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Improving safety of interfactory and company motor and electric vehicles by introducing modern digital devices

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Introduction. Industrial injuries are one of the most pressing problems in the field of occupational safety at enterprises of the main industries in the Russian Federation. Most cases of such injuries are noted when moving goods and people by means of various types of interfactory transport. A set of regulatory documents developed in recent years by the Government of the country is dedicated to solving this problem. In accordance with the current trends in the development of new technical solutions, the use of a complex of devices based on IT-technologies is effective. This article is devoted to improving the safety of interfactory and company motor and electric vehicles by introducing modern digital devices.

Problem Statement. Almost all large industrial enterprises have a need to move goods and personnel both to the place of production activities and within the enterprises. Motor and electric vehicles used for these purposes do not always undergo a maintenance check, they often undergo technical inspection and repairs with whatever funds remains, and always the personnel operating these vehicles do not have permission to drive. Possible accidents with interfactory and company vehicles occurring as a result of insufficient control over the technical condition of vehicles and inadequate or absent medical and administrative checks of the operating personnel can lead to injuries at the enterprise.

Theoretical Part. This article proposes methods for reducing traffic accidents of interfactory and company motor and electric vehicles of industrial enterprises and warehouse enterprises through the introduction of remote monitoring of operation based on IT-technologies, operating with the use of mobile applications that use Internet of Things technologies. The options for introducing security elements designed to reduce the number of transport accidents in internal transport of industrial enterprises and warehouse complexes are considered. An experiment was carried out to introduce system components to vehicles of an industrial enterprise.

Conclusion. The use of the proposed monitoring and control system for motor and electric vehicles at machine-building enterprises and warehouse complexes will make it possible to quickly resolve issues related to labor protection, the economy of the enterprise and compliance with the labor discipline. In particular, it is planned to reduce vehicle failures due to mechanical failures, as well as to make timely decisions on the removal from driving the drivers who are not feeling well.

Keywords: interfactory transport, injuries, industrial accidents, vehicle monitoring, traffic accidents, occupational risk, sensors and tracking systems.

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Introduction. The Government of the Russian Federation issued Decree No. 833-r of 26.04.2019, which defines measures aimed at reducing the incidence of occupational injuries and bringing the result to the level of economically developed countries, encouraging employers and employees to improve working conditions and preserve the health of employees.

The set of measures includes four sections:

— improvement of mechanisms for preventing occupational injuries and occupational morbidity;

— encouraging employers and employees to improve working conditions and preserve the health of employees;

— motivating citizens to lead a healthy lifestyle;

— monitoring activities [1].

The adoption of this set of measures allowed the Ministry of Labor and Social Protection of the Russian Federation to draw certain conclusions already at the end of 2019.

In 2019, there was a certain movement towards reducing the level of occupational injuries. According to the data obtained, the number of group accidents, as well as cases with serious and fatal outcomes decreased: in 11 months of 2019, 4,078 accidents with serious consequences occurred, which is 9% lower than in the same period of 2018 (4,479 cases).

In 2019, there was a decrease in the number of deaths at industrial enterprises: in 11 months of 2019, employees died by 12% less than in the same period of 2018 (1,018 and 1,158 people, respectively).

However, the death toll in engineering, construction, and transportation is still high compared to other economic activities.

Problem Statement. In order to reduce the indicators of industrial injuries in interfactory and company vehicles, the authors have develop a system for monitoring and controlling safety in road transport in mechanical engineering. At enterprises, motor and electric transport is one of the priority areas of the production process. Industrial road transport is used for transportation within enterprises, as well as external transportation from enterprises to the nearest railway stations, ports, airports and supplier enterprises. Passenger motor transport is also widely used, designed to deliver workers to the place of employment. Road transport, in comparison with rail, cable, pipeline and other types of transport, is characterized by maneuverability and the absence of the need for the construction of complex engineering structures. This makes it possible to carry out cargo and passenger turnover within the districts and nodes directly from the shop (warehouse) of the supplier enterprise to the shop (warehouse) of the recipient enterprise without additional transshipment operations.

Vehicles operating both outside and inside the enterprise are an integral part of the production process. Various vehicles, both general-purpose and special-purpose, are used to perform technological and passenger transportation within production enterprises. In particular, fork loaders, bucket loaders, electric cars, automobile and electric tractors with trailers have become very popular.

However, as the number of vehicles increases, so does the risk of personal injury. Occupational risk is the probability of harm to the health of an employee as a result of exposure to a harmful and (or) dangerous industrial factor in the performance of the work function, taking into account the possible severity of the damage to health (the definition is given in accordance with draft Federal Law No. 1070354-7 "On Amendments to the Labor Code of the Russian Federation in terms of improving mechanisms for preventing occupational injuries and occupational morbidity" of December 07, 2020) [2]. Injuries resulting from road traffic accidents are the most common among accidents [3].

Now, not enough attention is given to monitoring of interfactory transport in mechanical engineering. In order to reduce costs, many large enterprises have disbanded internal road safety services, the technical control of vehicles is not carried out in accordance with the regulations and operating instructions, control over the health of drivers of interfactory transport is also not conducted (including checks for alcohol intoxication). All this increases the risk of accidents.

The draft Federal Law (draft No. 1070354-7) contains the following definition of occupational risk management. It is a set of interrelated measures and procedures that are elements of the occupational health and safety management system and include the identification of hazards, assessment of occupational risks and the application of measures to reduce the levels of occupational risks or prevent their increase, monitoring and review of the identified occupational risks. Based on this definition, the authors developed a system that uses remote control (monitoring) based on digital information technology systems and operates using mobile applications.

Theoretical Part. The reduction of risk in the movement of interfactory transport is as follows — it is proposed to implement a project on the introduction of digital electronic devices that work in two directions. The first direction is monitoring the performance of routine maintenance work on transport, including daily technical inspections, daily medical examinations of drivers with possible vehicle blocking if the parameters exceed critical values. The second direction is the use of real-time transport monitoring systems that monitor the health status of drivers of

industrial transport both inside and outside the enterprise, compliance with Traffic rules, the technical condition of cars and other transport units, the microclimate in the workplace, as well as the introduction of a system for warning personnel about the approach of a vehicle.

The developed system makes it possible to unify and systematize the requirements of supervisory authorities for construction equipment, machine operation, and technological equipment, and makes it possible to make recommendations based on objective data taken at the site, improving the quality and transparency of the work of state regulatory services [4].

Implementation of the project is possible both on cars of machine-building enterprises used on public roads (cars, trucks, buses), and on interfactory vehicles (loaders, electric cars, tractors).

The proposed system composition. Elements of the first direction. A key chip reader/writer with a prescribed daily code consisting of the data of the equipment manager, medical worker and the dispatcher of the enterprise is loaded in a personal computer. The key chip is a common USB flash drive. The code of the equipment manager is the data on the technical inspection of vehicles, the time and order of routine maintenance, the validity period of the certificate of insurance of compulsory civil liability insurance or the policy of voluntary insurance against damage or theft (depending on where the vehicle is operated). The code of the medical worker is formed from the data of the daily medical examination of the driver. The codes of both specialists are recorded by the dispatcher of the enterprise in the chip key of the driver or operator of the self-propelled car. The daily code of the equipment operator is also registered via a Wi-Fi in the memory of the digital mini-computer installed on the vehicle. In addition, the dispatcher records the unique data of the vehicle in the driver's chip key, which will be used to remove the lock on starting the engine. If the key chip does not have any data from one of these specialists, the vehicle will be unusable. The codes of the medical worker and the dispatcher are also transmitted via coded means of wireless communication to the mini-computer of the vehicle.

A mini-computer is an electronic device in the form of a digital-to-analog converter that performs an algorithm for checking codes from a USB key and codes received via wireless communication systems. If the codes match, an analog command is sent to close the ignition switch or starter switch (depending on the vehicle design). The mini-computer does not require serious and expensive installation; it is performed by a specialist in automotive electrical equipment. The installation of this system does not require approval from the traffic police, because it is not a conversion of the vehicle.

An additional positive feature of the proposed system for vehicles operated outside the enterprise is the anti-theft functions.

Elements of the second direction. The head unit that works with all types of sensors is the GPS/GLONASS monitoring module, hereinafter referred to as the master module (Fig. 1).

Such modules have extensive configuration and programming capabilities [5].

The main task of the module is to transmit data about the location of the vehicle, its speed of movement at a certain moment. By means of the built-in SIM cards, the module can transmit and receive a large amount of information. In particular, it can be used to monitor the compliance with Traffic Rules, namely the speed limit and the deviation from the requirements of road signs [6].

Fig. 1. Master module based on GPS/GLONASS monitoring device

The second necessary device is a module for monitoring the driver's well-being. The principle of operation of such devices is different — the data come from the built-in cameras monitoring the driver's eyes (Attention Assist system — Germany, Driver Alert Control — Sweden, Seeing Machine system — UK), or it uses the bracelet and the ring that controls body temperature (Vigiton system — Russia (Fig. 2) [7].

Fig. 2. Vigiton System

The control over the technical condition of the vehicle is assigned to the module built into the dashboard of modern cars. The data on critical values of various parameters are transmitted via the CAN bus and can be processed and transmitted via the GPS/GLONASS monitoring module to the enterprise server, where the settings will either signal the dispatcher and the chief mechanic to personal mobile devices, or block the fuel supply to the vehicle [8].

The microclimate in the workplace has a serious impact on the well-being of the driver of the vehicle. A comfortable temperature must be observed in the car interior for high productivity. For its control, either standard built-in cabin temperature sensors are used, or additional ones are installed. The information from them is also transmitted via the CAN bus or via an analog-to-digital converter to the master module, through which, in turn, it is transmitted to the server.

An important factor affecting the fatigue of drivers and operators of self-propelled vehicles is carbon monoxide. This factor is especially important in large indoor production facilities, where several loaders can work

simultaneously, equipped with internal combustion engines [9]. The amount of carbon monoxide (CO_2) is proposed to be estimated by gas analyzer sensors, the data on exceeding critical readings of which are also transmitted to the dispatchers for making appropriate decisions (Fig. 3).

Fig. 3. Carbon monoxide sensor

Injuries in poor lighting of the workplace are quite frequent cases. Many machine-building enterprises operate around the clock, which forces interfactory transport to work in the dark. Failure of the lighting lamps or parking lights can also have a negative impact on the injury situation. To monitor the serviceability of the lighting equipment, it is proposed to introduce a lamp-monitoring module that determines the fault by the drop in current consumed by the lighting lamps [10].

The authors also suggest that when moving goods that reduce visibility to the driver or operator, the ZoneSafe Compact sensor module should be implemented on the vehicle, which reduces the risk associated with vehicles at the enterprise [11]. The module automatically detects the presence of any person or vehicle within a radius of up to eight meters from the vehicle and turns on the light signal for all objects within the range of this module (Fig. 4).

Fig. 4. ZoneSafe operation principle

Research Results. Currently, an experiment has been conducted to implement this system on Lada Kalina and Lada Largus cars of one of the production enterprises of the Rostov region. The installation of the system on cars has revealed the following features: when using the CAN bus in cars, the installation of the system requires less effort due to the more extensive functionality for transmitting information from the built-in engine control unit, as well as the presence of a large number of built-in electronic components, such as outdoor lighting control units or distance detection modules. For interfactory transport the installation of this system requires the implementation of a certain number of analog-to-digital converters that will convert the analog signal to the engine overheating, including, for example, the control lamp on the dashboard, to a digital signal for transmission through the master module in the mobile device of the dispatcher and the chief engineer. At the time of the experiment, the screen of the enterprise dispatcher's tablet looked like this (Fig. 5).

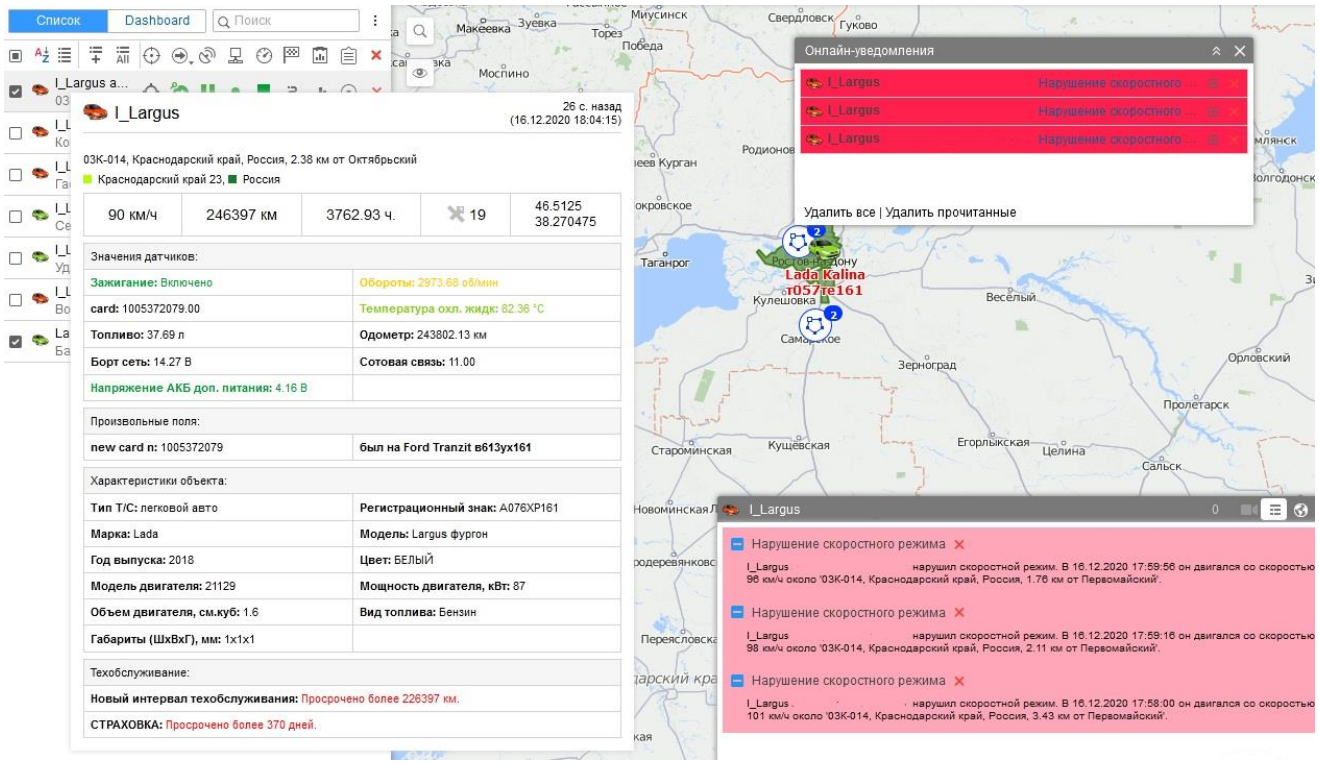

Fig. 5. The tablet panel of the motor transport enterprise dispatcher

This picture shows that the driver of the Largus car violated the speed limit, the car is overdue for maintenance and the insurance policy is overdue for a year.

A certain disadvantage in the operation of the system is associated with the use of the GSM network as a data transmitter. In places where there is no coverage of this network, there may be problems with the information transmission. However, when the signal appears, all information is transmitted in a single packet for the entire time that the vehicle was out of the network coverage area. If the company is located outside the mobile operators signal range, you can use the company's Wi-Fi network (with a certain upgrade of the master module).

Conclusion. The use of devices for monitoring and controlling company and interfactory transport at machine-building enterprises will allow us to quickly solve issues related to labor protection, the economy of the enterprise and the compliance with labor discipline. In particular, operational monitoring of the technical condition of the vehicle at a given time, signaling to the dispatcher's console about the fact that the controlled parameters exceed critical values and timely taken measures in this regard will prevent traffic accidents. Also, the monitoring system, which is being developed, will not allow faulty vehicles operation, and will not allow non-accredited personnel and unauthorized persons to drive. The presented system, in addition to machine-building enterprises, can be implemented at large warehouse complexes, logistics enterprises, and airports.

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