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TÍTULO: Aumento de la eficiencia del funcionamiento de las empresas de inspección de Vehículos.

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RESUMEN: El nivel actual de saturación de megaciudades con el transporte por carretera es un grave problema en el campo de la seguridad ambiental y vial. El artículo está dedicado al desarrollo de un sistema de gestión para la inspección técnica de vehículos diseñado para mejorar la eficiencia de los procesos de servicio. Las etapas y el algoritmo del proceso tecnológico de inspección técnica del transporte motorizado se consideran y compilan. Se desarrolla la estructura del sistema de gestión de la información para la inspección técnica, que simplificará el trabajo de la empresa en su conjunto. Se propone el sistema de gestión.

PALABRAS CLAVES: sistema de gestión de la información, modelo de simulación, inspección técnica.

TITLE: Increase in the efficiency of the operation of vehicle inspection companies.

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ABSTRACT: The current level of saturation of megacities with road transport is a serious problem in the field of environmental and road safety. The article is dedicated to the development of a management system for the technical inspection of vehicles designed to improve the efficiency of service processes. The stages and the algorithm of the technological process of technical inspection of motorized transport are considered and compiled. The structure of the information management system for technical inspection is developed, which will simplify the work of the company as a whole. The management system is proposed.

KEY WORDS: information management system, simulation model, technical inspection.

INTRODUCTION.

Road transport is represented as an integral part of the transport system of the world economy, which claims to be the most important link in the economic life of countries. Efficiency and safety of road transport work is based on the reliability of the vehicle fleet, which is ensured by the timeliness and quality of the vehicles maintenance and repair.

A feature of the Russian automobile fleet is a large proportion of vehicles that do not fully meet international requirements for the technical level and safety of the structure. At the same time, about half of the country's fleet has a service life of more than 10 years. In addition to the direct aging of

the fleet, the deterioration of the technical condition of vehicles was affected by the increase in the number of economic entities - owners of vehicles of all ownership forms. All this was accompanied by a reduction in volumes and a decline in the quality of maintenance. This is due to the lack or weak development of the production and technical base, low qualifications of performers and non-compliance with the relevant regulations of automobile manufacturers.

Untimely maintenance and repair in combination with a low professional level of driving inevitably lead to a decrease in the level of traffic safety, increase in accident rate and the harmful impact of vehicles on the environment. Under these conditions, the task of monitoring the technical condition of vehicles in service is particularly important.

Vehicles technical inspection (TI) takes place at technical inspection points. From January 1, 2012, the vehicle can be inspected in any region and at any technical inspection point in the Russian Federation.

DEVELOPMENT.

Methods.

The problems of the TI influence on the technical state of the vehicle are devoted to a lot of research.

In works [P. Christensen, R. Elvik, 2007; S. Fosser, 1992; K. Saito, 2009], the influence of periodic inspection of vehicles on accident rates is considered.

In the work [P. Christensen, R. Elvik, 2007], negative binomial regression models were fitted to data on accidents and inspections created by merging data files provided by a major insurance company and by the Public Roads Administration. Technical defects prior to inspection were associated with an increased accident rate. Inspections were found to strongly reduce the number of technical defects in cars.

Author of study, K. Saito [2009], analyzes the effect of mandatory periodic safety inspections on traffic accident rates. Using a data set of more than 15,000 auto insurance policyholders in Japan, he investigates the relationship between car age and accident rates.

The data [O. Schoor, J.L. Niekerk, B. Grobbelaar, 2001; S. Hakim, D. Shefer, A.S. Hakkert, I. Hocherman, 1991; B.J. Schroer, W.F. Peyton, 1979] suggests that poor mechanical condition is a significant factor in motor vehicle accidents.

Authors of study [S. Blows, R.Q. Ivers, J. Connor, S. Ameratunga, R. Norto, 2003] analyze association between periodic motor vehicle inspection and frequent tyre pressure checks, and the risk of car crash injury. Vehicles that did not have a current certificate of inspection had significantly greater odds of being involved in a crash where someone was injured or killed, compared with cars that had a current certificate. Vehicles that had not had their tyre pressure checked within the past three months also had significantly greater odds of being involved in a crash, compared with those that had a tyre pressure check.

These studies confirm the need to expand the TI network, as well as to improve the work of existing points.

Shaburov V.N. noted in [V.N. Shaburov, 2005], the capacity increase of the TI points is made by adding complete diagnostic lines, which leads to uneven loading of equipment for various operations and unnecessary costs for TI, and accordingly, to an increase in prices. In addition, when deciding whether to equip an enterprise with equipment, the fact that the incoming vehicle flow for passing a vehicle inspection includes at least two parallel flows - primary and secondary (vehicles that have not passed the inspection for some diagnostic parameters from the first time). Also, the laws of these flows formation taking into account specific features of the region, as well as the reliability of the diagnostic equipment itself, which to a large extent determines the throughput

capacity of the TI points for the corresponding diagnostic operations, aren't considered. This reduces the efficiency of the TI points.

In his work, Shaburov V.N. carried out simulation of the functioning process of the TI point with sets of equipment, formed depending on the number of incoming requests, and on this basis he determined the optimal set of equipment.

Kulev M.V., constructed a mathematical model for determining the necessary number of diagnostic lines for TI of vehicles, mathematical models for changing the number of vehicles in the region on the basis of artificial neural networks, experimentally determined the labor intensities of diagnosing the technical condition of vehicles as part of the state TI [M.V. Kulev, 2010]. Malashchuk P.A. carried out simulation modeling for the point of vehicles maintenance [P.A. Malashchuk, 2009].

The article [S.K.J. Nur, A. Norazura, Z.A. Norhaslinda, 2018] is devoted to the development of a methodology for estimation the service centers network. A review of methods for estimation the service centers effectiveness was conducted. In the work [P.A. Byuvol, L.M. Gabsalikhova, I.V. Makarova, E.M. Mukhametdinov, G.R. Sadygova, 2017] a framework of simulation-based DEA model is proposed to determine the most efficient strategy to reduce the problem of customer waiting time at vehicle inspection center.

The usage of tools and methods of system analysis [I.V. Makarova, P.A. Byuvol, R.G. Khabibullin, 2013] and application of modern information technologies is a powerful tool that allows solving problems of improving the work of the TI points effectively.

Results and Discussion.

Stages of TI.

The process of TI begins with the acceptance of the vehicle. Reconciliation of registration and identification numbers with the help of the device for determining the authenticity and a device for

checking the marking data of units and assemblies are carried out. The expert-controller checks the condition of the suspension and steering gear on the backlash detector, as well as visually assesses the state of the brake system. Beats and gaps in the details of the suspension, steering rods; cracks, traces of permanent deformation are not allowed. For removing exhausts, a rail extraction system is used, which allows the vehicle to move freely along the line of technical control.

Then, the brake properties of the vehicle on the brake power stand are determined. The force on the control device is no more than 686 H, the specific braking force is not less than 0.51, the relative difference of the braking forces of the wheels of one axis is allowed for the front axles not more than 20%, for the next axles and semitrailers not more than 25%. The parking brake system must provide a specific braking force of at least 0.16.

The next stage is:

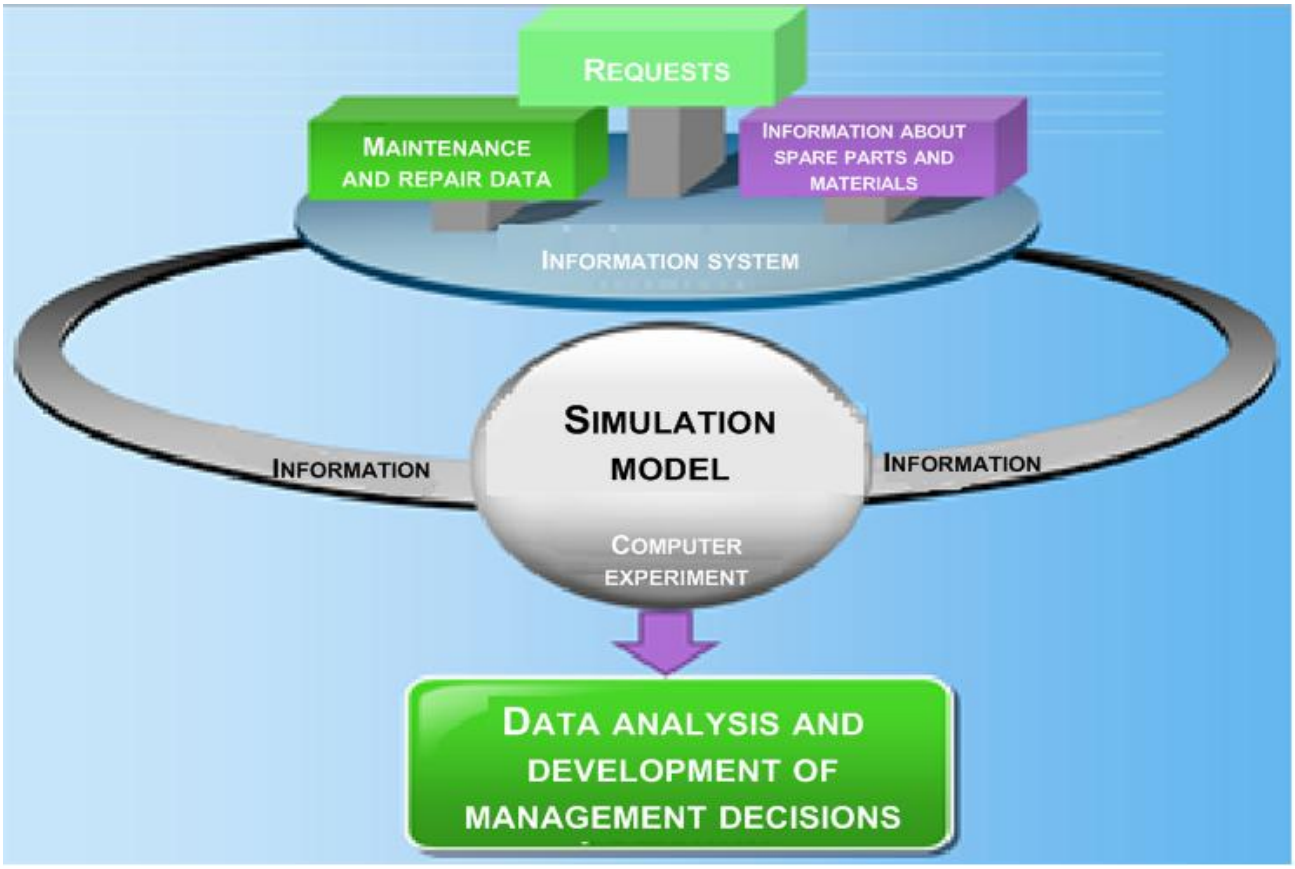
- Determination of toxicity or smokiness of the exhaust gases of the vehicle engine.
- Determination of the total backlash of the steering (passenger cars 10, buses 20, trucks 25 degrees).
- Checking the performance of external light devices, windscreen wipers and windshield washers, the condition of wheels and tires, the exhaust system, the transparency of the glasses and the condition of other structural elements.

The results of the visual evaluation should be transferred to the central computer and automatically recorded in the appropriate fields of the diagnostic map of this vehicle.

Designing and development of a management system for TI.

The vehicle transport management system should include three main subsystems: the information input and storage system, the intellectual core of the management system, the basis of which is the simulation model, as well as the system for developing managerial decisions (fig.1).

Figure 1 – Scheme of information management system of the road transport.



In this case, the experts of the TI points should be able to print out the diagnostic maps filled in the system, as well as contracts for carrying out TI with individuals and legal entities.

Based on the results of the TI operation, the system should allow to generate daily, weekly and quarterly reports for the Russian Union of Motor Insurers, unload them in the established format and send by e-mail.

The TI operator can distribute the requests himself and regulate the workload of the points and the TI experts by maintaining the schedule in the system.

Information about the applicant and the vehicle, indicated when applying for the passage of TI, should be automatically imported into the diagnostic map; thus, the system must implement the following functional:

1. To transfer data from the TI operators in a single automated information system for TI using a specialized data processing center.

2. To generate reports on the results of TI for the operator automatically.

3. To save and print the diagnostic card.

4. To fill out and print out agreements on the conduct of TI both with physical and legal entities automatically.

Development of the intelligent core of the TI management system.

One way to increase the profitability and competitiveness of the TI point is to increase revenue by reducing costs associated with idle equipment and workers. However, approbation of various options for working on a real system is expensive, and sometimes even impossible in principle. In this connection, it is necessary to develop a simulation model for the operation of a TI center.

The simulation model makes it possible to find all the necessary characteristics of systems, taking into account the stochasticity of the processes taking place in the real system. The functioning of the system displayed in the simulation model is as follows: a road transport enterprise has a certain initial fleet of vehicles. TI is made periodically. In this case, the violation of the periodicity of TI increases the probability of failure and the cost of maintenance. The cost of operation is also directly dependent on the age of the fleet.

Servicing of incoming requires is as follows (fig. 2):

1. The vehicle passes the TI on the diagnostic line.

2. If the vehicle meets the requirements for passing the TI, it is issued a "positive" diagnostic card and the require leaves the system.

3. If any violations are found, the vehicle can either leave the system or go through a repair line consisting of 4 posts and then go back to the diagnostic line:

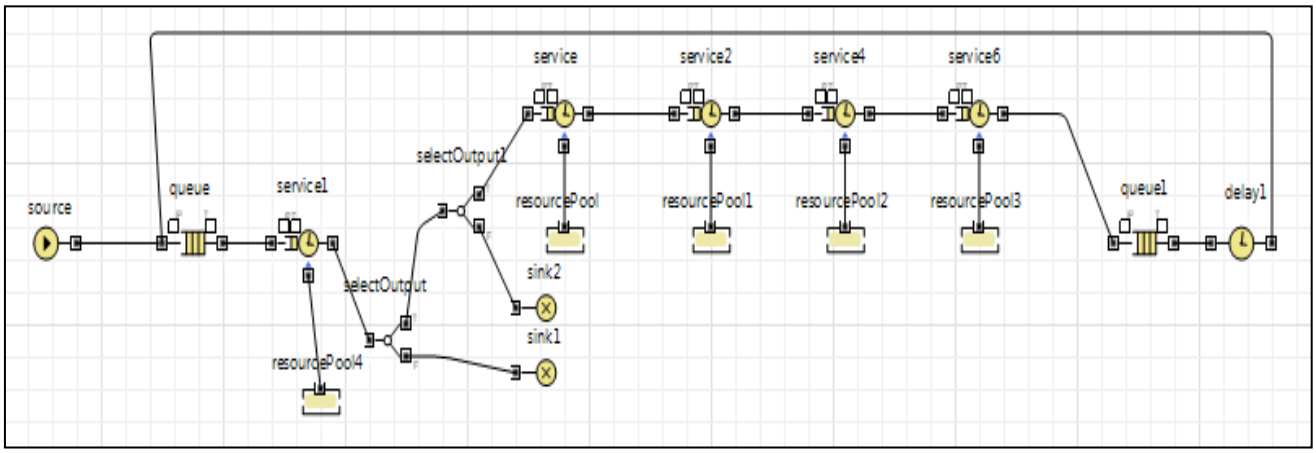
a. General post (combined with the electrical equipment repair area and battery area).

b. Chassis repair post.

c. Post of repair of high pressure fuel pumps and internal combustion engines.

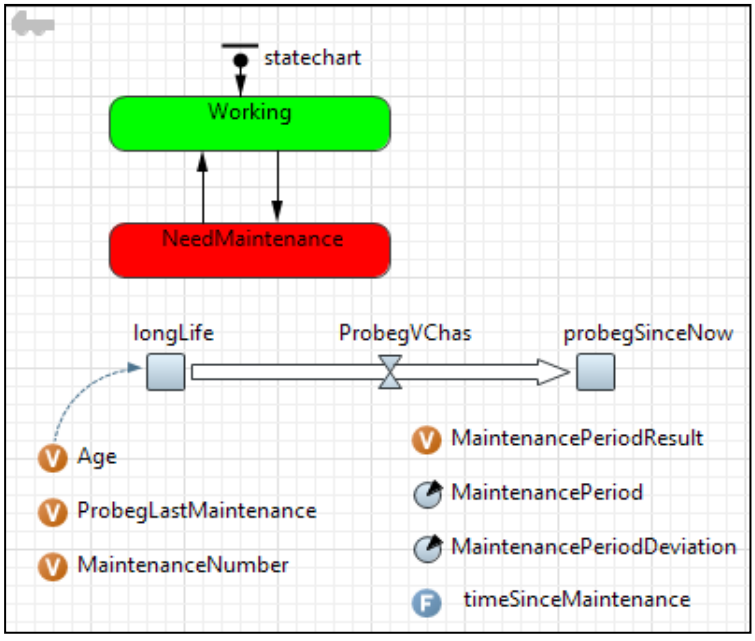
d. Lubrication and adjustment post.

Figure 2 – The process diagram of TI.



When constructing the simulation model, a combination of discrete-event and agent approaches to modeling is used. The agent is a truck whose state diagram is shown in fig. 3.

Figure 3. Diagram of the agent "Truck" states.



Optimization of processes consists in finding such a number of repair posts and workers, in which income from the provision of TI will be maximum, and the percentage of repair lines loading is not lower than the established standard.

In summary, the structure of the IT management information system is developed, which will simplify the work of the enterprise as a whole.

The proposed management system includes software modules for the collection, storage and analysis of information and a simulation model implemented in the simulation environment AnyLogic 6.

When developing the control system, we proceeded from the ability to implement, in a qualitative and effective way, the general purpose of the TI subsystem in maintaining the safety of road transport in operation and the need to develop recommendations for the implementation of activities aimed at ensuring quality and timely TI.

CONCLUSIONS.

The perspective development of enterprises and organizations of all forms of ownership, as well as the population of the country, is inextricably linked with the transport complex.

The obtained scientific and technical discoveries led to radical changes in the structure of the economy, included in the production and marketing of new models of vehicles, equipment, materials and technologies; changed the organization of production and distribution system; led to an accelerated moral aging of vehicles and equipment, and shortened the time of their replacement. Safety in the operation of vehicles fleet can be achieved by timely and qualitative performance of works on their diagnosis, TI and repair in case of non-compliance.

Organization of the TI is the most important subsystem of the country's road transport complex, which largely determines the safety of road vehicles in operation.

As a result of the implementation of the developed system, it is possible to achieve an increase in the safety of the vehicle fleet through qualitatively conducted diagnostics and verification of compliance of the vehicle with mandatory safety requirements, a justified conclusion on the possibility of operating the vehicle and allowing the vehicle to participate in road traffic, and an increase the profitability of the enterprise by TI service delivery.

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