

# Descriptive model of functioning in aggregate of auto transportation system dispatch of freight by vehicles in cities

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**Abstract.** The transport operator needs instruments for making calculations that will permit determining the possibility of fulfilling obligations for the contract on a scientific basis. The existing models of auto transportation systems involve transportation of freight on several simultaneously and isolated functioning separate pendulum routes with a reverse unloaded run. The use of this model of vehicle systems has produced a negative result. This served as the basis for the development of a new model. The article describes the developed descriptive mathematical model of the aggregate of micro motor transport systems for the carriage of freight by vehicle dispatch in cities. This model permits considering features of practice within operational planning.

## 1. Introduction.

Obligations and responsibility of a transport operator by the contract dispatch of freight have been determined in accordance with the legislation of the Russian Federation. For the act of the specified obligations, the transport operator needs instruments to carry out the calculations. These calculations will allow defining a possibility of obligations implementation on a scientific basis.

Application of earlier drafted theoretical provisions and mathematical models does not allow considering practical features of functioning of the auto transport and with the required accuracy to plan transportation in the aggregate of the micro auto transportation system ( $\Sigma$ Smicro).

During the period since 1991 there had been essential changes in economy of Russia that were noted and considered in the works of scientists [1, 2, 3, 4]. For example, professor Lukinsky V.S. in work «Logistics of the auto transport» noted: «Now the tendency to a reduction of a consignment of goods that is connected with lack of places for storage of raw materials or production for the consumer or with unwillingness to have excessive stocks in warehouses was outlined. Such requirement leads to the new restriction in a transport task connected with the size of consignment which the supplier will send and the consumer will accept».

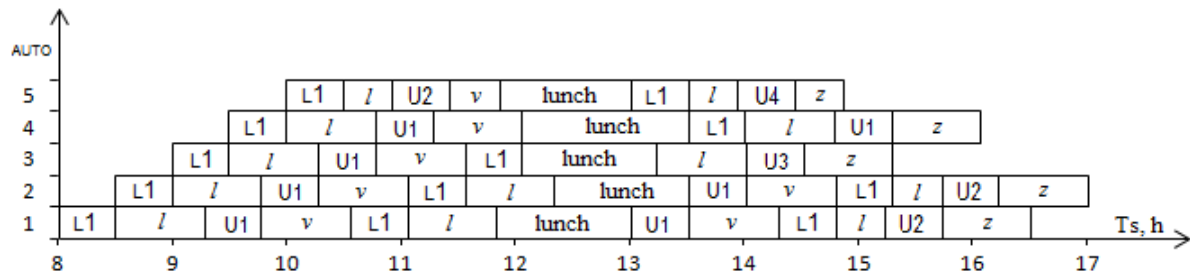
## 2. Materials and methods.

Our conclusions confirm results of observations, which were made by the authors of the article in the city of Omsk during the period from 9/1/2013 to 10/1/2016. In the course of observations, features of modern practice of transportations of construction freights have been studied: sand, brick, concrete goods, metal wares, timber. Production of the enterprises in the city of Omsk: ZAO «ZSZHB №6», ООО «Gidrotransservis», ООО «ZAVOD ZHBI №7», ООО «Kirpichnyy zavod SK» of auto transportation systems dispatch of freight by vehicles was also considered in [5, 6].



Earlier, in SIBADI, classification of auto transportation systems dispatch of freight by vehicles in cities was developed. In the thesis «Scientific bases of improvement of the theory of freight automobile transportation» written by professor Nikolin V.I., it was specified that the main objective of classification of auto transportation systems dispatch of freight was to limit the choice of approaches to display of the systems observed in practice, to develop description language that is the most suitable for the considered systems where micro and other auto transportation systems dispatch of freight has been for the first time formulated and described. The last option of definition of the term «micro auto transportation systems dispatch of freight» and its model was given in the work written by professor Vitvitskiy E.E. «Modeling of transport processes» where the microsystem was understood as set of point of loading and point of unloading, transport communications between them, freights, the vehicle and a control system. The technological scheme of transportations of freight in the micro auto transportation system dispatch of freight is the pendular route with the return unloaded run on which, according to the need for transportations, it is necessary to have no more than one vehicle.

One of definitions of the term «average auto transportation system dispatch of freight» and its model was given in the monograph written by professor Mochalin S.M. «Scientific bases of improvement of the theory of freight automobile transportation along radial routes» where «it is necessary to understand a set of one central and a set of the peripheral points connected among themselves by the transport network as the average system of freight delivery and transportation of freight are made by vehicles along a radial route, which directions on a configuration correspond to pendular and loop transport schemes». In them, dispatch of construction freights occurs: sand, brick, ferro-concrete products, etc. Aspects of concrete dispatch are also presented in work [7]. The schedule of the work of vehicles in the simple average unsaturated auto transportation systems, dispatch of freight of the 1st type is given in fig. 1.



where  $U_m$  – point of unloading,  $1, \dots, M$  – number of point of unloading;  $L_n$  – a loading post,  $1, \dots, N$  – number of a post of loading;  $l$  – the movement with freight;  $v$  – a vacant run; lunch – a lunch of drivers and freight points,  $z$  – a zero run.

**Figure 1.** The work schedule of vehicles in idle time in average to the unsaturated auto transportation systems dispatch freight of the 1st type

Today, transportations of construction freights are carried out not only in the micro auto transportation system dispatch of freight or in the average unsaturated auto transportation system dispatch of freight of the first type (illustration 1). Transportations of construction freights are carried out at the same time on several separate pendular routes with the return unloaded run; one vehicle separately works at each of which.

### 3. Results and Discussion.

Application of the above-stated models of auto transportation systems dispatch of freight and the simple unsaturated average motor transportation system of transportation of goods for planning of transportations on several separate pendular routes with the return unloaded run, separately works at each of which one vehicle has a negative result. It became the basis for development of a new model.

### Descriptive model of set of micro auto transportation system dispatch of freight

« $\Sigma$ Smikro» is understood as several micro auto system dispatches of freight (Smikro) united in the aggregate, which are working separately from each other in the interests of the consignor within operational planning.

Points of loading Smikro are in the isolated territory of one consignor, and points of unloading of each of Smikro are different and located in the territory of the city. Smikro entering  $\Sigma$ Smikro have the general time of functioning, transportation of freight by vehicles, public auto transport. Practice of transportations in  $\Sigma$ Smikro represents single work of separate vehicles in several separately functioning Smikro (in each of which only one vehicle works) that causes lack of need in creation of the general schedule of vehicles' work for minimization of idle times of the vehicle waiting for service. The planned volume of transportations in separate Smikro can be from minimum (one trip) to maximum (a maximum value possible number of trips of one vehicle during functioning of dispatch of freight of the micro-auto transportation system).

1. The structure of model  $\Sigma$ Smikro is:

$$\{\text{Smikro1, Smikro2, ... Smikro}_m; T_s; Y; \text{summary sheet of account}\}$$

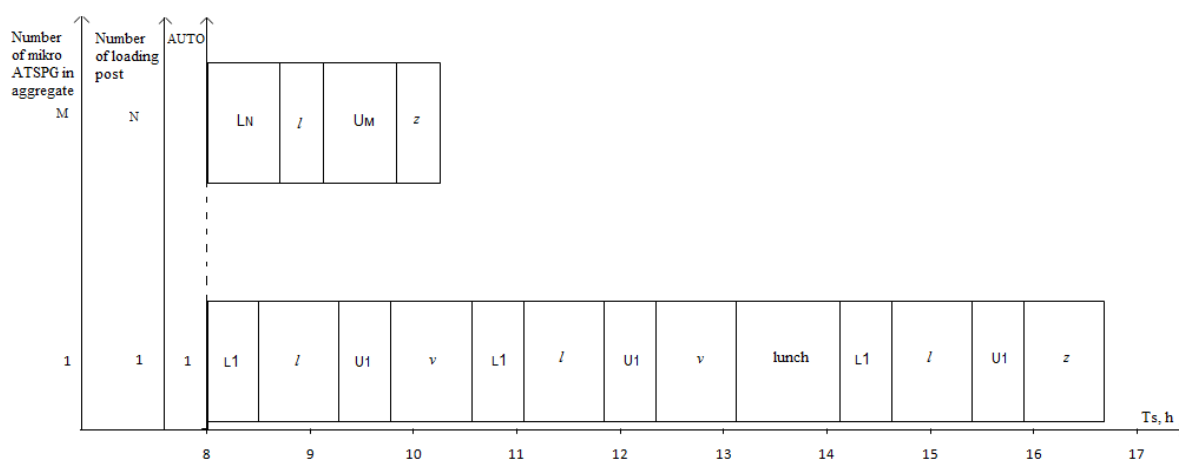
where Smikro1,2 ..., m – serial numbers of Smikro.

The quantity of Smikro (m) in  $\Sigma$ Smikro is limited: either quantity of posts of loading of the consignor (n) or the number of consignees ( $\Sigma$ CN) in work change, on condition of Smikrom-1 Smikrom, where it does not cross the dispatch of freight of the auto transportation system.

2. Functioning time  $\Sigma$ Smikro for all vehicles begins at the same time, with the beginning of functioning time of the consignor ( $t_1$ ), for example from 8:00. Completion of the concrete vehicle work in separate Smikro is defined by performance time of planned volume of transportations from a separate post of the consignor ( $t_2$ ):

$$T_s = \{t_1, t_2\}. \quad (1)$$

3. The tool for management in  $\Sigma$ Smikro (At) is the summary sheet of the dispatcher intended for use in operational planning, the organization of transportations and dispatching regulation (if necessary) and the subsequent analysis of results of the performed works (Figure 2).



**Figure 2.** Summary sheet of the dispatcher (work scheme of vehicles in total micro auto transportation system dispatch of freight)

There is the operating plan dispatch of freight in the separate micro-auto transportation system dispatch of freight at the minimum planned volume of transportations.

Route length:

$$l_r = l_l + l_v \quad (2)$$

where  $l_l$  – a mileage with freight, km;  $l_v$  – a mileage without freight (vacant run), km.

For this plan of lx, it is equal to zero.

Trip time:

$$t_t = \frac{l_r}{V_T} + t_{lu} \quad (3)$$

where  $l_r$  – length of a route, km;  $V_T$  – average technical speed, km/h;  $t_{lu}$  – time of loading - unloading of the vehicle.

Considering that  $t_{lu} = \tau_{lu} \cdot q\gamma$ , formula 4 will take a form:

$$t_t = \frac{l_r}{V_T} + \tau_{lu} \cdot q\gamma \quad (4)$$

where  $\tau_{lu}$  – time for loading-unloading of one ton of freight, h;  $q$  – loading capacity of the vehicle, t;  $\gamma$  – coefficient of static use of loading capacity.

Output in tons per a trip, work shift, day ( $Q_{smicro}$ ):

$$Q_{smicro} = q\gamma \quad (5)$$

Output in tons in this operating plan per a trip, work shift, day is equal.

Output in ton-kilometers per trip, work shift, day is:

$$P_{smicro} = q\gamma \cdot l_l \quad (6)$$

Development in ton-kilometers in this operating plan per trip, work shift, day is equal.

The general mileage per shift, day is:

$$L_{gen} = l_{z1} + l_l + l_{z2} \quad (7)$$

Time in a shift is:

$$Ts_{act} = \frac{l_{z1}}{V_T} + \left( \frac{l_l}{V_T} + t_{lu} \right) + \frac{l_{z2}}{V_T} \quad (8)$$

The operating plan dispatch of freight in the separate micro-auto transportation system dispatch of freight occurs with the maximum planned volume of transportations. The length of a route is calculated by formula 3. Time of a trip, turn is calculated using formula 4 or 5.

The number of trips per work shift:

$$Z_t = \left[ \frac{T_p}{t_t} \right] + Z'_t \quad (9)$$

where  $Z'_t$  – a possible trip for the rest of time ( $\Delta T_p$ ) after execution of an integer of the  $[X]$  turns.

The planned operating time of the vehicle is equal in Smikro ( $T_p$ ) to the Ts (Ts – duration of functioning of Smikro):

$$T_p = T_{pv} - t_{z1} \quad (10)$$

where  $t_{z1}$  – time for the first zero run, h;  $T_{pv}$  – planned operating time auto transportation, h.

$\Delta T_p$  is calculated by:

$$\Delta T_p = T_p - \left[ \frac{T_p}{t_t} \right] + t_t. \quad (11)$$

A possible trip for  $\Delta T_p$ :

$$Z'_t = \begin{cases} 1, & \text{if } \frac{\Delta T_p}{l_l/V_T + t_{lu}} \geq 1 \\ 0, & \text{otherwise.} \end{cases} \quad (12)$$

Output in tons of a vehicle per shift in the micro auto transportation system dispatch of freight is:

$$Q_{S_{micro}} = q\gamma \cdot Z_t \quad (13)$$

where  $q\gamma$  – the actual loading of the vehicle, t.

Output in ton-kilometers of vehicle per shift in the micro auto transportation system dispatch of freight is:

$$P_{S_{micro}} = q\gamma \cdot Z_t \cdot l_l. \quad (14)$$

Mileage of a vehicle per shift:

$$L_{gen} = l_{z1} + l_r \left[ \frac{T_p}{t_t} \right] + l_l + l_{z2}. \quad (15)$$

Actual time per shift:

$$Ts_{\frac{a}{c}}^t = \frac{l_{z1}}{V_T} + \left[ \frac{T_p}{t_t} \right] t_t + \left( \frac{l_l}{V_T} + t_{lu} \right) + \frac{l_{z2}}{V_T}. \quad (16)$$

where  $l_{z1}$ ,  $l_{z2}$  – respectively the size of a zero run daily when giving the vehicle for the first loading and returning the vehicle from the last unloading in a haulage company (car-park).

The formula of  $l_l/V_T + t_{lu}$  takes place in case if  $Z'_t = 1$ .

2. It is calculation of results of the vehicle work in  $\Sigma S_{micro}$  per shift.

The required number of vehicles per shift:

$$N_{AUTO} = m \quad (17)$$

where  $m$  – quantity at the same time and separately of the working  $S_{micro}$  per shift, a unit of measurement.

Output in tons ( $Q_{\Sigma S_{micro}}$ ) in total of the micro auto transportation systems dispatch of freight is:

$$Q_{\Sigma S_{micro}} = \sum_1^m Q_{S_{micro}}. \quad (18)$$

Output in ton-kilometers ( $P_{\Sigma S_{micro}}$ ) is:

$$P_{\Sigma S_{micro}} = \sum_1^m P_{S_{micro}}. \quad (19)$$

Mileage of all vehicles in total to the micro auto transportation system dispatch of freight: ( $L_{\Sigma S_{micro}}$ ), km:

$$L_{\Sigma S_{micro}} = \sum_1^m L_{gen}. \quad (20)$$

The number of car-hours of vehicle work (labor input of the contract):

$$Ahp_{\Sigma S_{micro}} = \sum_1^m Ts_{act}. \quad (21)$$

#### 4. Conclusion

The model, which we have developed, will permit considering features of practice of transportations of construction freights in cities within operational planning of work of a group of vehicles, each of which works separately. The application of this model has shown its efficiency. It allows providing the required accuracy and time of calculations.

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