Remote identification of damages of freight by means of transport telematics

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Abstract. The article informs about the possibilities of means of transport telematics, which are mentioned in the confirmation or refutation of the road accident and the assessment of possible damages during the road traffic accident. In addition, the article examines aspects of the practical application of information on the dynamic parameters of a vehicle obtained by means of transport telematics.

Keywords: means of transport telematics, detection of cargo damage.

1. Introduction
Globalization presupposes a high rate of mutual adaptation of national economies and open markets for trade operations. Cargo transportation is of fundamental importance in the implementation of international economic activity. To meet the needs of consumers of transport companies' services, cargo transportation must be safe, timely and accessible to a wide range of users, but it is especially important that the goods are delivered to their destination safely and securely.

According to the information from the Ministry of Transport of the Russian Federation, from January to September 2016, the freight turnover of road transport amounted to 169.8 billion ton-kilometers. According to the traffic police data, more than 6 million trucks have been registered in Russia, and the number of violations of traffic rules and the use of vehicles by truck drivers amounted to 2,903,701 cases. This statistics allows drawing a conclusion that the losses connected with accidents or careless driving can be considerable that increases importance of the research connected with quality of freight automobile transportation.

The problem of the quality of transportation of goods truck involves the formulation a number of tasks aimed at identifying the causes of costs, developing methods for estimating losses, developing recommendations for the formation of a risk system and developing requirements for the safety of the transportation process in order to improve the quality and competitiveness of freight road transport.

It should be noted that the analysis of information carried out in this direction showed the lack of practice in the use of means of transport telematics for the operational control of the quality of the transportation process, consisting in the detection of accidents and careless driving. Moreover, no methodology has been found for the remote evaluation of cargo damages in the performance of dangerous maneuvers or accidents. This circumstance narrows the range of potential applications of transport telematics and creates prerequisites for carrying out research in the field of improving the quality of freight motor transport, taking into account the use of information obtained by means of transport telematics.
2. Transport telematics

The term "telematics" is derived from the words "telecommunications" and "informatics". Accordingly, the concept of "transport telematics" covers the area of using the capabilities of telecommunication technologies and informatics in solving technological problems in transport. Telematics means a set of interrelated automated systems that solve the tasks of traffic management, monitoring and managing the operation of all modes of transport (individual, public, freight), informing citizens and enterprises about the organization of transport services on the territory of the region [1].

The main technologies used in transport telematics systems in road transport and in the road sector are:

- coordinate-time and navigation technologies;
- geoinformation technologies;
- telecommunication technologies, including mobile communication and navigation technologies;
- technologies for collecting, storing and processing information on a computer [2].

3. Detection of cargo damage

In theory, overloading refers to the ratio of body weight to gravity acting on this body or increasing the body weight when additional acceleration acts on it. Overload is expressed by the term g, in physics means – acceleration of gravity. The term g is used in astronautics, aviation, motor sport. Overloads occur when the vehicle speed changes (braking, accelerating or changing the trajectory). At large (more than 5g) overload values, negative consequences can be observed: the movement of loose cargo, the destruction of structural elements of the vehicle and cargo, the deterioration of the well-being or health of people subjected to the forces that caused the overload.

To detect damage to the cargo, it is necessary to know the values of the overloads recorded by the monitoring system in order to calculate the force that acts on the cargo during the accident. Perhaps this is due to the built-in accelerometer, which measures the projections of accelerations in three planes (longitudinal, transverse, vertical) and in the event of an accident, the values of overloads increase, thereby signaling a dangerous road accident.

As a simplified example of the detection of cargo damage, which is a concrete construction structure weighing 150 kg, it is possible to describe a situation in which the monitoring system fixes an overload in the longitudinal direction equal to 0.05 g. It is known, that the concrete design has the module of elasticity of 1.1 MPas (for cellular autoclave curing of the Б1 brand) which is equal to the applied force in 11.22 kilograms. At speedup 0.05g force operating on freight makes 7.5 N or 0.075 MPas, or 0.764 kilograms of force. This approach has drawbacks, which will be mentioned at the end of the article.

4. Experiment

For confirmation of a hypothesis of a possibility of application of means of transport telematics for the purpose of identification of damages of freight during transportation the experiment regarding a possibility of fixation and drive in real time of information on the arising overloads in the database of the operator of monitoring system was made.

The components of the experiment were as follows.

- Test stand-laboratory equipment that allows simulating an accident without the use of a vehicle.
- The monitoring system is a system installed on a wheeled vehicle and designed to determine the location and traffic parameters of a vehicle according to GLONASS or GLONASS signals in conjunction with other global navigation satellite systems, the transmission of a message and other information about the vehicle in a traffic accident.
- The operator – the organization which installed monitoring system collected and stores the data obtained from the monitoring system in the database.
- The software is the software of the Operator.

The experiment consisted in simulating an accident with a test stand, on which the monitoring system was given an acceleration in the range from 1 to 10 g with an exposure time of 25 to 100 ms. The device was fixed to the platform, the platform accelerated, then struck against the obstacle. If the accelerometer
fixes an acceleration greater than 1 g for 25 ms along the x and y axes and / or 2 g on the vertical z axis, the monitoring system records data into the random access memory for subsequent transmission to the operator's server. Accelerometer readings were recorded for each of the three coordinate axes (x, y, z) 3 seconds before and 3 seconds after exceeding the specified acceleration thresholds with a frequency of at least 100 records per second.

As a result of the experiment, the following information was received in the database of the monitoring system operator:

- the date and time of the event;
- coordinates of the vehicle;
- vehicle speed;
- identification number (VIN);
- identification number of the body;
- state registration plate;
- the values of the overloads that occurred;
- confirmation of the device at the time of a dangerous event.

| 1. State registration plate of the vehicle: T47 ** |
| 2. Vehicle VIN: K17 ** |
| 3. Date and time of the accident (date and time of operation of the accelerometer): 29-1AN-17 12.45.06.0000 PM + 00: 00 |
| 4. Coordinates of the accident 55.80309906479152 37.529457807540894 |
| 5. The speed of the vehicle at the time of the accident: 0 km / h |
| 6. The values of the accelerations along the three coordinate axes: X = 2.375, Y = 1.85, Z = 1.002 |
| 7. Data efficiency of the navigation information unit: YES |

**Figure 1.** Information entered into the database

![Diagram of information interaction](image)

**Figure 2.** Scheme of information interaction

The experiment confirmed the possibility of using means of transport telematics for remote detection of cargo damages arising from road accidents or careless driving.
5. Method of calculation of the loadings influencing a transport package

All loadings operating on a transport package can be divided into static loadings which are shown at rest or uniform motion without speedup and dynamic which are shown in the form of action on a package of inertial forces in the course of transportation with change by speed, and also at blows and pushes. As dangerous road incidents are characterized by dynamic, but not uniform motion with identical speed, for calculation the corresponding method will be used. The dynamic loadings operating on a transport package include vertical, longitudinal and cross forces.

**Vertical force is determined by a formula:**

\[ F_v = v_s M (q_v r - 1) \]  

\( v_s \) = vertical speedup in shares of g, m/s²;  
\( q_v r \) = quantity of vertical rows;  
\( M \) = mass of freight in a container, in a transport package, kg.

**Longitudinal force is determined by a formula:**

\[ F_l = I_s (c_u l_d - 1) M \]  

\( I_s \) = longitudinal speedup in shares of g, m/s²;  
\( c_u l_d \) = number of cargo units in the longitudinal direction;  
\( M \) = mass of freight in a container, in a transport package, kg.

**Cross force is determined by a formula:**

\[ F_c = c_s (c_u c_d - 1) M \]  

\( c_s \) = cross speedup in shares of g, m/s²;  
\( c_u c_d \) = number of cargo units in the cross direction;  
\( M \) = mass of freight in a container, in a transport package, kg.

Examples of calculations:
Calculating the loads acting on the transport package made up of boxes with household appliances, we will use the values given in Table 1 as the values of the accelerations.

**Table 1.** The size of impact of blows on a container and freight under various conditions of transportation by the motor transport

| Conditions of transportation | Load value g, m/s² |
|------------------------------|-------------------|
| On asphalt surface           | 1.5               |
| On a dirt road               | 3.5               |

**Table 2.** Calculation data

| Material, from which freight is made | Module of elasticity of material (E) |
|-------------------------------------|-------------------------------------|
| Iron                                | 200 HPa                             |

On asphalt surface:

\[ F_v = 1.5 \times 9.81 \times 6 \times 3 = 265 \text{ H (2.65HPa)} \]  

\[ F_l = 1.5 \times 9.81 \times 6 \times 1 = 88 \text{ H (0.88HPa)} \]  

\[ F_c = 1.5 \times 9.81 \times 6 \times 2 = 177 \text{ H (1.77HPa)} \]

On a dirt road:

\[ F_v = 3.5 \times 9.81 \times 6 \times 3 = 618 \text{ H (6.18HPa)} \]  

\[ F_l = 3.5 \times 9.81 \times 6 \times 1 = 206 \text{ H (2.06HPa)} \]  

\[ F_c = 3.5 \times 9.81 \times 6 \times 2 = 412 \text{ H (4.12HPa)} \]

Calculating the loads acting on the transport package made up of boxes with glass products, we will use the values given in Table 3 as the acceleration values.
Table 3. The size of impact of blows on a container and freight under various conditions of transportation by the motor transport

| Conditions of transportation | Load value g, m/s² |
|-----------------------------|------------------|
| On asphalt surface          | 1.5              |
| On a dirt road              | 3.5              |

Table 4. Calculation data

| Material, from which freight is made | Module of elasticity of material (E) |
|--------------------------------------|-------------------------------------|
| Glass                                | 56 HPa                              |

On asphalt surface:

\[ F_V = 1.5 \times 9.81 \times 13 \times 1 = 191.3 \text{ H (1.91HPa)} \] (10)
\[ F_I = 1.5 \times 9.81 \times 13 \times 3 = 574 \text{ H (5.74HPa)} \] (11)
\[ F_C = 1.5 \times 9.81 \times 13 \times 2 = 382.6H \left(3.83 \text{ HPa}\right) \] (12)

On a dirt road:

\[ F_V = 3.5 \times 9.81 \times 13 \times 1 = 446 \text{ H (4.46HPa)} \] (13)
\[ F_I = 3.5 \times 9.81 \times 13 \times 4 = 1339 \text{ H (13.39HPa)} \] (14)
\[ F_C = 3.5 \times 9.81 \times 13 \times 2 = 893 \text{ H (8.93HPa)} \] (15)

The calculations made allow us to assume that in all cases there is no destruction, but if the conditions have been increased by increasing the weight of the cargo and the number of boxes, the force acting on the cargo will increase.

\[ F_I = 3.5 \times 9.81 \times 40 \times 5 = 6867 \text{ H (68.67 HPa)} \] (16)

6. The next stage of scientific work

This method has drawbacks associated with the abstract representation of the application of the force acting on the load, as well as the area of this impact, which greatly affects the accuracy of the calculation.

In addition to these formulas to clarify the results you need to know:
- class, load capacity of the semitrailer/container;
- the number of overpack located inside the semitrailer/container;
- scheme for placing transport packages inside the semitrailer/container;
- type of pallets used;
- layout of the boxes with cargo on the pallet;
- characteristic of the cargo;
- Characteristics of cargo packing.

When these factors are taken into account, opportunities are opened in the field of developing a risk system and finalizing the requirements for the safety of the transportation process, which in this case must take into account the data obtained by means of transport telematics.

7. Conclusion

Thus, it is theoretically possible to use means of transport telematics for the purpose of remote analysis of the transport process for the detection of traffic accidents, detection and evaluation of cargo damages resulting from accidents or careless driving. The information transmitted by the monitoring system, as well as the developed methodology, may be of interest to the following users:
- transport companies will be able to monitor the safety of the transportation process in order to maintain competitiveness, which is to reduce the risk of damage or loss of cargo, in addition, this information may be proof of the absence of the fault of the carrier for the damage caused to the goods in case the cargo was damaged not during transport.
the insurance companies will quickly get information about the occurrence of an accident and information about damage to the cargo as a result of this event in order to settle the losses, which will minimize the risk of financial losses associated with fraud and speed up the process of registration of insured events;

- the customs, in order to optimize operational activities, will be able to obtain information about an accident that occurred while the vehicle was traveling to perform customs operations;

- consumers of transport services need to have an idea of how well the transport companies provide services in order to further select the most suitable and safe, based on the statistics of emergency situations and violations of the mode of transport of goods;

- The Russian Association of International Road Carriers will be able to collect statistical data on the quality of transport services for compiling the rating of the best carriers and further taking measures to improve the efficiency of the transport process on the territory of the Eurasian Economic Union.

The application of means of transport telematics in the implementation of international road transport facilitates:

- creation of the practice of using indications of navigation and information devices when verifying the fact of an accident;

- increase of evidence, objectivity and accuracy of detecting accidents;

- creation of additional mechanisms to resolve differences between insurers and Insurants;

- creation of a system for assessing the quality of goods road transport;

- optimization of the operational activities of customs authorities in the performance of customs operations.

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