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Mutual Coordination of Logistic Activities of Vehicles and Shippers Servicing Them

Kuziev Abdimurot Urokovich; MuratovAbobakr Kholikberdievich

Candidate of Technical Sciences, Associate Professor, Termez State University, Uzbekistan.
Lecturer, Termez State University, Uzbekistan.

ABSTRACT: In recent years, the growth of urban populations, the growth of urbanization and the development of the economy have created serious problems in the provision of transport services in cities.In particular, during the transportation of goods, the following problems are observed: an increase in the number of cars in cities, a high level of noise and congestion, as well as a negative impact on the urban atmosphere.The article describes how to organize the transportation of construction goods in cities, coordinates the work of shipping and receiving points, and increase the efficiency of transportation.

KEYWORDS: cargo turnover, carrying capacity, consignee and shipper, construction transportation, efficiency, freight, logistics, radial route, road transport.

I. INTRODUCTION

It is known that the administrative management of road transport is not carried out by the state, today each economy independently solves its own transport tasks.As a result, it is generally accepted that current practice is such that the efficiency of such car activities is not at the required level.This causes a lot of problems, especially in urban conditions.Growing urbanization and economic development cause serious problems in urban transport, while urban transport is an important element in retail and industry, but has a negative impact on urban life in terms of increased traffic flow and exhaust gases (Bram Keane, Sarah Verlinde, Cathy Macharis 2017, Dablanc, 2007, Verlinde, 2015).

II. MATERIALS AND METHODS

A significant share of cargo traffic in cities is made up of various construction loads.According to the classification of goods by industry [4], construction goods occupy the largest share in mass transportation of goods in urban conditions.Construction loads are distributed by specific weight as follows: soil (soil) (31-38%), inert materials up to 25%, concrete mixture up to 22%, reinforced concrete products up to 16%, bricks (1.6-6.9%). [5].
The scientific works show the peculiarities of mass transportation of construction goods in urban conditions [5]:

- Transportation is carried out over short distances;
- Use of specialized equipment;
- The direction of cargo flow is mainly one-way (from the production site to construction sites, warehouses, etc.);
- Several flights per shift;
- Traffic restrictions (prohibition of traffic on central highways, streets with one-way traffic, sections of roads with restriction of possible loads, as well as reduction of road capacity in certain days and hours of the day and other factors);
- Possibilities of application of economic and mathematical methods (EMM) in transportation planning, as well as for additional grain construction loads;
- Duration of loading and unloading in relation to crumble goods;
- The need for additional operations during cargo transportation (loading, binding, opening and closing of boards);
- Development of clear schedules for transportation of materials for the arrangement of warehouses around construction sites.
- The use of radial routes in the transport of goods is observed in practice, and this is also noted in [6, 7], where one of their possible options is shown in figure 1, where the delivery of goods from a single centre of the sender (SCS), the recipient (R) us establish regions and vice versa.

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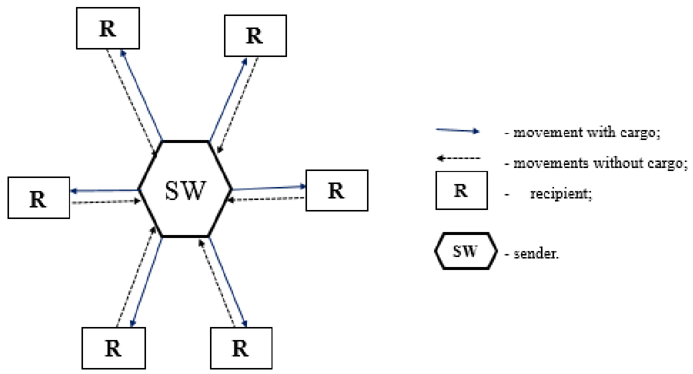

Figure 1. Radial direction.

In cities, construction goods are delivered radially from production premises or warehouses of facilities (reinforced concrete, brick factories and warehouses) to warehouses of construction facilities and other places (intermediate warehouses, etc.) where materials are required.Thus, each reinforced concrete or brick factory or warehouse is a central link in freight transportation.In many cities, such senders (quarries, container stations, reinforced concrete, brick factories, warehouses and other large senders) are usually few.In practice, the situation shown in Figure 2 is observed.
The flow of goods from different senders may be the opposite, and some recipients may be interested in the cargo of several senders. Figure 2.

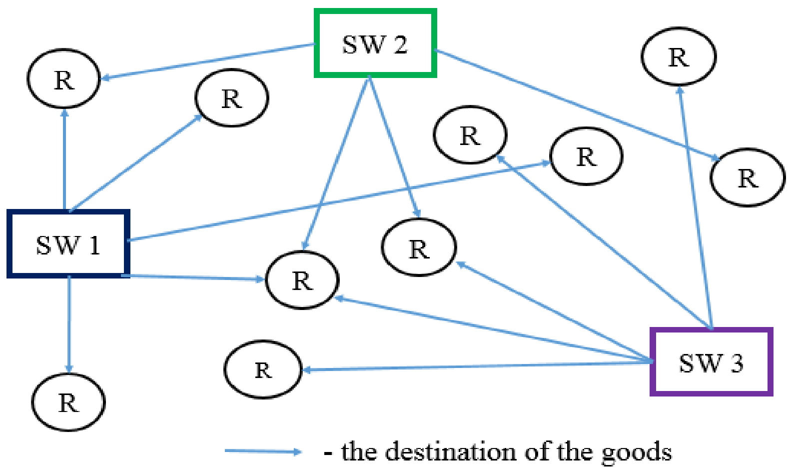

Figure 2. Senders (SW) and recipients (R) location and cargo flow direction.

The relations between the shipper and the consignee are based on economic (cost of materials, methods and conditions of payment), technical (nomenclature and quality of materials), transport (distance, delivery time, duration of cargo operations), subjective (kinship, friendship) and other conditions. Withdrawal is based on contracts.Goods carried according to the scheme shown in the example (figure 2), regardless of the difference in different nomenclatures and volumes, are considered to be the same mode of transport and are carried by the same vehicle.
For this, as shown below, today's practice in the republic and abroad uses the previously tested form of transportation organization, which showed its positive aspects - centralized transportation.At the same time, observations show that each shipper (the shipper's method) carries out transportation on the basis of its interests, without taking into account the interests of other shippers, especially the population in the service area.This leads to excessive use of vehicles and, accordingly, to an increase in the cost of products and services, as well as to harmful effects on the environment in the form of exhaust gases, noise, reduced road capacity, and so on.
It is known that the service intensity of shipping (receiving) points during transportation should correspond to the time

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intervals of their entry into the service system, which is formed depending on the number of allocated vehicles.Otherwise, the inefficient waiting time for points or vehicles will increase.In this case, it will be necessary to agree on the flow indicators of incoming to the service system and the serviceability of the points. This is:

- the number of points depends on the intensity of the flow entering the system or
- planning of the incoming flow, which is formed depending on the number of cars in service, according to the served capacity of the points.Such planning should aim to ensure that the amount of economic loss resulting from the mutual expectation of claimants and scores is minimal.

The methodology for solving this problem using the quantitative apparatus of the general service theory is as follows [8].

Suppose that the set of consumers receiving cargo from one delivery address is set to $J = \{1, 2, ..., j, ..., j_{ox}\}$.

The volume of cargo delivered to each consumer is known as Q_j, and the distance l_j, $j \in J$. Transportation is carried out on cars with q carrying capacity. Daily operating time of cars T hours. Under these conditions of transport, it is necessary to find such several shipping points and vehicles that the sum of the economic losses from the waiting time of cars and points is the least important. When using the analytical apparatus of the general service theory, this problem is solved using the following algorithm:

- the input of initial data;
- load capacity Q_j assigned to each consumer j, load capacity q of the vehicle and usage factor γ_{cm}, based on the daily working time values T, the flow intensity of incoming to the address of the sender from the j - route (consumer) is determined by λ_j, i.e.

$$\lambda_j = \frac{Q_j}{q \cdot \gamma_{cm} \cdot T} \quad \text{[avt/hour]} \quad (1)$$

the minimum number of service points (load increasing mechanisms) is determined by n.

$$n = \frac{\sum_{k=1}^{j_{ox}} \lambda_j}{\mu}, \quad (2)$$

where μ - the efficiency (intensity of service) of the single mechanism of the increase in loading, avt/h.

- The time spent by the car on one turn of the route when transporting cargo to each j consumer is equal to t_j:

$$t_j = t_{жс} + t_к + \frac{2\, l_j}{V_j^T} + \bar{t}_{кут} = t_{жс-к} + \frac{2\, l_j}{V_j^T} + \bar{t}_{кут}, \quad (3)$$

here $t_{жс}$, $t_қ$ – average shipping and receiving times (hours);

$\bar{t}_{кут}$ - the average waiting time in each cycle of the applicant;

$\bar{t}_{кут}$ = 0 in the beginning;

V_j^T – average technical speed (km/h);

$t_{жс-қ} = t_{жс} + t_қ$ – shipping and receiving times.

The minimum number of vehicles required to achieve the specified speed is determined.

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– j for the consumer $m_j = \lambda_j t_j$;

– forallconsumers
$$m = \sum_{j=1}^{j_{ox}} m_j = \sum_{j=1}^{j_{ox}} \lambda_j t_j \quad (4)$$
considered. In addition (5) the average intensity of the flow of incoming applicants from all routes is λ, that is calculated. In addition, in (5), the average intensity of the incoming flow of applicants from all routes is λ, i.e.

$$\lambda = \sum_{j=1}^{j_{ox}} \lambda_i . \quad (5)$$

The number of cars assigned to all consumers is rounded up to the larger value *m*.

– The norm for entering a separate vehicle into the service system is λ /:

– $$\lambda^{/} = \lambda \cdot \frac{1}{m}; \quad (6)$$

– The load factor of all service points determines Ψ:

– $$\Psi = \frac{\lambda^{/}}{\mu n}; \quad (7)$$

– y_0= 1 accepted as, because $y_\kappa = P_\kappa / P_0$ from being, $\kappa=0$ when y_0= 1, and then (8) based on the following reckurent formulas y_κ values are determined:

$$y_k = \begin{cases} \dfrac{m-k+1}{k} \quad \Psi\, y_{k-1}, & k \in \left\{ \overline{1,\ (n-1)} \right\}; \\ \dfrac{m-k+1}{n} \quad \Psi\, y_{k-1}, & k \in \left\{ \overline{n,\ m} \right\}. \end{cases} \quad (8)$$

The probability that there is not a single applicant in the service punk (in the service of the load-bearing mechanism) P_0 is determined as follows:

$$P_0 = \left(\sum_{k=0}^{m} y_k \right)^{-1} . \quad (9)$$

The probability that the service point is in a free state, P_0 (9) is calculated using the formula above.

– the probability that cars with the number c will be located at the delivery address is determined by the P_k:

$$P_k = y_k \cdot P_0 . \quad (10)$$

– calculates the average number of vehicles (HT) that are located at the delivery address (as a delivery service and waiting in line):

$$\overline{m}_{xm} = \sum_{k=0}^{m} k P_k . \quad (11)$$

– average number of vehicles (queues) waiting for service to start:

$$\overline{m}_{нав6} = \sum_{k=n+1}^{m} (k+n) P_k . \quad (12)$$

– An average number of unemployed ($\overline{n}_{бўш}$)points (mechanisms) waiting for the arrival of job seekers:

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$$\overline{n}_{бўш} = \sum_{k=0}^{n} (n-k)\ P_k\ . \qquad (13)$$

– verifies that the following inequalities are met, i.e.

$$\lambda^{/}\left(m-\overline{m}_{XT}\right) \geq \lambda \cdot 0,999. \qquad (14)$$

– If the condition to be checked is met, control proceeds to the next step, otherwise recalculation.
– $\lambda^{/}$ new value is found, ie

$$\lambda^{/} = \frac{\lambda}{m-\overline{m}_{xm}}\ . \qquad (15)$$

– It is then calculated from Control (15) to (6).
– Average wait time ($\overline{t}_{кут}$) corresponding to one car:

$$\overline{t}_{кут} = \frac{\overline{m}_{навб}}{\lambda^{/}\left(m-\overline{m}_{xm}\right)}\ . \qquad (16)$$

– *the time when the j went into the car circle on the route, the new value of t_j- $t_j^{я}$*

$$t_j^{я} = t_j + \overline{t}_{кут}\ , \qquad j \in \left\{\overline{1-j_{ox}}\right\}. \qquad (17)$$

– The new value of the number of cars (m) for transportation is $m^{я}$:

$$m^{я} = \sum_{j=1}^{j_{ox}} \lambda_j \cdot t_j^{я}\ . \qquad (18)$$

The optimum number of vehicles required to complete the transport process shall be determined on the basis of the following considerations.
In the 4 statements described, the value $t_j$is defined without regard to the time-out that may occur initially.
If we enter the waiting time in this formula, we will find that the new value of the turning time of the car on the route $t_j^{я}$, and the new value of the number of corresponding cars will be $m^{я}$.
If the new value found is equal to the previous value of $m^{я}$, then the new value determined by the number of cars will be optimal.
Otherwise, m=$m^{я}$is assumed, and the calculations for the new $m^{я}$ value are repeated.
Cycles of such calculations continue until the difference ($m^{я}$) becomes zero.
– It is checked that the difference m-$m^{я}$ is zero. If this condition is not met, then in the next step m-$m^{я}$ is taken and control is recalculated by formula (6).

Conversely, if the condition verified by the operator is met, the management proceeds to the next stage, in which the cost of one-day economic losses resulting from mutual waiting of vehicles and trucks is calculated as S_{days}:

$$S_{day}(n) = \left(C_{кут}^{T}\ \overline{m}_{нав} + C_{кут}^{к}\ \overline{n}_{бўш}\right) T\ . \qquad (19)$$

– the number of points n of its maximum possible numerical equation for N_{max}, i.e. n=N_{max}? The separation of state is investigated. If n<N_{max}, then control is transferred to the next step, where the number of points is multiplied by 1 *(n=n+1)*, and then calculated (6).

Otherwise, if n =N_{max}, proceed to the next step and define the number of points (n_{onm}) and the number of cars (m_{onm}) corresponding to min S_{day} (n).
We will now perform the simulation using the above algorithm.
The methodology for solving this problem using the quantitative apparatus of the general service theory is given below.

III. CONCLUSION

Suppose that the consignment is delivered from the sender's address to consumers $j\epsilon J$={1,2,3,4}.
Transportation is carried out on dump trucks of volume Q_j={330, 480, 235, 195} ($j\epsilon J$={1,2,3,4}) respectively in tons.

Actual average lifting capacity of one machine $q_n\gamma_{cm}$=5,26 ton, average loading time per machine $\bar{t}_{\text{хиз}}$= 3 min, and unloading time $\bar{t}_{\text{т}}$= 3 minutes.
Sending address running time T = 8 hours.
From the solution of this problem, it has become clear that the increase mechanism $n=2$and $m=47$ of vehicles work consistently and efficiently when performing a given transport for the given conditions.
The intensity of traffic on city streets is significantly reduced, which allows polluting the city air pool with exhaust gases and reducing noise levels.
The results of this article are taken from a study conducted as part of the practical project No. №OT-Атех-2018-352 "Wide application of logistics principles for the optimal development of the regional transport network and effective management of future cargo flows."

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AUTHORS BIOGRAPHY

Candidate of Technical Sciences, Associate Professor,
Termez State University, Uzbekistan.

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MuratovAbobakrKholikberdievich Lecturer, Termez State University, Uzbekistan.