

Development of Methodological Approaches to the Planning of Operation of Road Transport Systems

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Abstract - Methodological approaches to the planning of operation of road transport systems have been developed following the research results for the existing theoretical approaches to planning, studying the practice of road transport systems at the global and national levels. Theoretical approaches to planning have been studied in the context of the industry-specific planning; the planning of transport and technological systems; the operational planning of road transport systems represented by cargo carriage routes; as well as of road transport enterprises. It is established that a motor transport company is a motor transport system consisting of the process of carriage cargo and maintenance of technical sound state of rolling stock. The purpose of it is to meet the terms of contracts and make a profit. A conclusion has been drawn on the probabilistic nature of the system operation. Entrances to the system, environmental factors, exits from the system, as well as significant factors affecting the results of the current activities of a motor transport company have been identified. Methodological approaches corresponding to the modern practice of a motor transport company will be aimed at considering randomness as a system property when the terms of contracts are met, assuming that the operation of a motor transport company is subject to continuous random changes.

Keyword – transportation system, cargo carriage, maintenance of technically sound state of rolling stock

I. INTRODUCTION

In the modern context, great attention is paid to automobile transport, since first of all, this mode of transport can deliver cargo where other transports fail. This mode of transport plays a special role in the carriage of construction cargo in a city and in the intercity carriage. The door-to-door delivery is performed. The process of cargo carriage by rolling stock is included in the overall production system; however, this process is planned at the level of road transport companies. The current planning of operation of a road transport enterprise is determined both by the state and the functioning of the system. The state of the system is characterized by internal inherent properties corresponding to the purpose of this system. These properties depend on indicators of the process of cargo carriage and the process of maintenance of technically sound state of the rolling stock. Operation of the system involves the interrelation of processes for the fulfillment of the terms of contracts under the influence of external factors.

The study of a motor transport company as the interrelation of the process of cargo carriage and the maintenance of technically sound state of the rolling stock within a system, will make it possible to implement the main function of road transport activities, which is defined in the Civil Code of the Russian Federation, i.e. the meeting the terms of contracts and making a profit. The development of methodological approaches to the planning of operation of the motor transport system, which in the modern context is represented by a motor transport company, is a major scientific problem.

Solving this problem will ensure the fulfillment of responsibilities of the motor transport company with regard to the important role of transport in socio-economic development of the country, which role can be defined as access to safe and high-quality transport services. The implementation of methodological approaches to the planning of operation of the transport system, corresponding to the current practice of the motor transport company, will ensure responsibility for the implementation of the process of cargo carriage and the process of maintenance and repair of the rolling stock while implementing the main function of transport as one of the largest strategic industries closely connected with all elements of the economy and social sphere.

II. THEORY (RESEARCH DATA AND METHODS)

Modern methodological approaches to the planning of operation of motor transport systems have been developed by domestic and foreign scientists. The author of this article classified the existing methodological approaches in the context of various levels of planning, including:

- Road transport industry
- Transport and technological systems,
- Road transport systems are represented by cargo carriage routes;
- Motor transport company

Methodological approaches to the planning of operation of road transport systems began to develop before 1990, when central planning existed. During this period, road transport was treated as a system consisting of three main subsystems, viz. management, commercial operation and technical support of the transport process. In the modern context, V.M.

Kurganov [1] has drawn a conclusion that formalized approaches to the analysis of nonlinear dynamics of transport systems based on mathematical models are advisable. In the mathematical models developed by the author [1], the number of uncertainties in the operation of a system is contemplated through the modes of operation, which are described in historical documents.

V.I. Rassokha [2] proposed to use a situational approach, including system analysis and justification of the choice of controlled objects, which made it possible to treat the efficiency of road transport operation as a comprehensive qualitative and quantitative characteristic of the fulfillment of all its main functions – economic, social, political, and military. The author [2] presented the structure and functional interaction between the main components of the efficiency of road transport operation and dealt with the problem with due regard to the requirements of an interconnected interdisciplinary approach to its solution. E.A. Lebedev [3] used the logistic integral approach as a methodological basis for describing the operation of freight road transport. This made it possible to reflect the organization of the truck haulage business, with individual firms, organizations or systems treated as some centers of logistic activity, directly or indirectly interconnected within a single integral process of material flow management. In [3], to simulate the transport and technological process, the controlled object was treated as an interconnected closed network in the queuing system, which includes a motor transport company (carrier), a cargo-generating object, a cargo-absorbing object and a road. Each element of the system was characterized by a certain functional pattern described in mathematical terms.

With regard to the motor transport company (carrier), it was found that the release of vehicles on the road (vehicle utilization) is characterized by the probability of timely vehicle utilization and the probability of delay for a random time, which is described by a truncated normal law. S.S. Voytenkov, E.E. Vitvitskiy [4] presented a methodological approach to the planning of cargo carriage, based on the need to create a unified city dispatch service, which considers the operation of many consignors and consignees within the framework of an improved management structure of the freight transport system of a city in the Russian Federation. A similar methodological approach was proposed in Frankfurt-Rhine-Main [5]. The authors [5] represent methodological approaches to the planning of freight transport operations, with due regard to the operation of the City Consolidation Centers, which are aimed at consolidation of freight traffic flows in order to reduce urban freight traffic activity. The paper presents the research results comparing deliveries of a group of carriers, which involve or do not involve City Consolidation Center following various scenarios of city access. Methodological approaches to the planning of operation of transport and technological systems were based primarily on the study of integrated transport and technological systems, where the emergence property may manifest itself. S.A. Lyapin [6] applied an integrated approach to the process of using motor vehicles in the management of multi-stage technological processes of cargo handling for large enterprises. The paper [6] solved the problem of improving the

efficiency of transportation management in the context of open road transport systems, considering that «environmental quality standards for the processes of moving material resources along the supply chains connecting producers of material resources and consumers are formed at the regional level». The development of methodological approaches to the planning of operation of transport and technological systems promoted the study of relationship between the volume of carriage and the industrial structure, performed by K. Sun, C. Jing [7]. The authors [7] obtained vector auto-regression models for analyzing the relationship between the volume of carriage and the performance of industries. **The development of methodological approaches to the planning of operation of road transport systems, represented by cargo transportation routes**, was reflected with regard to the microsystem, a particularly small system and small systems [8]. Mathematical models and methods of operation of the average carriage systems have been developed [9].

Methodological approaches to planning the operation of road transport companies have been developed in the study of the operation of a rolling stock unit. In the modern context, S.A. Borodulina [10] proposed a process-oriented management structure for transport enterprises, which allows smoothing the consequences of unstable development. The paper [10] presents the results of the study of a road transport company as a dynamic system. The principles of the process management of a road transport company under the conditions of instability allowed smoothing the frequency and cyclic nature of crises. Under the current conditions, the purpose of a road transport company as an economic entity provides for making profit, however it can be implemented subject to the requirements of road safety [11]. This condition is established by the legislation not only in Russia, but also in many foreign countries where it is kept under tight control. Evidence suggests that road traffic offenses by freight vehicles are relatively high compared with the provisions of the current regulations and, thus, can reduce the level of safety, road service and environmental sustainability [12]. In this regard, in the period 2008 to 2016, the focus of methodological approaches to the planning of the operation of transport systems has been shifted to the maintenance and repair of rolling stock of a road transport company [13]. Strengthening the role of state policy in the formation of methodological approaches to the planning of the work of carriers has been mentioned by J. Monios [14]. The author emphasizes that if policies and regulations tend to focus on the provision of transport services by the private sector, this will lead to a reduced role for the public sector. J. Monios [14] concludes that management analysis should include not only formal management mechanisms, but also the ability and willingness to apply suitable tools to regulate the market in order to improve economic well-being.

The authors indicate the methodological approaches based on in-sync and PI-models. T. Ambra, A. Caris, C. Macharis [15] presented the results of the relationship between these two concepts and their role in the socio-economic and environmental sustainability of logistics transport systems. The paper [15] has identified capacities for interaction, directions for future research, and critical issues that should be

considered by model developers and policy makers in the development of the transport industry [15].

B. Zgonc, M. Tekavčič, M. Jakšič [16] described the influence of the distance of cargo carriage on the choice between intermodal rail transport and unimodal road transport. In [16], the hypothesis was confirmed that the distance is an important factor influencing the choice between rail and road transport. The authors [16] have determined the distance that ensures break-even transportation. It is proven in the paper that the distance of cargo carriage considers randomly generated locations of consignor and consignee in two separate market areas, regardless of a particular transport corridor. G. Aifadopoulou, I. Stamos, M. Giannini, J.-M. Salanova [17] emphasize that road cargo carriage should be dealt with in terms of the volume of cargo carried and its dynamics over time, the number of cargo freight operations by commercial vehicles, age of vehicles and kilometers covered, which depend on the length of a cargo haul cycle in Europe. The interrelation between these indicators has enabled the authors to present a critical review of cargo carriage in Europe regarding global trends and future factors determining successful business options in this sector. In previous studies, methodological approaches to the current planning of a road transport company, which is a transport system consisting of the process of transporting cargo and ensuring a technically sound state of a company, have not been stated.

In the research work [18], it was established that the main sections of the current plan are the plan for the operation of rolling stock and the plan for maintenance and repair. In the preparation of these plans, the relationship is associated with the influence of the length of a cargo haul cycle, i.e. the length of the path of a laden vehicle between two destinations, where loading and unloading were performed. The length of a cargo haul cycle is used for determining the output in tons and ton-kilometers, and the total mileage, which are the indicators of commercial operation and ultimately make it possible to calculate the amount of profit of a road transport company. The length of a cargo haul cycle is used to determine the total mileage, number and complexity of technical impacts that are indicators of technical operation. Studies were performed for the transportation of piece and roll cargo by drop-side trucks under urban conditions.

However, modern construction technologies involve the employment of special-purpose rolling stock for the transportation of concrete. To determine the methodological approaches to planning the operation of a road transport company, the process of cargo carriage and maintenance of the technically sound state of the rolling stock has been studied. In-situ observations were made of the operation of special-purpose rolling stock of various carrying capacities (from 10 to 15 tons; from 15 to 20 tons and over 20 tons) during the year. The study considered a rolling stock of four sizes ($q\gamma$ – carrying capacity): $q\gamma = 8 \text{ t} - 4$ units; $q\gamma = 10 \text{ t} - 10$ units; $q\gamma = 11.1 \text{ t} - 3$ units; $q\gamma = 22.2 \text{ t} - 3$ units; $q\gamma = 26.2 \text{ t} - 3$ units. Mileage varies with a load daily from 15 to 45 km; average technical speed of a special-purpose rolling stock $V_T = 25 \text{ km/h}$; the carrying capacity utilization factor is $\gamma = 1$. The number of observations was determined by a non-repetitive sample with a confidence level of 0.95.

The results of the observations are presented in Figure 1. The curves corresponding to the change in the output of special-purpose rolling stock in tons (Fig. 1, a)), ton-kilometers (Fig. 1, b)); total mileage (Fig. 1, c)) allows the conclusion that operation of the transport system is of probabilistic nature. To develop methodological approaches to the current planning of the operation of road transport companies, output in tons (Fig. 2, a)) and total mileage (Fig. 2, b)) for a month have been calculated according to the methodology developed for operational planning by scientists of the Siberian Automobile and Highway University [8, 9]. The results of the study of the influence of the length of a cargo haul cycle under urban conditions on the results of the operation of special-purpose rolling stock are presented in Figure 2.

The built graphs allowed the conclusion that the state of the system, characterized by output, total mileage and labor-intensiveness, changes intermittently, which does not correspond to the current operation of a road transport company. Methodological approaches to the current planning should consider the block diagram that reflects the processes occurring in the system over time, influenced by major factors. The entrances to the system are: the cargo transport characteristic; the need for cargo from the consignee; availability of cargo from the consignor; transportation arrangement diagram of consignors and consignees. The environment depends on the work results of the commercial department engaged in the conclusion of contracts; irregular production intended for transportation; conditions and restrictions for cargo carriage in the city and in the intercity service [19]. Exits from the system: profit due to the fulfillment of the terms of the contracts; scope of work performed; term and quality of work performed [20]. The major factors determining the planning of the current activities of a road transport company should include the carrying capacity of the rolling stock in tons of a certain standard size when transporting a particular type of cargo; mileage of the rolling stock of a certain standard size from the beginning of the operation; the duration of the maintenance and repair of the rolling stock; the labor intensity of the technical impact in the performance of a particular type of work in relation to the rolling stock of a certain standard size; the cost of drivers' labor with due regard to deductions; fuel costs; and the cost of the maintenance and repair of the rolling stock.

The factors that consider the possibility of changing the output of the road transport system as compared to the state during the year should include the demand for transportation of a particular type of cargo; mileage with cargo; carrying capacity of rolling stock of a road transport company in tons; as well as the time to perform loading and unloading operations.

The indicator values assume that the flow of the motor transport process in conjunction with the technology of maintenance and repair should be taken into consideration.

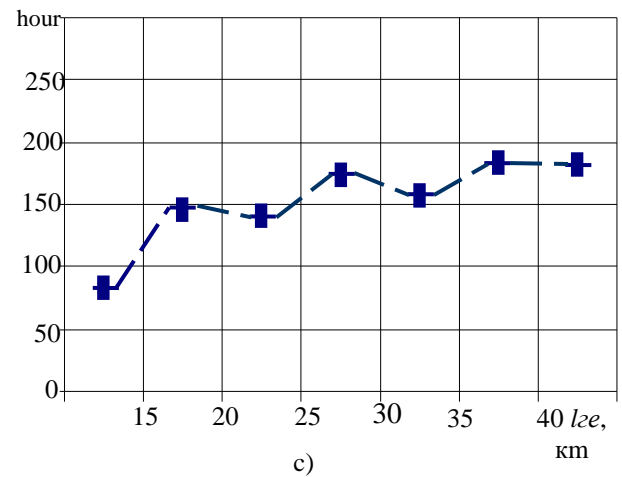
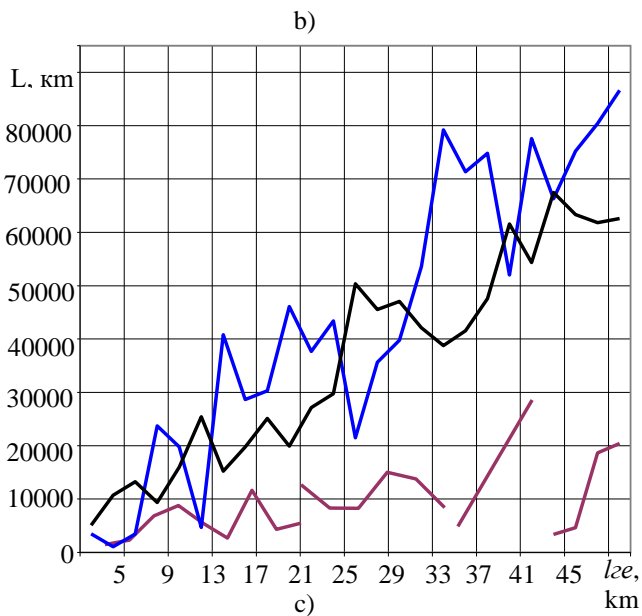
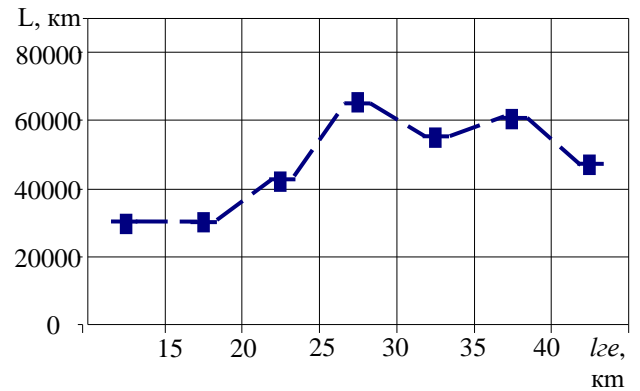
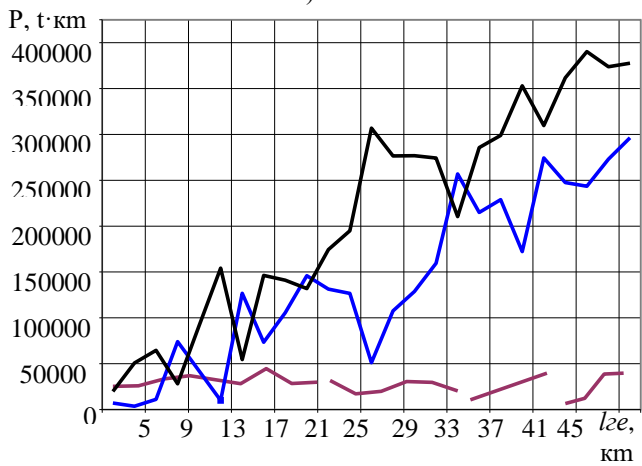
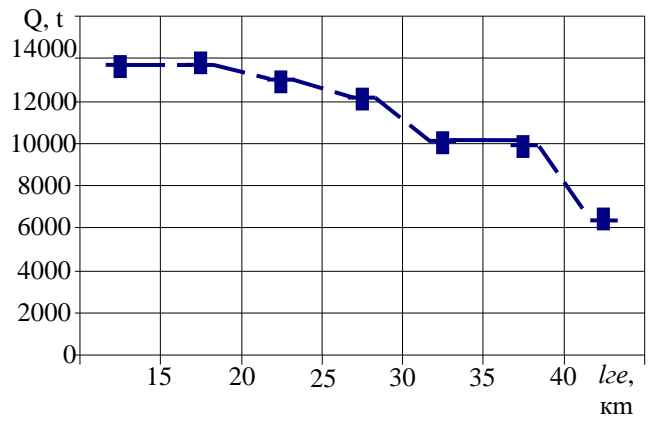
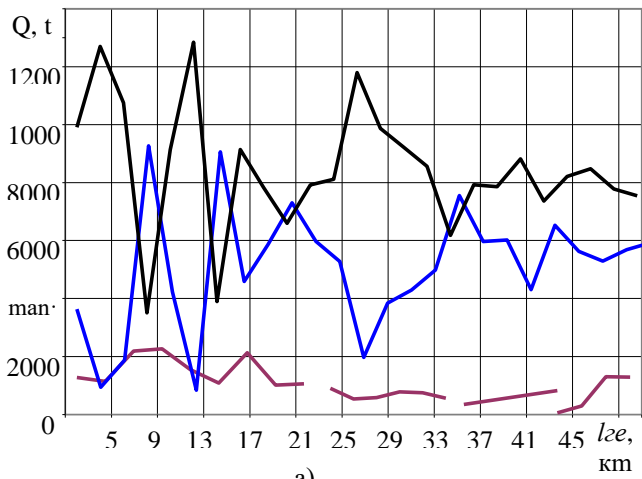


Fig 1. Curves corresponding to the change in the output of special-purpose rolling stock in:

- a – in tons; b – ton-kilometers; c – total mileage, km;
- load capacity from 8 to 12;
- load capacity from 12 to 20 t;
- load capacity over 20 t

Fig 2. Results of the study of the influence of the length of a cargo haul cycle under urban conditions on the results of the operation of special-purpose rolling stock: a – tons; b – total mileage, km; c – laboriousness, man/hours;

III. CONCLUSION

The results of the analysis of the existing methodological approaches to planning do not take into account the functioning of a road transport company as a transport system, with the process of cargo carriages synthesized and the technical state of the rolling stock maintained. In order to meet the terms of contracts for the current planning of a road transport company, the lengths of haul cycles should be considered, which, under conditions of uncertain demand are probabilistic values not corresponding to average values. Methodological approaches corresponding to the modern conditions of the operation of a road transport companies will consider randomness as a property of the system when determining the volume of traffic under contracts, assuming that the operation of a company is subject to continuous random changes. Methodological approaches to current planning should be based on the synthesis of subjective probability methods and the methods of classical probability theory. The developed multifactor models will help to reflect the process of cargo carriage in different periods of a year as detailed as possible, taking into account the demand for cargo from consumers; to trace the trends in the internal relations between indicators. Multifactor models will allow for more accurate assessment of the impact of technical and organizational measures on the resulting indicators, identifying the nature of the relationship and interconnection between the factors. Treating a road transport company as a road transportation system in the presence of the process of cargo carriage and the process of maintenance and maintenance of rolling stock will be aimed at identifying signs of consistency.

For the purpose of the study, the object will be represented in terms of structure and functioning. This will make it possible to single out the object a road transport company is focused on, i.e. the transportation cycle with the necessary production cycles by operating the subsystems over time as a single whole to achieve the set goal, which is the fulfillment of the contract terms. Subjects of activity are rolling stock; technologies for maintenance and repair of rolling stock; technological equipment; spare parts, materials, tools and the sequence of their use; as well as the organization of work. The result of the operation of a road transport company is the receipt of cargo in accordance with the terms of the contract by performing the transport process with working rolling stock, and making a profit.

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