Management of preventive maintenance of vehicles

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Abstract. The article discusses the issue of the application and improvement of the control system and decision-making when servicing vehicles. For more effective management of the vehicles technical condition, a complex of programs developed at the Department of “Transport” of the PI SFU is proposed. Their use will help to reduce the time spent on decision making, increase the level of reliability and durability of vehicle components, study the patterns of changes in reliability indicators and monitor the effectiveness of decisions made.

1. Introduction

Daily quality of the motor transportation enterprises (MTE) work is estimated by thousands of residents. Most of the transport is used when serving the population for transportation in the city by buses. Without buses served on time, passengers will not get to their destinations in time, and the work of the entire city will be disrupted. Therefore, in accordance with the schedule, buses are delivered to the routes, ensuring a high level of traffic, environmental ecology, and safety. To maintain a high level of technical readiness, a stepped system of maintenance and repair (MRS) is used. In the applied strategy, part of the work is mandatory (procedural), and the rest is carried out on demand. Late completion of routine maintenance of vehicles reduces the level of technical readiness and release of vehicles to work, respectively, increasing the waiting time in the passenger line at bus stops. As a result, there are cases of cabin overload, uncomfortable conditions are created for the passenger, the amount of revenue is reduced. When working on the route, there are occasional sudden failures of doors, vehicle structural elements. All this leads to a premature derailment of buses from the route and a violation of the timetable. As a result, the work of the management system for the preventive maintenance and repair of buses at the ATP or service station is disrupted. The system of maintenance and repair works randomly, with overload or underload, violating strategies - decision rules. A particular difficulty in making decisions is due to the fact that in the passenger park there are more than a hundred vehicles of various capacities. The most complex design of buses consists of many parts of units, units, the service nomenclature of which exceeds dozens of operations. In turn, the maintenance and repair complex, the most complex queuing system, consists of a multitude of subsystems, models of regulatory, informational, organizational, technological and economic support.

Therefore, today it is difficult to imagine the process of management and decision-making without the availability of information technologies for digitizing the manifestation of random events, for creating regulatory technologies, accounting and control systems, and technology to encourage workers to increase productivity and quality of work in the maintenance and repair system.
2. Problem solution

Research and improvement of methods, methods of management and ensuring a high level of reliability, durability, safety, and efficiency of MTE and motor vehicles (MV), including using information technologies, are carried out by scientists from various fields of transport, information technologies and other areas [1-8]. However, the introduction of such management schemes and software products aimed at the maintenance (prevention) system of the vehicles is rather limited and as a result, in some enterprises, the document flow is formed only in paper form, which complicates information analysis processes.

In order to modernize the existing MRO system and form a system for the prevention of MV, it is proposed, using a systematic approach, to develop a research methodology (Figure 1). In which each stage combines the study of a set of issues related to the solution of this problem in a common problem.

At the first stage, the analysis of technologies, methods, and methods of ensuring the reliability of equipment during operation, especially about the existing system of maintenance and repair of MV, is carried out.

| STAGE 1. Development of technology for digitizing information for automated accounting, control and processing |
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| Development of technical documentation and classifiers and information coding system. | Creating databases for accounting information. | Development of the algorithm and software for accounting information. |

| STAGE - 2. Creating databases of regulatory indicators of reliability and recovery process |
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| Development of the algorithm for the operation of the maintenance and repair complex. | Development of experimental data technology design models. | Creating the structure of the information flows interaction. |

| STAGE - 3. Creating a mechanism for the design of technology prevention |
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| Development of an algorithm for evaluating statistical information. Creation of databases of standardized reliability indicators and recovery process. | Development of a model for estimating the stages of prevention at periodic intervals of a technical resource. | Development of a forecasting and planning model for prevention stages. |

Figure 1. Research methodology.

At the second stage, the proposed technology information and regulatory support system maintenance and repair MV. It includes: a model for estimating the sample size, a module for developing technical documentation for the operational accounting and management of production sites of the prevention system; a database is being created on a variety of reliability characteristics: durability, reliability, and maintainability of the elements included in the variety of technical impacts. At the next stage, a mechanism is developed for designing varieties of technical effects of the replaced elements formed on the principle of equal durability, taking into account the basic principles, decision-making strategies, and diagnostic tools.

At the third stage, a theoretical approach to the creation of a multi-level technology for the formation of preventive steps is considered, including:
an algorithm for statistical evaluation of the distribution patterns of random events that determine reliability indicators;
- analytical model for estimating the optimal technical resource of MV elements;
- an economic-probabilistic model for forecasting and planning preventive stages at periodic intervals of a technical resource.

The final stage of the research is the creation of an algorithm and software for computer-aided design of prevention technology using innovative optimization and control models.

The department "Transport" PI SFU, developed a comprehensive computer program and implemented at the MTE, including modules of statistical, analytical, regulatory and economic support [9] (Figure 2). The technology of digitizing data in the form of a software product introduced in the passenger bus enterprise. As the analysis of the implementation shows, the proposed technology of automated control can significantly increase the level of labor productivity and the technical readiness of vehicles and their release into the line.

![Figure 2. Interface of the program for collecting and processing information.](image)

The application of the program allows you to perform the functions of management and decision-making assistance systems bus prevention: analyze the statistics of work performed depending on the MV, the date of arrival or mileage; to carry out planning of putting buses on planned types of work. It also helps to monitor the costs of maintaining buses in good and working condition, study the change of markers and patterns of changes in the state of elements and systems of the vehicle and others. The program interface is easy to learn, which allowed its implementation directly in the service area of the MV. The production manager or shift manager can, without leaving the workplace, obtain the necessary information and decide on the technological process of servicing the MV systems.

The idea, the mechanism of formation of the set of names of operations of failed elements in the "nests, groups, clouds", is to study the patterns, proper strategies, – regulations of the process of restoration of the object, at different levels of the periodicity hierarchy, or technical resource. For the design of innovative prevention technology, a module was created, including an algorithm and a program for assessing the reliability characteristics. At the Department of "Transport" PI SFU a program for assessing the reliability of indicators was developed [10] (Figure 3).
Figure 3. Interfaces of the evaluation program of engine reliability indicators.

In Figure 3, the graph of the probability of failure-free operation (POF) of the engine shows that the average resource of foreign production, operated in actual operating conditions, is before the first restoration $L_{av} = 468$ thousand km. The set of graphs of the POF forms a regulatory and technological reliability map, which reveals, in terms of reliability and durability, parts limiting reliability that require high-quality refinement both in assemblies for design, technology for manufacturing MV in the production sector and for designing preventive technology in the field of operation (Figure 4).

And by creating a database of such information, additional levels of service can be developed for MV — types of technical influences that would be performed in a planned manner, thereby reducing bus downtime during maintenance, and the logistics division knew in advance about the necessary spare parts and components. The interaction of scientific developments in the field of reliability at the factory of manufacturers and in the field of operation will lead to a significant improvement in manufacturing quality and reliability improvement.

The formation of a prevention system is described in [1]; however, there are a number of shortcomings. Therefore, when grouping elements into a variety of technical impacts (VTI), this is used by average values, and the effect in the development of prevention stages using different “service strategies” (group, regulatory, according to need) is not specified. These shortcomings are areas for further research.
3. Conclusion
The application of the developed methodology and computer programs contributes to improving the management process of the MV service system, making decisions when servicing buses. This will ensure minimization of time spent, a higher coefficient of technical readiness of the vehicle, which ultimately affects the level of transport on the routes, underlies the formation of new levels of vehicle prevention.

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