Algorithm of automated distribution of automobiles, used in an interurban communication, on request

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Abstract. The paper presents the algorithm of an automated distribution of automobiles on request, which allows to simultaneously perform complex operations of planning of vehicles work with a minimum of effort. The algorithm is based on a time tracking operator and a time intervals overlap factor "time of request" and "vehicle occupation status". The algorithm allows to obtain the exact value of a required number of vehicles for requests' fulfillment, to schedule vehicles' work considering a rhythm of a cargo's shipment, to carry out a specified number of shipments with minimal capital investments in vehicles and transportation expenses, to reduce transportation planning labor expenditures of a dispatch department.

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Introduction

An overall estimation of an existing methodological basis of an operative planning allows to note that it is segmented and describes a separate stages of a shipments' scheduling process, such as an automobile selection, a designation of rational payload of a vehicle for a shipments' conduction [1, 2, 3, 4], a calculation of technical and economic indices (TEI), including a necessary number of vehicles [2, 4, 5], a requests distribution of vehicles with an implementation of a linear programming [4, 6], making of an operating schedule of vehicles for a verification of a shipments' conduction possibility by a calculated number of vehicles [7], a calculation of shipments expenditures and others. A fulfillment of such a variety of isolated operations and tasks in nowadays conditions is ineffective without a complex approach towards their accomplishment and also without an automation of processing of significant information amounts [8]. In nowadays conditions it is necessary to adopt in motor transport companies a complex automation of all basic operations related with vehicles work scheduling.

Despite of the fact that in recent years in motor transport companies there is an active development and an adaptation of systems of automated documents circulation and vehicles work planning, such as DTKsoft: IAS "Freight", RARUS: Transportation planning, FORES: Motor transport, Ermasoft: CITY-Shipment, ITOB: Logistics center, ANTOR: LogisticsMaster, ESRI: ArcLogistics Route, TopPlan: TopLogistics, CDC: OPTIMUM GIS, Akselot: Shipments management and suppliers of products stated, that a system provides a division between vehicles [9], after examination of a products it is revealed, that:

- Information about an occupation status of vehicles on a route during a conduction of operation of "distribution by vehicles" is not taken into account;
- An automated distribution of vehicles by requests is not provided;
- "Minimal shipment expenses" criteria is not fulfilled;

In the present time there no existing methods which allow to provide a complex planning and an accomplishment of aforementioned tasks considering a particularities of interurban transportations in one software shell, in the same time, modern trends of motor transport in Russia are related with an intense development of interurban automobile cargo transportation.

Method

An algorithm of automated distribution of vehicles by requests in interurban routes allows to obtain a number of required vehicles more precise in comparison with existing methods, to automatize a process of distribution of automobiles by requests, to obtain an operative information about a process of shipments in any time, to increase a speed of that information's processing and, thus, to increase an effectiveness of a shipments planning process.

To carry out an operative planning according to the presented algorithm, it is necessary to form a database (DB) of a source information "3_j" (incoming requests), "A_{ik} " (automobile fleet), where i – types of automobiles, i=1, …,n, k – automobile number, k=1,…,p - its nominal payload q_{Hi}.

Operative planning is conducted considering following conditions [10]:

$$\sum_{i=1}^{m} W_{ij} x_{ij} = Q_j,\ j = 1,2,\dots,n$$

where x_{ij} – required number of automobiles, pcs;

$$x_{ij} \geq 0,\ \ i = 1,2,\dots,m, j = 1,2,\dots,n$$

and criterion function

$$\sum_{i=1}^{m}\sum_{j=1}^{n} c_{ij}x_{ij} \to min \, .$$

In a motor transport or a forwarding company requests З$_j$ are incoming, j – a sequence number of a request *j*=1, …, *m*. In them following information is provided: cargo's name and properties; cargo's volume, which is declared for shipment Q_j, ton, j=1, …, m; a date of delivery t_{jend} and a delivery time T_j, days, j=1, …, m; location of a loading point and a destination point and, basing on that, a route distance j, km, j=1, …, m.

Productivity by request is calculated using equation:

$$W_j = \frac{Q_j}{t_{об\ j}}, \qquad (1)$$

where W_j – a requested productivity of vehicles by a request, ton/hour; Q_j – a volume of cargo declared for a delivery, ton; $t_{об\ j}$ – time of turnaround of an automobile by *request j*, hour.

Productivity of *i-type* vehicle by *request j* is calculated using equation:

$$w_{ij} = \frac{q_{нi}\gamma}{t_{об\ j}}, \qquad (2)$$

where w_{ij} – a productivity of *i-type* vehicle by *request j*, ton/hour; $q_{нi}$ - a nominal payload of a vehicle of *i-typer*, ton; γ – payload usage factor.

Novelties of the algorithm are following:

1. An implementation of an operator "$АП_{ij} \le АН_{ij}$", where a requested number of an automobiles of a maximum productivity is calculated using equation:

$$АП_{i,j} = \frac{W_j - \sum_{i=1}^{m-1} АВ_i w_{ij}}{w_{i,j}}, \qquad (3)$$

where $АП_{i,j}$ – a requested number of automobiles of *i-type* by *request j*, with a maximal productivity, pcs.; $АВ_i$ – automobiles of *i-type* chosen to work on *request j*, ед.; $w_{i,j}$ – a maximal productivity of vehicles by *request j* from those available in company, ton/hour.

2. *Identification of vehicles.* An additional index "*k*" is used in order to provide a selection of vehicles form unoccupied automobiles for work on *request j* with a higher preciseness and efficiency.

3. *An implementation of operator of time-accounting* (OTA), which captures:
   - A time interval "time of a fulfillment of *request j*" (T_j);
   - Points of a start and an end of work of and identified vehicle;
   - A time interval "an occupation status of an automobile of *i-type number k* by *request j*" (T_{Aikj}). It allows to account and regulate in time requests which are incoming to a motor transport or a forwarding company and in future to avoid a labor-intensive making of an automobiles departure diagram manually.

4. A determination of a possibility of use of automobiles of *i-type number k* for work on *request j* using OTA, DB "A_{ik}" and an overlapping factor. In a software shell a time interval "time of a fulfillment of request j" and time intervals "an occupation status of an automobile of *i-type number k* by *request j*" are compared. As a result of a calculation number of automobiles of *i=1 type* free for a fulfillment of a given request is determined and specified as $АН_i$.

Then, it is determined whether unoccupied automobiles of *i -type* are enough to conduct an amount of freight, if it is not, a selection form automobiles of *i+1 type* is conducted.

Specifying, whether there is a need in more automobiles:

$$\Delta W = W_j - \sum_{i=1}^{n-1} АВ_i w_{ij} \qquad (4)$$

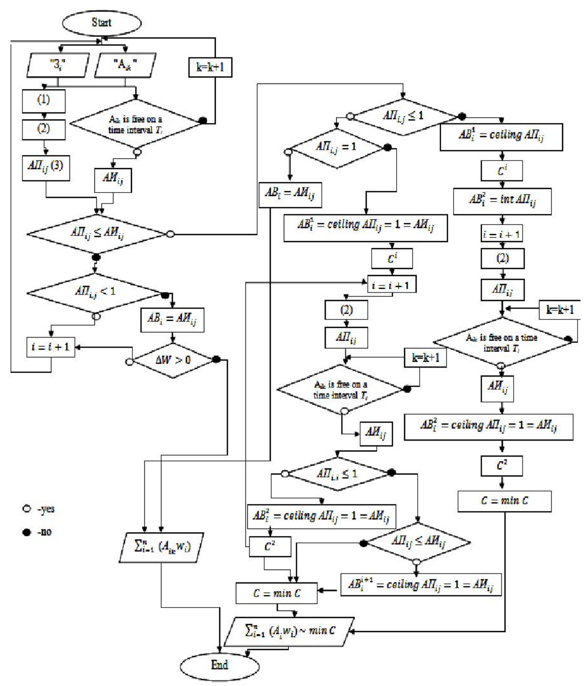

Fig. 1. Algorithm of an automated distribution of vehicles by request in interurban routes

Vehicles selection is finished with capturing a result $АВ_i$, where $АВ_i$ – automobiles departing for a shipment.

In a case when there is no unambiguous solution of a situation, the algorithm allows to compare alternative options of combinations of payload and number of vehicles considering shipment expenditures C.

A determination of requested number of automobiles by using the algorithm of an automatized distribution of vehicles by requests (fig.1) is conducted with a higher preciseness in comparison with existing methods, which is proved by results of the approbation in data in forwarding company "Centrus" ltd.

Results of calculation allow to say about significant inaccuracy, appearing during an implementation of existing methods of a calculation of technical and economic indices (TEI) in context of an each request (inaccuracy 24%), at the same time, an inaccuracy increases with an increase of a rate of a requests' appearance. That can be seen by a mismatch of points on curves "TEI" and "The algorithm and production chart" on fig.2.

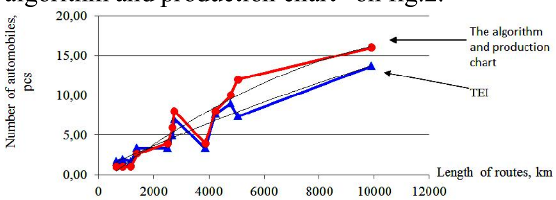

Fig.2. A requested number of automobiles on routes of length from 600 to 9000 km

A departure diagram allows to correct a number of requested automobiles by every route, but, first, these kind of works is made manually, which is related with significant labor expenses, and, in context of a whole company with a big number of request is ineffective, second, the diagram allows to correct a number of requested automobiles in a context of an each request, but lead to an inaccuracy (11%) in case of considering a combination of a company's requests in a certain period (fig.3).

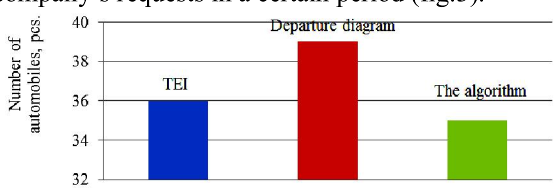

Fig.3. A requested number of automobiles for requests fulfillment, determined by various methods

A departure diagram allows to determine, that for requests fulfillment 39 automobiles are needed, but in a case of using the algorithm – 35 pcs. An implementation of the algorithm allows to achieve an economic effect of 3600000 rub./year in a case of using owned vehicles of the same type.

A complex automation of vehicles' work planning operations allows to process requests with less labor expenses, which is proved by an economic effect of 608400 rub./year in case of 12 routes of the company and 7098000 rub./year in case of all requests of "Centrus" ltd.

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