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METHODS FOR CHOOSING THE ROLLING STOCK, ROUTE AND SCHEDULE FOR CARGO TRANSPORTATION

The paper presents an improved method to choose the route of the vehicle in order to receive maximal economic efficiency while delivering products from a sender to a receiver as well as description of this method application by the example of practical task.

Key words: *driving route, routing, transportation schedule, vehicle, rolling stock.*

Introduction

Development of the economy and, therefore, development of production as well as of the range of provided services resulted in strong competition among product manufacturers. To solve the problem, researchers have analyzed the entire cycle of services offered on the way from a producer to a consumer and made the following conclusion: transportation costs reduction is an opportunity to save costs without compromising the quality of products.

Special attention should be paid to the routing of transportations because use of the rational routes is an obvious advantage of centralized transportations over decentralized ones due to the improvement of their economic efficiency. The development of routes for delivery of goods can help reduce downtime of the automobiles required for loading and unloading, to increase their productivity and, consequently, reduce the number of transport means arriving at the consignors, transportation volumes being the same. If definite routes are developed and the delivery deadlines are met, production supplies of consumers might be reduced by 1.5 - 2 times.

The aim of this paper is to improve the methods of choosing the vehicle route for distribution of goods.

Rational route selection in the organization of cargo transportations by automotive transport

In the organization of the process of cargo transportation by automotive transport driving route selection plays an important role. After receiving an application for transportation selection of the route is as important as the choice of rolling stock for transportation. Delivery of the cargo from the consignor to the consignee is possible using several motion route variants. Taking into account all those criteria, rational route selection determines the time of cargo delivery and its cost.

The problem of a rational route selection could be approached from different standpoints taking into account the requirements imposed by the “Driver – automobile – road – environment” (DARE) system. In the past route selection was conducted by quantitative criteria using mathematical problems of finding the shortest distance. The multi-pronged approach principle was considered both for choosing a carrier and a vendor. V. Lukinskiy proposes to solve the problem in terms of logistics taking into account qualitative and quantitative indicators because the efficiency of functioning of the transport service users depends both on the tariff for delivery and on such qualitative aspects of the delivery as timeliness, provision for cargo storage on the route etc. Therefore this method is proposed for the automobile rational route selection.

In order to solve the problem of route selection 14 criteria were elaborated which, according to the expert opinions, meet all the requirements of the DARE system to the route.

Criteria that characterize a driver include: correspondence of the driver qualification to the requirements of the route; the driver emotional load depending on driving conditions in the traffic flow.

Criteria that characterize an automobile include: correspondence of the technical characteristics of the vehicle to the route; deviation of the actual fuel consumption from the normative requirements; actual driving speed.

Criteria that characterize road conditions are as follows: category of the road; the distance of

cargo transportation; the type and condition of the pavement; total length of ups and downs with a slope greater than 40 %.

Criteria that characterize the environment include: the possibility of transportation of cargo with certain characteristics on the route; climate conditions (season, weather conditions); environmental restrictions on carrying certain types of cargo (the presence of human settlements and sanitary zones in the path of the cargo; restrictions on the delivery terms.

The criterion of ensuring the storage of goods on the way is a common characteristic for all DARE system components.

Using the method of expert estimates, 25 experts identified the rank of each evaluation criterion. The most significant criterion has the highest rank value.

Using the obtained ranking estimates of the criteria we determined the values of concordance coefficient W=0,61 > 0,6 and of Pearson criterion =198,7 > 22,4 which satisfy the condition of consensus of the expert opinions. From the determined weight coefficients γ_i for all criteria we identified the most weighty ones which satisfy the condition of $\gamma_i > 1/n$, where n = 14 is the number of evaluation criteria.

In order to determine all the possible alternative variants of the driving route and their evaluation, a total integral index was calculated. All the criteria were divided into quantitative and qualitative ones. Qualitative criteria were obtained on the basis of statistical, reference and report data and evaluated according to the three-point system.

In order to convert quality indicators to the numerical expression, desirability function is used. To evaluate alternative variants of the route according to quantitative and qualitative indicators, reference value for each criterion has been chosen – the maximum and the minimum one depending on its influence on the total estimate – and its relative value was calculated.

The total integral index K_0 is calculated by the formula:

$$K_0 = \sum_{i=1}^{n} K_i \gamma_{io} \longrightarrow \max, \qquad (1)$$

where K_i is arithmetic mean score in points of the i-th criterion, provided by the experts; γ_{io} – weight coefficient of i-th criterion.

According to the highest values of integral indices two alternative variants of the route are selected, for which the cost of the rolling stock operation is calculated and, after their comparison, the route having minimal cost is chosen. Final choice of the driving route is made in accordance with the lowest transportation cost.

This paper improves the scheme that makes it possible to choose the optimal route of the vehicles from several alternative variants. The novelty of the results consists in the following: for choosing criteria influencing the route selection, the conditions imposed by DARE system were taken into account.

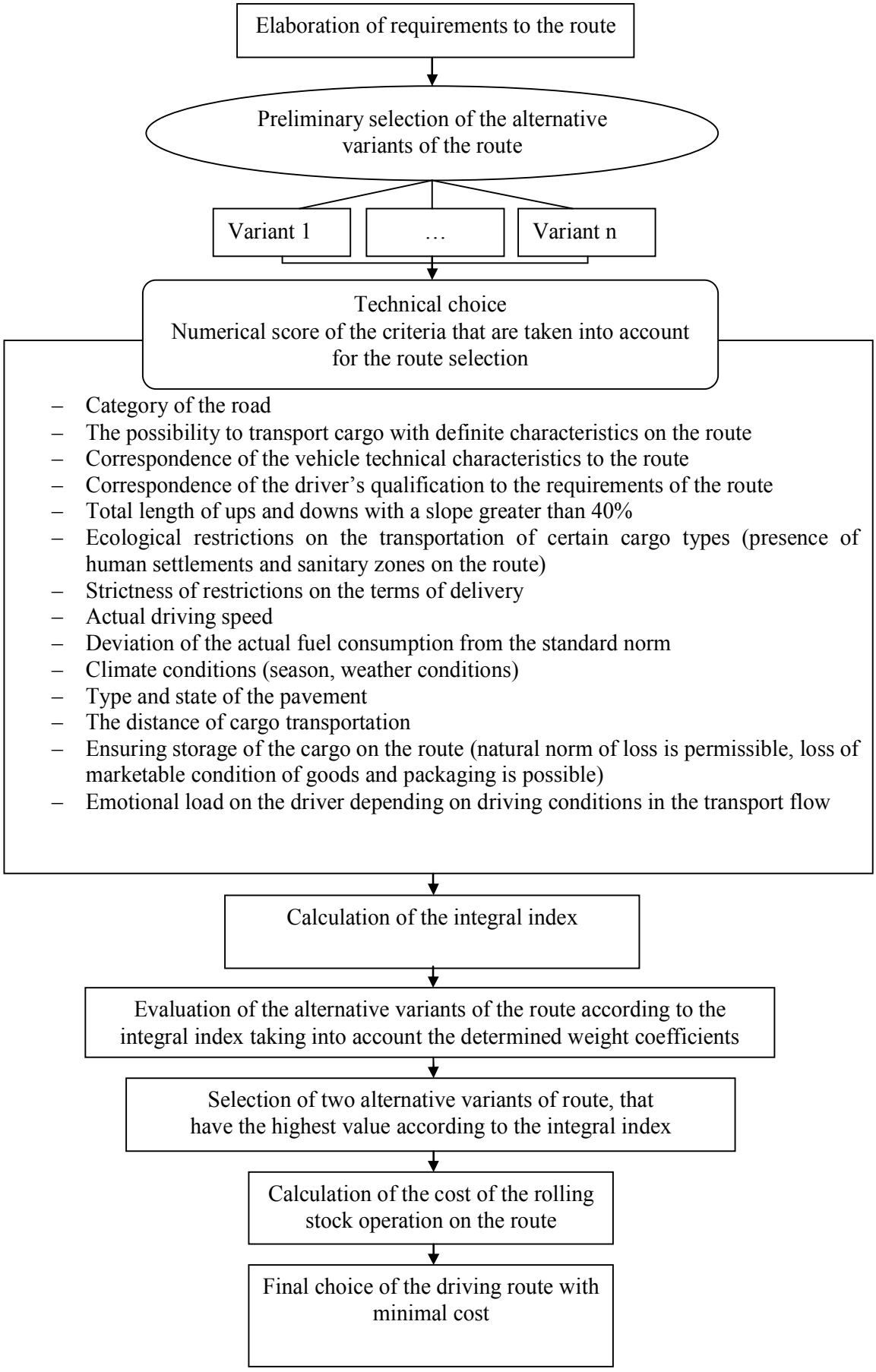

Fig. 1. Structural logic diagram for rational driving route selection

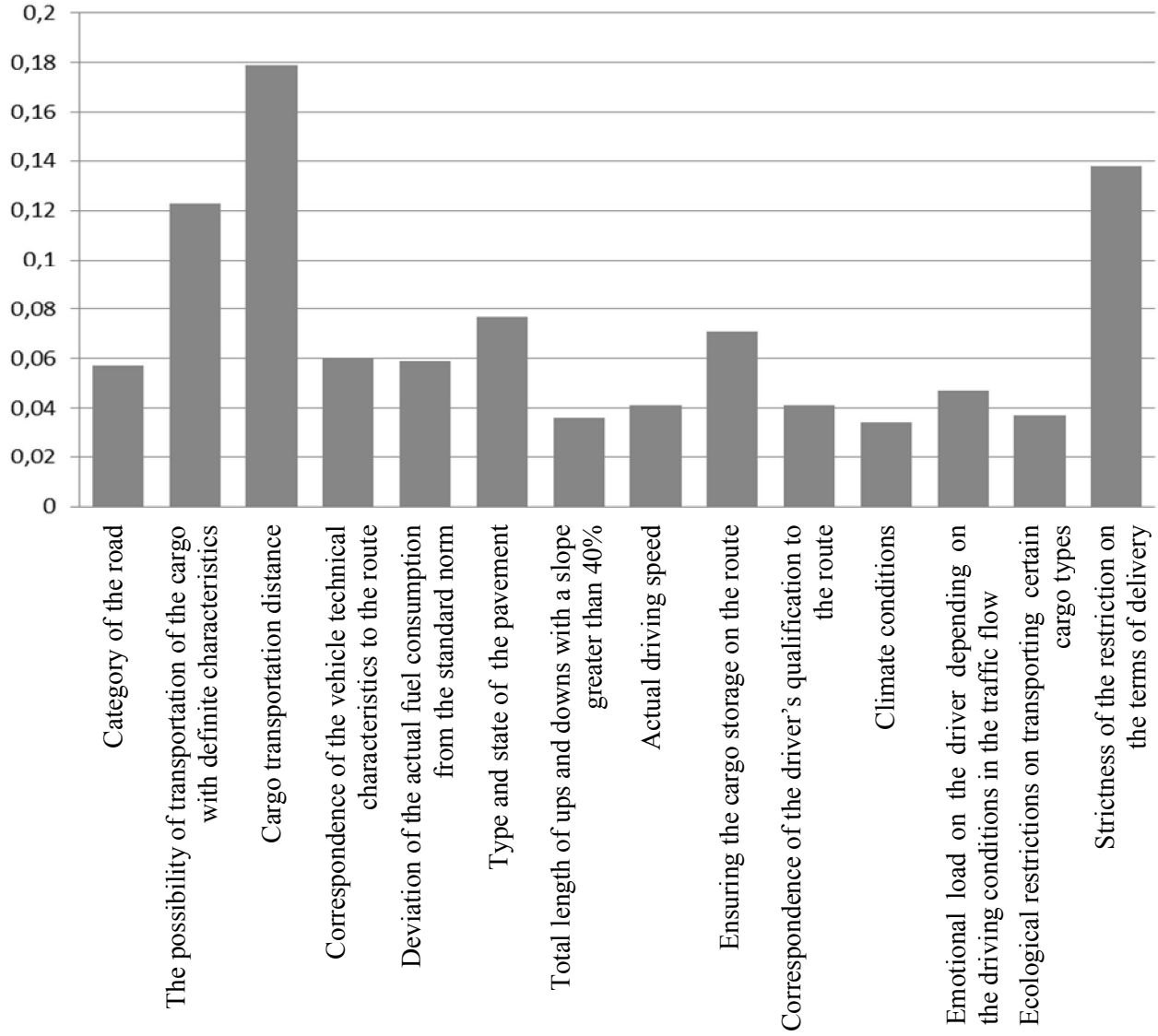

Fig. 2. Diagram of the values of weight coefficients for the criteria influencing the route selection.

Elaboration of the vehicle schedules

The vehicle schedule is elaborated in order to increase the efficiency of management and control over the transport means operation on the line both along the entire route and in its separate parts.

The schedule reflects all the transportation process elements in time and space. The schedule elaboration should be preceded by the calculation of technical and operational parameters on the transportation route:

1) time spent by vehicles on the line;
2) duration of the drivers' dinner and rest on the way;
3) downtime during loading and unloading;
4) a standardized driving speed on the route;
5) a number of vehicles on the route.

Vehicle schedules are elaborated for constant routes taking into account specific transportation conditions. The driving speed of vehicles on the route should correspond to the type of pavement nd the road profile. The idle time at the places of loading and unloading is determined depending on carrying capacity of the loading-unloading points taking into account the additional time spent on the vehicle maneuvering and registration of the transportation documents.

To determine the place and time of eating and resting for the drivers, duration of their work is

taken into account as well as availability

of public catering enterprises and places for rest.

In the schedule of the vehicle movement along the route the technical speed is shown by a fraction: the numerator denotes the speed in the forward direction and the denominator – in the reverse direction.

The correctness of the schedule construction is verified by summing up the time of all the transportation process elements and compared with the calculated time of operation on the line.

Application of the vehicle schedule is most feasible for long-distance transportation, especially for organizing decentralized transportation

Correctly-built vehicle schedules give the following advantages:

1) enhance more rational organization of transportations;

2) ensure rhythmical operation of vehicles, loading-unloading points and warehouses, coordinated work of the control points;

3) increase the discipline of the drivers' work.

During the elaboration of the delivery schedules the following conditions were taken into account:

1) presence of the required products at the warehousing complexes of the mediators;

2) availability of the transport means for servicing warehousing complexes of the mediators, taking into account the products to be supplied and average loading of the automobile.

Calculation should be performed not only for a certain amount of the rolling stock but also for a reserve in case of failures and due to other circumstances. Consumers must ensure timely reception of the products and unloading operations.

In order to observe the coordinated schedules of the delivery of products to the consumers from the warehouses of mediators it is necessary to perform definite kinds of work. According to the network schedule all these works should be performed consistently and in due time. Therefore, the time of their fulfillment is discussed beforehand. A network schedule reflects technological connection and the sequence of the works, so its application enables calculation of the duration of the transportation schedule development cycle.

While analyzing the application of transport means servicing the mediator companies, the dynamics of changes in transportation volumes and their proportion were determined, technical and operational parameters of the vehicle operation during transportation of products were analyzed, irregularity of the import and export of products to the warehousing complex within a certain period (year, quarter) was determined as well as the possibilities of loading-unloading operations at the warehouses and at the users' place.

Daily supply of products was determined dividing the annual demand of the consumers for the required products by the number of working days in the year. Then the daily supply of products should be coordinated with the consumer.

Rolling stock selection

Rolling stock selection task is formulated as follows: in the given conditions of the transport enterprise operation with the known restrictions regarding road and climatic factors it is necessary to choose the most rational types of the commercial vehicles and to calculate the demand in them for the planned period taking into account the necessity to meet all the requirements of the clients served at minimal cost.

An important task of the transportation management is selection of the most efficient vehicles which correspond to the given transportation conditions.

Availability of different brands in the vehicle fleet of the transport enterprise improves the transportation process efficiency but at the same time causes complications and increases the cost of maintenance and servicing of the vehicles.

In the transport means selection two interdependent problems are solved (fig. 3):

1) specialization is determined;

2) loading capacity is selected.

In order to make a correct choice of the vehicle the following final elements (factors) were taken into account::

1) transportation (system-forming) factors: the type of cargo and its characteristics; Partitioning of transportation; transportation volume and stability; transportation distance; ways of loading-unloading and warehouse equipment; time-table; types of the route and transportation management.

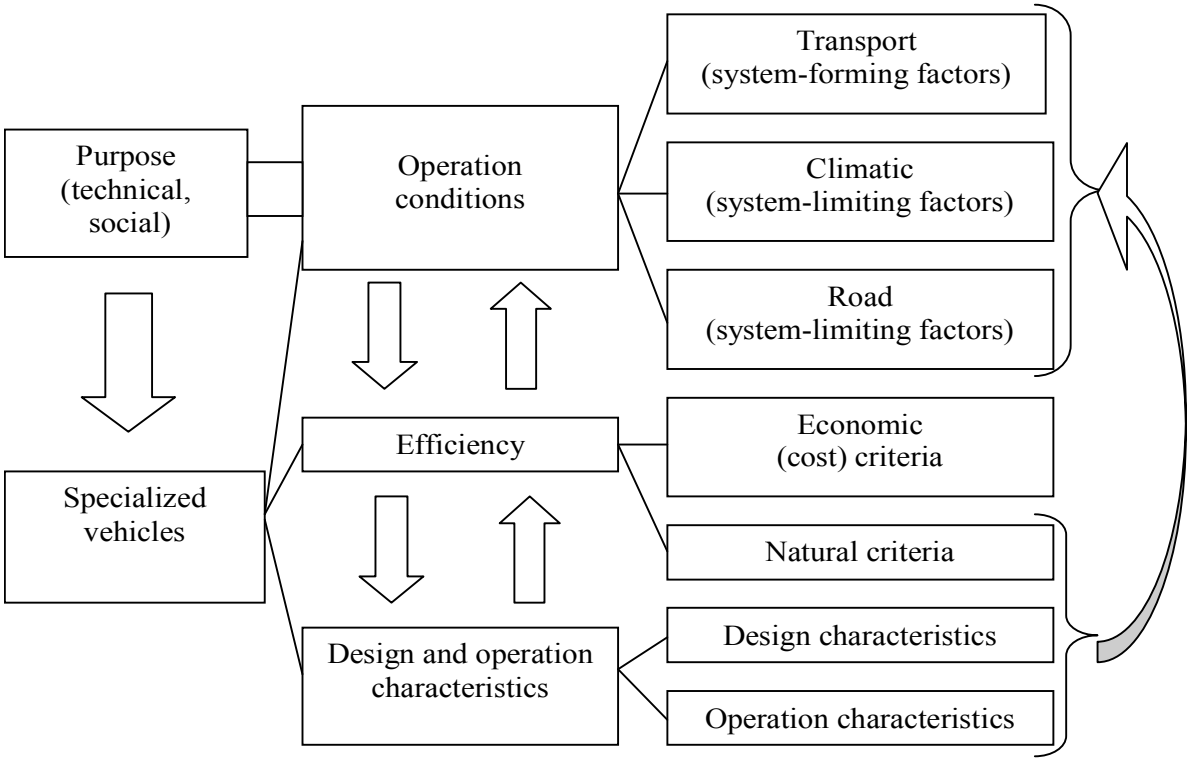

Fig. 3. Complex of interaction of the groups of factors that determine selection of commercial vehicles

2) Road (system-limiting factors): strength of the pavement (permissible axial loading); elements of the profile and plan of the road; traffic intensity; trafficability of the road;

3) Natural and climatic (system-limiting) factors: moderate climate zone; cold climate zone; hot climate zone; highland regions;

4) Design factors: body; use of the weight;

5) performance characteristics: adaptation of the body, tonnage; usability; trafficability;

6) economic and natural criteria: productivity; cost; consolidated expenditures; laboriousness of transportation; extra-transport effect.

Functional purpose of the vehicle ((dump truck, van, container truck, tank etc.) is determined on the basis of classification of cargoes and corresponding types of vehicles on the “cargo-body” principle.

Load capacity is one of the main parameters of a vehicle. However, it does not always reflect the actual amount of cargo that could be carried by a definite vehicle. Load capacity of transport means is determined as a function of partitioning of transportation.

Solution of the practical task

To evaluate the proposed methods we solved a practical transport problem of servicing a retail network by a transportation enterprise. It was necessary to deliver the goods from three producers to a group of grocery stores. Strict time limits were imposed on the delivery of goods. For solving the problem the following transportation method has been chosen: PRODUCER – INTERMEDIATE STORAGE – CONSUMER. At the final stage of elaborating the routes of product delivery from an intermediate warehousee to the consumer two variants were selected:

1) three light-duty vehicles (three routes);

2) one light-duty vehicle and one medium-duty vehicle (two routes).

The variant of delivering goods by one medium-duty vehicle was not considered as such delivery goes beyond the time limits.

Cars move along different routes from an intermediate warehouse to a consumer and deliver a combined load. To deliver goods from the manufacturer to the warehouse one medium-duty vehicle was chosen. It delivers a group of goods once in three days, that is, all groups of goods are delivered in three days. To determine the distances we used Googlemaps software.

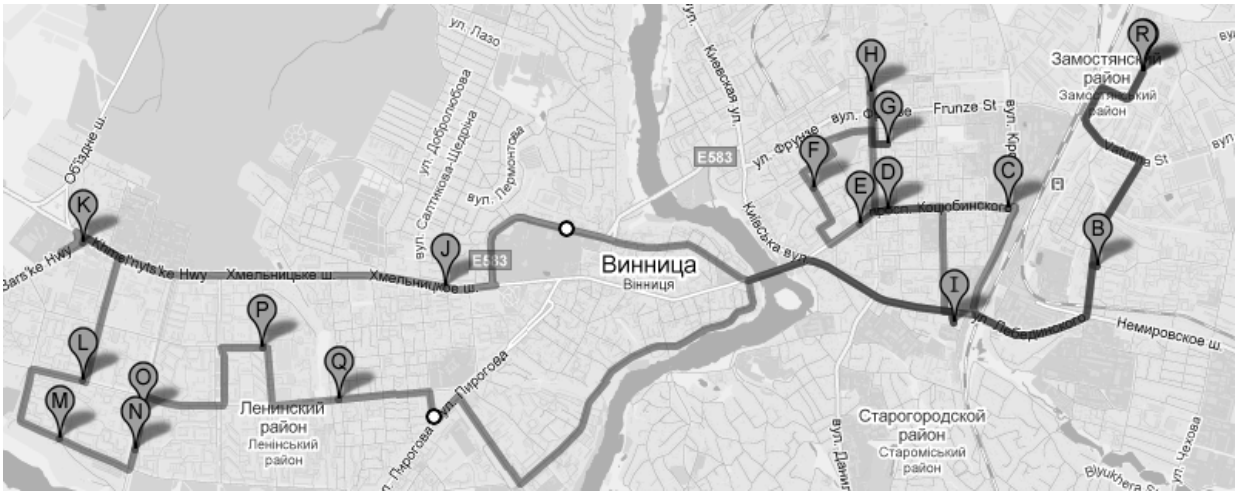

Fig. 4. Route of delivering goods from the intermediate warehouse to the consumer by a medium-duty vehicle

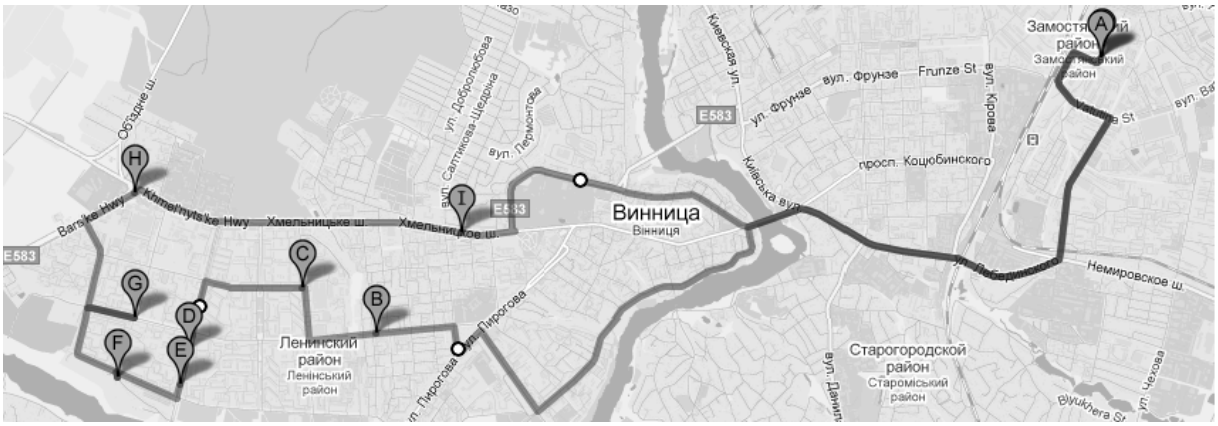

Fig. 5. Route 1 of delivering goods from the intermediate warehouse to the consumer by a light-duty vehicle

Fig.4. shows the route of a medium-duty vehicle and fig. 5, 6 present the routes of light-duty vehicles for servicing the same consumers.

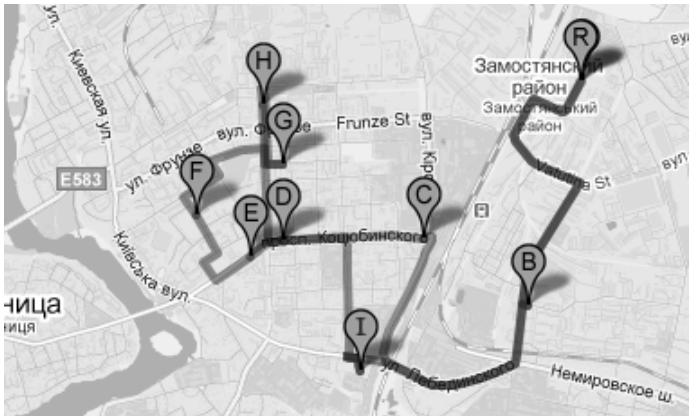

Fig. 6. Route 2 of delivering goods from the intermediate warehouse to the consumer by a light-duty vehicle

After selection of the routes fulfillment of the product delivery terms was checked and their length was calculated. To make a final choice of the route, transportation costs were compared (fig. 7, 8).

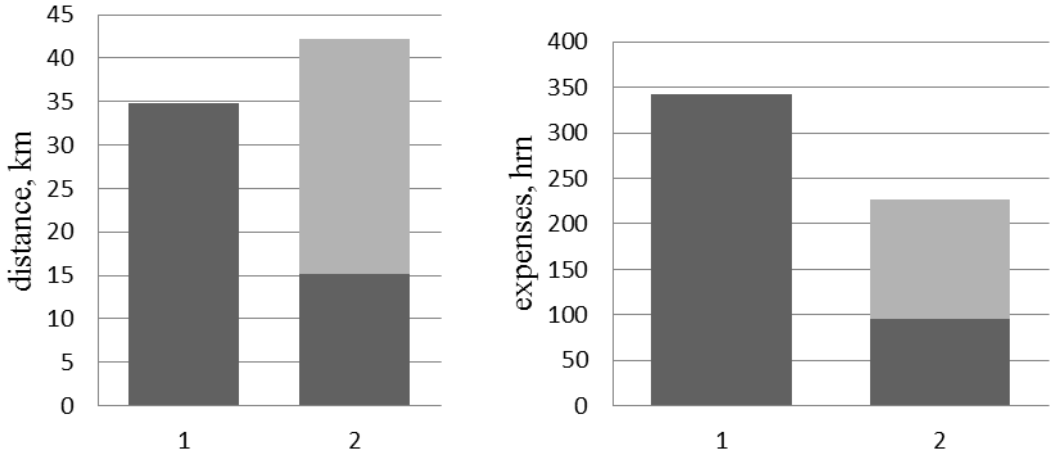

Fig. 7. Diagrams of the parameters:
1 – medium-duty vehicle;
2 – light-duty vehicles

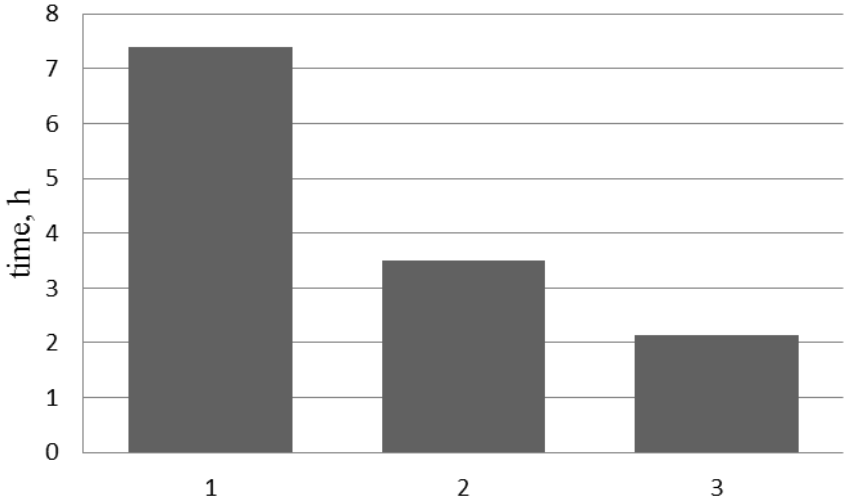

Fig. 8. Diagram of the time required for transportation:
1 – medium-duty vehicle;
2, 3 – light-duty vehicles.

Conclusions

At present transport service prices are growing due to the increasing fuel costs. This results in the increased cost of the products and services that depend on transportation. Therefore, making rational choice of the transportation parameters it is possible to achieve significant reduction of the transportation service expenses. After solving a specific task, we have seen in practice how important the correct choice of a route and vehicle is. We built several variants of the routes for different vehicles. Parameters of the obtained routes were calculated and compared. For a medium-duty vehicle the mileage turned to be 21,3% less as compared with the total mileage of two light-duty vehicles (fig.7) while there was spent 111% more time for the product delivery to the end user. Thus, shorter delivery time is an important advantage of the light-duty vehicles. They can provide fast delivery of perishable products with high accuracy in time. Delivery costs were the main parameter for route selection. When two light-duty vehicles were used for delivery, the economy of

29% was achieved as compared with a medium-duty vehicle.

In the delivery network formation special characteristics of the cargo and its delivery terms should be taken into account. For long distances from a manufacturer to a client that consumes small volumes of products it is feasible to create intermediate warehouses, which makes it possible to use the following scheme: delivery of goods from a producer to a warehouse by a heavy-duty vehicle and distribution of goods from the warehouse to consumers by vehicles with lower load capacity.

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