System planning the motor transport enterprise functioning in freighting in interurban communication

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Abstract. Modern economic conditions, requiring directors to make management decisions aimed at fulfilling the contracts terms and to earn a profit, are underscored. The purpose of the study is to develop a schedule-planning system of a motor transport enterprise (MTE) in order to fulfil the contracts terms and to earn a profit at the expense of commercial and technical maintenance interrelation during the freighting in interurban communication. Records of Commercial and technical operation are submitted in a form of indicators, depending on length of the ride in interurban communication with the cargo and the shipment mass. A scheme, scoring the results of scheduling the upper and lower limits of the ride haul distance with the cargo and the shipments mass with a probability of 0.95, is proposed. The system has been developed under the current methodology concept of the freight MTE work, contemplating the commercial and technical operation correlation and allowing considering the MTE running in the freighting in interurban communication as a probability process. The economic efficiency of the current MTE work scheduling is estimated by the profit margin. For the practical implementation of the proposed system, the author-developed scientific software was used. The use of the developed scheduling system on practice has provided more profit than the profit calculated by the applied method by 10.8%. The presented system will allow determining the planned indicators of commercial and technical operation, costs, results and profits to fulfill the contracts terms by a certain technological scheme in accordance with the needs for freighting, which should be taken into account when managing the resources and capacity of motor transport enterprises on the efficiency criteria basis.

1. Introduction

The relevance of developing a current planning scheme for a motor transport enterprise (MTE) for the freighting in interurban communication is related to the need to meet the Russian economy growth indicators, which for road transport are determined by the Federal Target Program “Development of the Russian Transport System” [1]. It is expected that the value of freight traffic in the inertial variant of the Russian transport system development until 2030 by motor transport will amount to 10,000 thousand tons, and the planned value of resource support for road transport in 2030 for the budgets of the Russian Federation constituent entities will be 1015 billion rubles. [1].

The problem of scheduling the motor transport enterprise functioning in freighting is in the purview and scientific works of many researchers, both domestic and foreign. For example, V M Kurganov and A N Dorofeev propose the methodology IDEF0 implementation in the enterprises’ practice [2]. Initially, the methodology was called “Structured Analysis and Design Technique (SADT)”. IDEF0 allows performing a description of complex objects using a simple and clear graphical language [2].
The IDEF0 modeling methodology is designed to analyze the entire system as a set of interacting, interrelated functions (works), and not its structural elements that make up the MTE. Focusing solely on the analysis of functions, regardless of the objects that perform them, does not allow considering the process of freighting and the process of rolling stock maintenance procedure and repair (MP and R) in interrelation. C M Mochalin, L V Tyukin, considering direct supply chains of goods to form a planning algorithm, use logistic concepts of JIT and JIS [3]. A P Zatvornitsky proposes the use of GPS systems as an element of planning in the metaheuristic algorithm of freight transportation planning [4]. J Browne, J Harhen, J Shivnan, studying the integrated perspectives of the production management system for planning the freight transport operation, used MRP information systems [5]. De Jong, G C Vierth, I Tavasszy, performed JIT studies using the example of national and international freight transport models in Europe [6]. M.F. Gorman and G. P. Conway [7], considering interurban freight as elements of supply chains, suggest using navigation software as an element of planning. The authors indicate that the use of information systems can make a significant correction to the planning methodology for freight transport infrastructure for observed traffic environment.

Information systems MRP, MRP II, ERP, MRP / DRP, DRP, JIT, Kanban, which implementation is presented in works [2-7], are designed to plan the material needs in production and logistics systems, and not for the freighting MTE planning. These planning tools may cause lower profits as a result of the fact that they have been developed for the industrial enterprises activities and do not take into account the peculiarities of the freighting process and ensuring the technically rolling stock good condition. Therefore, some agreements cannot be signed due to the fact that, according to the results of planning, there are not enough MTE resources; some contracts are signed, but cannot be fulfilled as a result of the technically sound rolling stock lack.

S S Voytenkov, E E Vitvitsky, considering the planning system for freighting, in his study focused on the need to take into account the many shippers’ and consignees’ functioning in the framework of the improved management structure of the urban freight transport system by creating a unite city dispatch service [8]. In work [9], the research methodology, the concept of creating a unite coordinating center for transport services when performing road freight transport in large cities, justified the need to use the mechanism of functional interaction between local authorities and business entities of the road transport industry for the current MTE work planning.

V V Anokhin [10] presented the results of a specially developed program “Planning the operation of a freight transportation company taking into account commercial and technical operation correlation” practical implementation. The computer program is designed for automated planning of the freight MTE work in the urban construction goods transportation. The developed program allows solving the optimization problem according to the profit maximization criterion and to determine: the transportation plan for a year with seasonal changes in demand by quarters; rolling stock operation plan in order to fulfill the contracts terms; the schedule of putting the rolling stock into maintenance and repair; cost, income and profit plan. The developed software product cannot be used in the practice of MTE in the freighting in interurban traffic, as it takes into account only the peculiarities of the MTE in the freighting in the city.

The need to use system analysis in planning was proved in works [11, 12]. In work [11], this necessity is proved by the example of the dynamic decision-making influence on the freight transportation network. X Wang, H Kopfer, OR Spectrum presented the results of studies using system analysis in the planning of oversized cargo shipment [12]. L G Reznik, O Iu Smirnova [13] indicated that the MTE activity results are influenced by many heterogeneous factors, which define processes that are different in their nature but closely interact with each other. Freight trucking system is a diffuse system with a constant informational exchange. The essential characteristic of the external environment in the market is its uncertainty and the variable nature of the demand for transportation. S A Yatsenko as a result of research, it was stated that the MTE functioning is determined by factors of the macro-environment, not susceptible to the company’s direct impact [14]. The issue of the efficiency criterion justification for planning the MTE work is in the field of view and scientific works of many researchers, both domestic and foreign. In work [15], as a criterion for the vehicle operation efficiency, it was
proposed to use the costs per performing a transport work unit, which can be defined as the total mileage for the accounting period, the total time in the duty for the accounting period, the total mileage with load for the accounting period, the shipment mass for the accounting period. The advantage of this methodical approach is the ability to optimize the model range of vehicles in use by comparing the unit costs of transport work for different vehicle’s technical lifetime period by one owner.

N Z Sultanov [16], as a result of the research, concludes that the vehicle fleet’s structure and size is interrelated with the efficiency indicator use under the controlled and uncontrollable factors influence. The author of the work [16] considers the tasks, operation modes, and the area of rolling stock specialization among the controlled factors. Among the uncontrollable factors is the frequency of applications receipt for certain type freighting, timeliness of delivery, change in the freighting conditions. The advantage of the methodology for optimizing the transport specialized system based on providing the business functions properties and type, is the choice of fulfilling a certain type of task, which is most likely relates to the tasks of operational planning of road freight transport.

H A Faskhiev [17] suggested using the net present value (NPV) to evaluate car’s operating effect, and investments in it. In the research [18], the issue of planning the motor vehicles operation was solved using net cash flow. Criteria such as net present value, discounted net spendings and net cash flow are used to assess car’s operating effect, as well as investments in it. The criteria are aimed at the formation of a car fleet that is structured in the external market, meets the requirements of customers and brings the maximum income to the manufacturer of transport services, taking into account the established service life of vehicles.

Thus, the diversity of approaches to the formation of a system planning the freighting confirms the relevance of the study, and also allows supplementing the existing approaches with your own new vision and possibilities of developing an MTE work planning system when transporting goods in interurban communication. Modern economic conditions require directors to make management decisions aimed at fulfilling the contracts terms. Therefore, at the modern scientific level, to solve the problem of the MTE work current planning involves the development of a system that takes into account the commercial and technical operation correlation, considering the MTE functioning during the freighting in interurban traffic as a probabilistic process. For the practice of the freight MTE work, the planning system designed to assess the performance of the freight MTE commercial and technical operation in compliance with the contracts terms, are developed. To do this, it is advisable to use methods that allow taking into account the results and costs when fulfilling the contracts terms. According to the results of the study, the most universal among the methods for evaluating the economic efficiency for the MTE work current planning is the method based on the calculation of annual profit [19].

Planning of MTE technological processes has its own characteristics: rolling stock acts both in the form of labor object (when doing maintenance and repair), and in the form of labor means (when performing the freighting process). Production processes in the MTE work are characterized by mobility not only of the labor objects, but also of the labor means. The planning system for the MTE operation during freighting in the interurban traffic is based on the use of a system analysis that allows using a structural and functional concept of the object. For the MTE work decomposition, a model for analyzing the labor process is used [19]. The main elements of the MTE planning system freighting in the interurban service are presented in the form of a diagram in the figure 1.
1. Raw data input

2. Scoring the results of scheduling the upper and lower limits of the ride haul distance with the cargo and the shipments mass with a probability of 0.95

3. Scoring the results of rolling stock operation

4. Formation of existing rolling stock combination by re-selection

5. Scoring the results of commercial and technical operation; cost, benefit and profit for each rolling stock combination

6. Are all combinations checked or not

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Road transport vehicles, freight haul distance, shipment mass

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End of selection

Choosing the best option by the criterion “profit”

Assuming responsibilities to fulfill the contracts terms for goods freight in intercity traffic

The approval of commercial and technical operation indicators

The expenses result and profit approval, at performance of contracts terms on transportation of goods in the long-distance traffic

Implementation of MTE work plan to fulfill the contracts terms and obtain maximum profit when freighting in interurban traffic

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Figure 1. System of the MTE at freighting in interurban traffic planning.

For the practical implementation of the developed system scientific software “Current planning of the MTE operation in freighting in interurban traffic” implemented in the computer environment Visual Basic for Applications. The computer program includes several modules: “Instructions”, “Database”, “Input of initial data”, “Results”. Working with the modules is carried out in the dialogue mode, implemented as a master, combining a number of steps and allowing for the user-entered data drawing up a current work plan for MTE during the freighting in long-distance communication. It is possible to print the results. The order of work with modules is chosen by the user, at each stage of work you can return to the main window and select another module. The “Instruction” module contains information about the modules, initial information for the work of the program and results [20].

Let us consider the main elements of the planning system in detail.
Stage 1. Raw data input. Information on rolling stock by frame sizes, on the duration of operations with different work organization of drivers is used as the raw data. Information on rolling stock by type includes:
- freight haul distance in interurban communication, thousand km;
- the number of rolling stock units in each type;
- loading and unloading time, taking into account the norms for loading and unloading operations, h;
- shipment mass, t;
- periodicity of MP-1, MP-2 thousand km;
- the complexity of MP-1, MP-2 + R, people.*h;
- cost of MP-1, MP-2 and R, rub. / pers. · h;
- mileage from the beginning of operation, thousand km;
- fund of working time for a month, h;
- hour tariff rate of the 3rd class driver, rubles / h;
- belt coefficient;
- the price of 1 liter of fuel; fuel consumption rate per 100 km of run, l / 100 km;
- tire price, rub.;
- number of tires per vehicle, pcs .;
- standard tire mileage, km;
- car carrying price, rub.

Data on market uptake is the volume of traffic by quarter.

Stage 2. Scoring the results of scheduling the upper and lower limits of the ride haul distance with the cargo and the shipments mass with a probability of 0.95.

It has been established that in modern conditions the indicators of commercial exploitation are generation and mileage, indicators of technical exploitation - the number and complexity of planned maintenance depend on the technical and operational indicator – freight haul distance. Under conditions of uncertain demand, the value of freight haul distance is random and is distributed according to a log-normal law. Experimental studies showed that the law of the log-normal distribution was proved and its parameters for a random variable — the haul distance with a long-distance communication with a probability of 0.95 for tractors with universal vans: MAZ-5440 + MAZ-975830-3021, KamAZ-5490 + Krone-SDP-24; truck tractors with specialized vans without special equipment (thermoses): MAZ-54323 + Fruehauf-T34C1RA, KAMAZ-5490 + Schmitz-SKO SDP-24; long-haul truck with a specialized van and with special equipment (refrigerator): DAF-105 FX + Schmitz-SKO 24 / L-13.4 FP-60 cool. The hypothesis that the data belong to the log-normal law was confirmed with a probability of 0.95 by the Pearson criterion and the Romanovsky criterion [19].

Experimental studies have allowed proving that the production during the freighting in the interurban communication depends on the mass of shipment for a specific size of rolling stock [19]. The law of normal random variable probability – the shipment mass of a cargo in a long-distance communication – was proved by the results of the experiment. The probabilistic parameters of the shipment mass interurban communication with a probability of 0.95 for MAZ-5440 + MAZ-975830-3021, KAMAZ-5490 + Krone-SDP-24, MAZ-54323 + Fruehauf-T34C1RA, KAMAZ-5490 + Schmitz-SKO SDP-24, DAF-105 FX + Schmitz-SKO 24 / L-13.4 FP-60 cool were identified. The hypothesis about the data belonging to the normal law was confirmed with a probability of 0.95 by the Pearson criterion and the Romanovsky criterion. The confidence limits of the shipment mass expectation in a long-distance communication with a probability of 0.95 for the rolling stock MTE standard sizes were determined.

Stage 3. Scoring the results of rolling stock operation.

The system planning the motor transport enterprise functioning in freighting in interurban communication required the need for the formation of the rolling stock indicators, which include:
- monthly production of the x-th unit of rolling stock of the j-th standard size when the conditions of the i-th contract for the freighting in interurban traffic in tons and ton-kilometers are met;
- monthly haul’s number of the $x$-th unit of the rolling stock of the $j$-th standard size when the $i$-th contract terms for the freighting in interurban service, units;
- freighting time in accordance with the selected mode of work and rest, the method of drivers’ work organizing of the $x$-th unit of the rolling stock of the $j$-th standard size when the $i$-th contract terms are met, h;
- time of cork-light return in accordance with the selected mode of work and rest the method of drivers’ work organizing of the $x$-th unit of the rolling stock of the $j$-th standard size when the $i$-th contract terms are met, h;
- monthly total mileage of the $x$-th unit of rolling stock of the $j$-th standard size when the the $i$-th contract terms for the freighting in interurban communication are met, km;
- annual total mileage of the $x$-th unit of rolling stock of the $j$-th standard size when the the $i$-th contract terms for the freighting in interurban communication are met, km;
- annual output in tons and ton-kilometers of MTE in freighting in interurban communication.

The above rolling stock operation indicators are determined by the upper and lower limits of the confidence interval of the mathematical expectation of the freight haul distance and the shipment mass for a specific size of the rolling stock with a confidence level of 0.95. Production and total mileage are determined by calculating the whole number of haul per month. The rolling stock development determines the drivers labor cost. The total mileage of the rolling stock is used when calculating the cost of lubricants, fuel, tires, performance of maintenance and repair.

Stage 4. The existing rolling stock by enumeration combinations formation. When forming combinations of existing rolling stock, compliance test are performed to meet the contracts terms:
- rolling stock production in tons for the combination found by volume, which is determined by the demand for the freighting in interurban communication by quarters in accordance with contracts;
- the complexity of the planned work for MP-1, MPO-2 labor-intensive, ensuring traffic safety;
- time for freighting according to the selected mode of working time and rest time of drivers, as well as the method of drivers work organizing for the required freighting time under the contract.

Stage 5. Identifying the indicators of commercial and technical operation; cost, result and profit for each combination of rolling stock. The indicators’ calculation is performed during the freighting in interurban traffic by quarter.

Stage 6. Whether all combinations are tested or not. To the case finishing the verification of existing rolling stock combinations to fulfill the contract terms, there is a transition to stage 7; otherwise, it returns to stage 4.

Stage 7. The end of selection. After the selection completion, the results of the combinations formation of the existing rolling stock MTE should be obtained to meet the conditions of contracts by quarters.

Stage 8. Choosing the best option for the freighting in interurban traffic on the criterion of “profit”. At this stage, the result and cost of freighting, as well as the value of the maximum profit, are calculated.

Stage 9. Making commitments to fulfill the contracts terms for the freighting in interurban traffic. At this stage, contracts for the freighting in interurban traffic are signed.

Stage 10. The statement of commercial and technical operation’s indicators. Approved planned figures for production, total mileage for each unit of rolling stock and for MTE per month, quarterly and per year, the planned number of shifts of each rolling stock unit for the selected mode of drivers’ working time and rest time, as well as drivers work organization. Approved planned figures for the number and labor intensity of MP-1, MP-2 for each unit of rolling stock and for MTE per month, quarterly and per year.

Stage 11. The statement of expenses, result and profit at performance of contracts terms on freighting in long-distance communication.

Stage 12. The MTE work plan implementation to fulfill the contracts terms and obtain maximum profit when freighting in interurban traffic. This stage involves the MTE work planning system practical implementation in order to fulfill contracts for the freighting in interurban traffic and obtain
maximum profit. The developed planning system is aimed at the contracts implementation for the freighting in interurban traffic and obtain maximum profit. Due to the developed system, a current plan was drawn up, which is implemented in the practice of MTE during food freighting from the city of Omsk to the Western and Eastern directions for rolling stock: MAZ-5440 + MAZ-975830-3021, KAMAZ-5490 + Krone-SDP-24, MAZ-54323 + Fruehauf-T34C1RA, KAMAZ-5490 + Schmitz-SKO SDP-24, DAF-105 FX + Schmitz-SKO 24 / L-13.4 FP-60 cool. Further economic assessment found that the application of the developed system in the MET practice will allow getting more profit than the profit that was expected in the enterprise by 10.8%.

There has been developed a system that allows implementing current planning for fulfilling the contracts terms and obtaining MTE profits through the commercial and technical operation correlation. The MTE work during the freighting in interurban traffic in the created systems is presented as a probabilistic process for which the planned indicators of commercial and technical operation are calculated for the upper and lower limits of the confidence interval of the expected freight haul distance in the interurban communication with a probability of 0.95 and the lower limit of the confidence interval of the shipment mass in a long-distance traffic mathematical expectation. The practical implementation of the created MTE system with the scientific software use will allow obtaining more profit than the profit calculated by the method used.

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