diagnostics tools is to reduce the time losses that occur when sending vehicles for maintenance, and to reduce the cost of maintenance and repair of foreign-made trucks undergoing maintenance and repair at a motor transport company (MTC) and at branded service stations. A simulation model is used as a tool for assessing the economic efficiency of various options for cooperation between a motor transport enterprise and a branded service station when performing maintenance and repair of light commercial vehicles of foreign production. The objective function of the simulation model contains components that estimate the loss of profit from the downtime of vehicles in the maintenance and repair area and the cost of organizing maintenance at the enterprise in cooperation with the company's service station. A comparative analysis of each variant of the organization of cooperation is carried out with and without taking into account the use of diagnostics. The currentness of the described methodology is explained by the fact that in the field of production of services for maintenance and repair of light commercial vehicles, fundamental changes have occurred, caused by a change in the form of ownership of both transport enterprises and maintenance and repair enterprises. In addition, the widespread use of foreign-made light trucks has led to the emergence of branded service stations that have licenses to service and repair foreign cars during the warranty period. This circumstance fundamentally changes the scheme of servicing these vehicles and increases the downtime of expensive foreign-made cars for organizational reasons.

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## 1 Introduction

Tough competition of road carriers in the transportation services market forced them to find measures aimed at reducing the cost of maintenance and repair of foreign commercial vehicles, including reducing downtime of vehicles in the areas of maintenance and repair of cars at the at the motor transport company in cooperation with the branded service stations [1]. One of the most effective and time-tested measures is to diagnose the technical condition of vehicles using specialized tools and equipment [2, 3].

Scientific work in the field of motor transport technical diagnostics began in the USSR since the sixties of the twentieth century. At this time, scientific schools were formed at the Moscow Automobile and Road Construction Institute (MADI) under the leadership of G.V. Kramarenko, LV Miroshnikov [1-5]. Analogue investigations were carried out at the Kharkiv Automobile and Road Institute (HADI) under the leadership of N.Ya. Govorushchenko [6]. Representatives of the MADI school have developed theoretical foundations for diagnosing vehicle's aggregates and assemblies using various diagnosis devices. The theoretical basis was created for using diagnostic information in control systems of the technical service of the motor transport companies. Methods for organizing maintenance and repair of vehicles with diagnostics were created. Experimental technical means of automating the logical process of diagnosing vehicle aggregates and assemblies were created [4, 5]. A number of domestic scientists considered diagnostics as one of the areas of technical cybernetics, and, using the cybernetic approach, developed a number of models and technical means of diagnostics [5].

The school of the Kharkov Automobile and Highway Institute made a significant contribution to the development of methods and means of diagnostics, including stand diagnostics [6].

These technologies began to be really introduced into practice at maintenance and repair enterprises. However, the collapse of the USSR not only forced to suspend work in this direction, but also changed the operating conditions of transport enterprises, in which the developed methods of organizing diagnostics were not entirely adequate to the current situation.

## 2 Features of the modern sphere of production of services for the maintenance and repair of light commercial vehicles of foreign production

In the sphere of production of services for the maintenance and repair of light commercial vehicles, many fundamental changes have occurred, caused by a change in the form of ownership of both transport enterprises and enterprises of maintenance and repair [7]. In addition, the appearance on the market of foreign-made trucks in an amount comparable to the number of domestically produced trucks has led to the emergence of branded service stations, which have licenses for the production of maintenance and repair of foreign cars of the corresponding manufacturers and brands during the warranty period [8]. This circumstance forces transport companies to service new imported cars only at branded service stations. If it becomes necessary to carry out routine repairs during the warranty period, the repair must also be carried out at a branded service station, so as not to lose the warranty. However, in the post-warranty period, a significant part of the maintenance work for commercial vehicles also has to be carried out at branded service stations for light commercial vehicles of foreign production. This leads to a significant increase in the time of servicing vehicles at the service station, due to the time spent on clarifying the technical condition of the sent vehicle, agreeing on the nomenclature and scope of work with the customer, determining the availability of necessary spare parts in the central warehouse,

waiting for the release of the necessary specialized post and other equipment for production of works. An enlarged scheme of interaction between the customer (transport company) and the branded service station during the performance of work is shown in Figure 1.

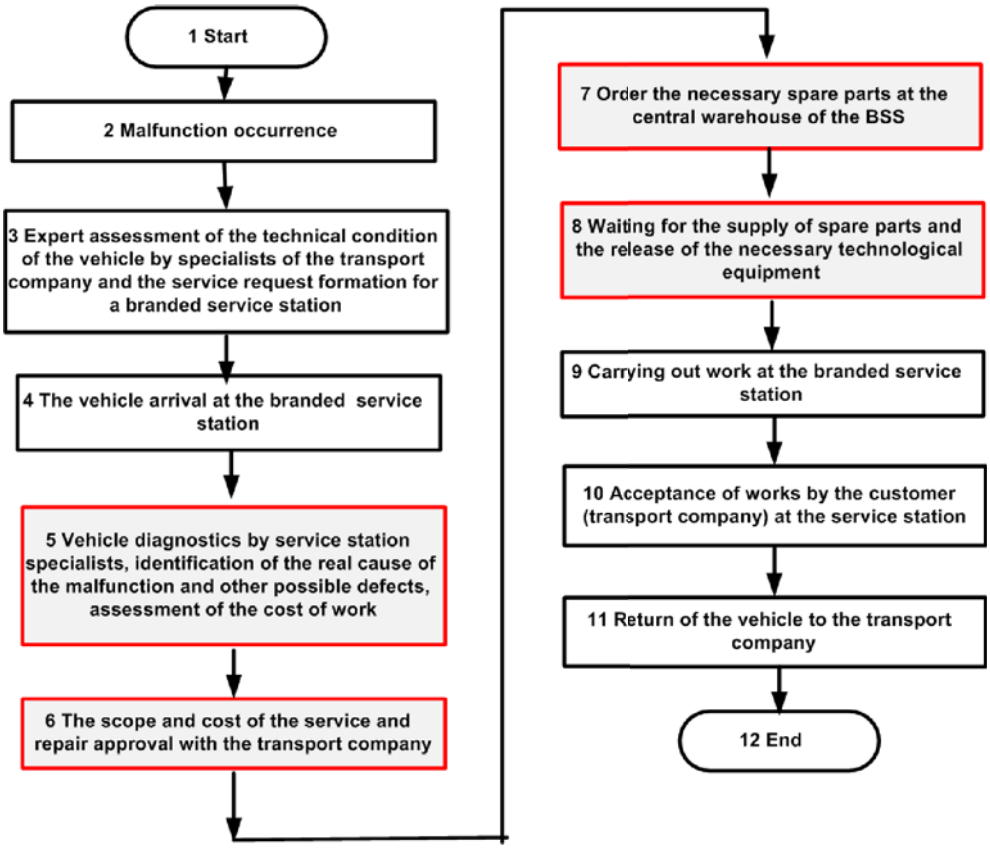


**Fig. 1.** Scheme of interaction between the customer (transport company) and the branded service station during the performance of work.

The main reason for the existing industrial cooperation with a branded service stations is the absence at most transport companies of diagnostics means for foreign-made light commercial vehicles. This is due to the policy of manufacturing firms to obtain additional profit from the use of branded service stations in the post-warranty period of operation, which significantly increase the costs of service for transport company [8]. Currently, the transport company, having drawn up an request, sends the car to the branded service station, indicating the signs of a possible malfunction. In fact, the car represents a "black box" for the workshop specialists. The presence of diagnostic tools in the transport company will not only prevent the occurrence of complex malfunctions and failures, but also simplify the processes of organizing work and troubleshooting technologies. In the case of using diagnostic tools at a transport company, the scheme of interaction with the company's service station changes, as shown in figure 2.

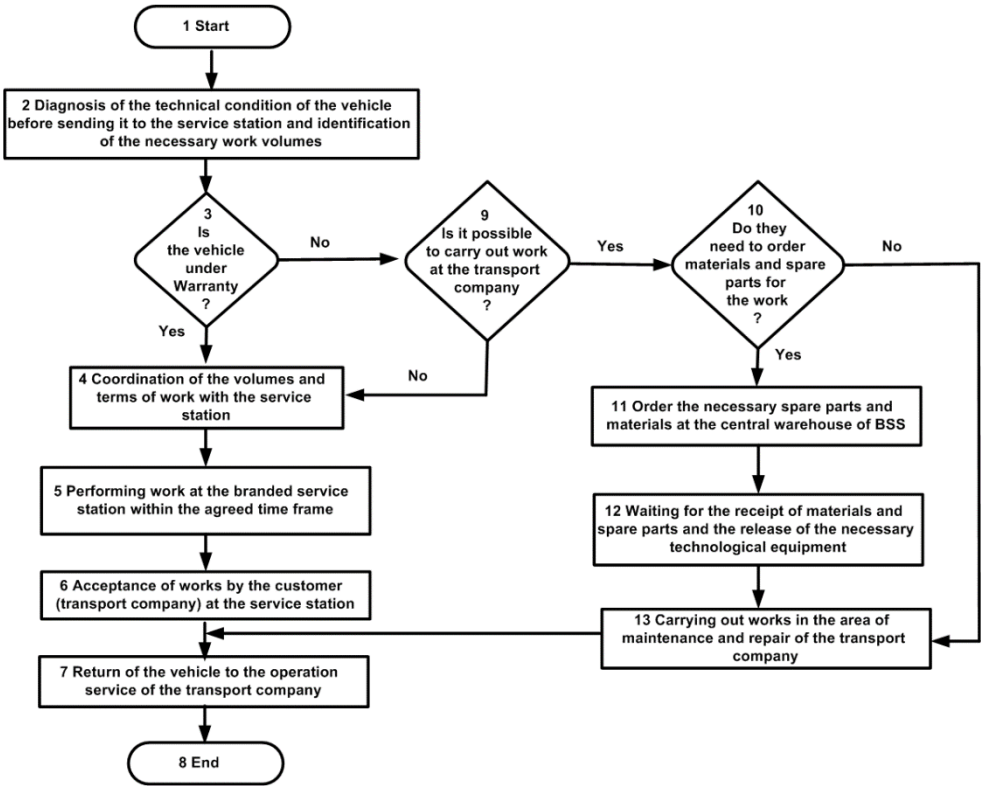


**Fig. 2.** The main stages of maintenance and repair of foreign made vehicles with diagnostics at the transport company

The first, basically, the nomenclature of works can be found out by the results of diagnostics. This allows transport company to coordinate the timing of the arrival of the vehicle at the branded service station with the exception of additional downtime due to the lack of materials, spare parts, resources of technological equipment. Secondly, in many cases, in the post-warranty period, the work can be performed by the specialists of the transport company itself.

The urgency of this problem in Russia is explained by the widespread use of diesel light commercial vehicles of foreign production. In this regard, significant interest is aroused by the work on the production and testing of diagnostics tools of domestic production, which make it possible to assess the technical condition of light commercial vehicles. One of such devices is the portable “StarDiagnosis” unit for complex diagnostics of light trucks, including German Mercedes-Benz Sprinter. The results of the experimental testing of this unit at one of the specialized transport companies of emergency medical care show the feasibility of its use to improve the environmental safety of vehicles while reducing the cost of maintenance and repair. In particular, it was established that the unit, in some cases, can regenerate particulate filters, affecting the smoke parameters [8]. These works have acquired particular relevance in connection with the sharply tightened requirements for the environmental friendliness of cars [9, 11].

## 3 Development of a methodology for simulating the processes of maintenance and repair of vehicles with diagnostics at the transport company in cooperation with branded service stations

The use of diagnostic tools for testing light commercial vehicles should be economically justified. This justification can be the results of modeling maintenance and repair processes with diagnostics at transport company in cooperation with branded service stations, showing the effect-cost ratio for various parameters of the organizational structure of the maintenance and repair system analyzed on the model.

The developed methodology is based on the use of the method of imitation discrete-event modeling [12, 13], which adequately reflects the maintenance and repair processes at transport company and branded service stations. The representative of the languages of discrete-event modeling is GPSS, which provides the creation and effective implementation of simulation models of queuing systems, which include the systems of maintenance and repair of cars [14, 15].

The developed method includes the following main stages:

- a description of the technological process of maintenance and repair of light commercial vehicles in cooperation with branded service stations in two versions: with and without the use of technical diagnostics at the transport company;
- a description of the characteristics of the initial statistical data and mathematical expressions describing the characteristics of the maintenance and repair processes at the transport company and at the branded service station;
- development of the target function, describing the effect of the introduction of diagnostic tools on the transport company;
- choice of language for simulation, development of logic and main stages of simulation of maintenance and repair processes;
- description of the main blocks of the model in the chosen modeling language. To ensure the possibility of comparing the results of diagnostics usage, two simulation models should be built;
- formation of statistical data describing the results of simulation in terms of objective function.

The approach to building a simulation model is based on the following provisions:

1) The main reporting period for which the simulation results are evaluated is a calendar month. The simulation results for the month are formed by summing the simulation results on the working days of the month;

2) The amount of work and the number of vehicles arriving for maintenance and repair are random variables, the characteristics of which should be determined based on the analysis of statistics on maintenance and repair work at the enterprise and at the company service station.

3) Maintenance planning is carried out in advance; the monthly scope of work is determined based on the fleet vehicles' mileage. After that the maintenance plan is formed for each working day of the month.

4) Planning of repair is carried out according to incoming claims, the daily number of claims for repair is a random variable, the parameters of which are determined by the results of processing statistical data.

The object function of total costs is calculated based on the results of the simulation model. It has two components:

Losses of income ( $C_{am}$ ), depending on the time spent on maintenance and vehicles repairs at the transport company and branded service station:

$$C_{am} = C_{1am}^{h} \sum_{i=1}^{n_{TC}} \left( \sum_{j=1}^{m_{ij}^{TC}} \tau_{ij}^{M} + \sum_{j=1}^{n_{ij}^{TC}} \tau_{ij}^{R} \right) + C_{2am}^{h} \sum_{i=1}^{n_{BSS}} \left( \sum_{j=1}^{m_{ij}^{BSS}} w_{ij}^{R} + \tau_{ij}^{R} \right) \quad (1)$$

where $C_{1am}^{h}$ - cost of one car-hour for cars serviced by a transport company;

$n_{TC}$ - the number of working days of the maintenance and repair area of the transport company in the planned period (month);

$m_{ij}^{TC}$ - the number of vehicles received for maintenance in a transport company on the *i*-th working day;

$\tau_{ij}^{M}$ - time spent on the maintenance of the *j*-th vehicle that arrived on the *i*-th working day for maintenance in the transport company;

$n_{ij}^{TC}$ - the number of vehicles received for repair at the transport company on the *i*-th working day;

$\tau_{ij}^{TP}$ - time spent on repairing the *j*-th vehicle that arrived on the *i*-th working day for repair at the transport company;

$C_{2am}^{h}$ - cost of one car-hour for vehicles serviced at the branded service station;

$n_{BSS}$ - the number of working days of the branded service station in the planned period (month);

$m_{ij}^{BSS}$ - the number of vehicles delivered to the branded service station on the *i*-th working day;

$w_{ij}^{R}$ - time spent waiting for the repair of the *j*-th vehicle that arrived on the *i*-th working day at the branded service station;

$\tau_{ij}^{R}$ - time spent on maintenance and repair of the *j*-th vehicle that arrived on the *i*-th working day at the company branded service station.

Costs ( $C_{eq}$ ) for the operation of the maintenance and repair area of the enterprise and for corporate maintenance of light commercial vehicles of foreign production:

$$C_{eq} = C_{rent}^{TC} + H_{TC} \left( \sum_{i=1}^{m} C_i^h n_i \right) + \sum_{i=1}^{n_{BSS}} \sum_{j=1}^{m_{ij}^{BSS}} c_{ij}^{R}, \quad (2)$$

where $C_{rent}^{TC}$ - fixed costs associated with the lease of the transport company maintenance and repair area;

$H_{TC}$ - the number of working hours of the maintenance and repair area of the transport company in the reporting period (month);

*m* - the number of different types of technological equipment used in the process of maintenance and repair of vehicles at the transport company;

$n_i$ - the number of technological equipment of the *i*-th type used in the process of maintenance and repair of vehicles at the transport company;

$C_i^h$ - the cost of one hour of using technological equipment of the *i*-th type in the process of maintenance and repair of vehicles at the transport company;

$n_{BSS}$ - the number of working days of the branded service station during the planned period (month);

$m_{ij}^{BSS}$ - the number of vehicles delivered to the branded service station on the *i*-th working day;

$c_{ij}^{R}$ - the cost of maintenance and repair work for the *j*-th car that arrived on the *i*-th working day at the company service station.

## 4 Conclusion

The lack of accurate information about the technical condition of a vehicle sent for repair to a branded service station leads to waste of time spent on making a technical diagnosis, ordering the necessary spare parts and materials at the service station. The use of portable diagnostic equipment in the process of maintenance and repair of light commercial vehicles allows transport company to reduce the downtime of the vehicles by eliminating the unproductive time spent on clarifying the technical condition of the vehicle sent to the branded service station, and reduce downtime at the service station pending the start of repair work.

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