Software Engineering
2018; 6(2): 63-68
http://www.sciencepublishinggroup.com/j/se
doi: 10.11648/j.se.20180602.15
ISSN: 2376-8029 (Print); ISSN: 2376-8037 (Online)

Management of Freight Transport Projects in Cities in Assessing Their Effectiveness

Dolia Kostiantyn[1], Dolia Olena[2], Lyfenko Sergey[3], Botsman Anastasiia[3]

[1]Department of GIS, Land and Real Estate Appraisal, O. M. Beketov National University of Urban Economy in Kharkiv, Kharkiv, Ukraine
[2]Department of Project management, O. M. Beketov National University of Urban Economy in Kharkiv, Kharkiv, Ukraine
[3]Department of Transport System and Logistics, O. M. Beketov National University of Urban Economy in Kharkiv, Kharkiv, Ukraine

Email address:
c.dolya@ukr.net (D. Kostiantyn), olena.dolya@ukr.net (D. Olena), sergiilyfenko@ukr.net (L. Sergey), botsman.nastya@gmail.com (B. Anastasiia)

To cite this article:
Dolia Kostiantyn, Dolia Olena, Lyfenko Sergey, Botsman Anastasiia. Management of Freight Transport Projects in Cities in Assessing Their Effectiveness. *Software Engineering*. Vol. 6, No. 2, 2018, pp. 63-68. doi: 10.11648/j.se.20180602.15

Received: June 30, 2018; **Accepted**: July 16, 2018; **Published**: August 17, 2018

Abstract: Modern scientific approaches to modeling the schemes and schedules of traffic in the city, as well as the tasks and disadvantages of modern software products for modeling such schemes are considered in the article. It is established that the definition of approaches to optimizing the route network of urban freight traffic between time and distance of the trip has not been fully explored. On the basis of analysis methods, computer simulation and statistical analysis methods, an advanced approach for determining the criterion of optimization of freight transportation between the length of the route and the time of the trip was developed. The proposed approach takes into account the intensity of the traffic flow in individual sections of the road network. With the help of comparison of the basic indicators of the functioning of the modeled routes optimized by two criteria, the approach for determining the optimization of the length of the route or the time of the trip was defined.

Keywords: Optimization of the Route Network, Time of the Trip, Length of the Trip, Efficiency of Transportation

1. Introduction

The question of optimizing the functioning of engineering networks is relevant in modern times. Authors of work [1] identified transport networks, which are the most common engineering networks in the world. The main function of transport networks is to provide the necessary conditions for the transportation of vehicles. The identified movements of vehicles for the carriage of passengers and cargo are realized on the calculated routes. The principal difference between urban passenger routes and freight routes is that the schemes and schedules of the traffic of the latter, for the most part, are not static. This is due to the availability on the modern market of software products for modeling routes for the transport of goods. These software products include ArcMap, PTV Visum, Horizon, QGIS, and others.

Defined software products solve the problem of modeling freight routes, but also have significant drawbacks. These disadvantages include:

1. not taking into account the state of the intensity of traffic of vehicles on the arcs of the network in real time, which affects the actual correspondence of the planned time of the trip to the actual time;
2. determining the length of the route by the criterion of optimization, which makes it impossible to carry out the appropriate modeling with the optimization by the parameters of the travel time;
3. static characteristics of cargo, which is a deterrent to the full use of these software products in certain areas, for example, mail;
4. the software architecture of the named software products does not include client-server relations between the vehicle and the route planning center; this determines the impossibility of re-scheduling a given vehicle's task in real-time, taking into account changes in the route.

The main task, which is solved by the mentioned software products, is the modeling of the scheme of movement of a freight vehicle in the network [2]. The determined modeling takes into account the possibility of introducing transportation parameters, namely: the features of the arcs of the network; the characteristics of the cargo and the vehicle; loading/unloading characteristics; start/end of the work shift and break, etc.

2. Theoretical Background

Modeling of urban routes is a topical issue of our time [3]. The definition of approaches to establishing schemes and timetables for the movement of vehicles across the city was considered for both passenger and freight transportation [4]. Scientists [5] considered the socio-economic impact of the quality of the organization of passenger transportation throughout the city. In the work of the authors [6] specific features of the organization of freight transportation by road transport are determined. Authors of the work [7] determined the ecological load of motor transport on the city. In the work [8] approaches to determination of cost of transportations taking into account factors of length of a route are considered, and in the works [9] – factor of duration of a trip. In these works, various issues are thoroughly and variously considered.

The results of the simulations are a scheme and a timetable of the movement. The routes proposed for use take into account the optimization of the efficiency of the transportation process, minimizing the number of vehicles and their mileage. Prognostic parameters of the transportation process are defined, such as: time in the run and movement time, the number of shifts, the mileage, the total time of service of the order, the total amount of costs spent in the run, the costs per one kilometer, the costs per hour, and others.

It is determined that the planning of schemes for the movement of freight trucks on the territory of the city is a topical issue. Modern scientific approaches to optimizing urban freight transport have thoroughly proved the need to take into account many factors [10] in carrying out this optimization. Scientists [7, 10] also determined the impact of the organization of freight transportation on socio-economic indicators of regional development. At the same time, the question of determining the factor of optimization of the route network between time and distance of the trip is not studied to the fullest.

3. Materials and Experiments

3.1. Route Modeling

Nowadays in the world the information about traffic intensity in the network becomes publicly accessible []. Such companies as Google, Inrix, TomTom, NAVTEQ, Sygic, Navigon, Yandex and others can be named among providers of such information. Modern information technologies allow taking into account the intensity of traffic on the links of the network and offer variants of routes, which differ in time and the trajectory of motion. Such calculations are based on almanacs (accumulated statistical information on arc characteristics in time) or data obtained in real time.

To find the approach for the determination of the criterion for optimizing transportation between the length of the route and the time of the trip, appropriate simulations were carried out on an example of the Paris city. The research uses methods of system analysis in the analysis of modern scientific approaches in planning route networks; computer modeling method for the construction of the trajectory of motion; statistical analysis method to determine the response functions.

The ArcMap software was used to plan the freight transportation routes in Paris. In the modeled route network there are 56 units – unloading places, one node –loading place, duration of the driver's working shift, time of work of unloading places.

As a result of the simulation, the main characteristics of the obtained route network were obtained, which are given in Table 1.

Table 1. *The main performance indicators of routes optimized by* l_p.

Route number	Costs per hour, Z_{hrs}, (c.u.)	Cost per kilometer, Z_{km}, (c.u.)	Time of the run, T^{lp}, (hrs)	Length of the run, l^{lp}, (km)
1	28.71	18.71	1.31	12.47
2	32.09	24.02	1.68	16.01
3	37.33	24.78	1.73	16.52
4	34.77	33.17	2.32	22.11
5	42.15	30.83	2.16	20.55
6	63.6	33.26	2.33	22.17
7	70.52	39.75	2.78	26.5

The disadvantage of the conducted modeling is the failure to take into account the intensity of traffic on individual sections of the road network. In fact, considered transportation takes place on a network that has variables of time in the parameters of the intensity of traffic in arcs. This suggests that the road network may have the characteristics in which it is possible to determine variants of routes with less time of movement in the run (t_p) with change of l_p due to optimization of route modeling by the t_p criterion.

3.2. Optimization of the Vehicle’s Trajectory of Movement

The received model of the route network determines the number and type of vehicles, as well as their routes. The repeated calculations of the basic indicators of functioning of these routes with optimization of the vehicle’s trajectory between the T^{lp} nodes are carried out.

It should be determined that the modeling of the route of the vehicle in the network by the T^{lp} parameter will have excellent results both during the day and on different days of the week. This is due to the fact that the speed of movement along the network links is not static in time.

Conducted modeling of the T^{tp}-optimized routes for work and weekend days provided the baseline performance indicators of routes functioning at different times of the day. This provided the opportunity to compare the basic performance indicators of routes operation optimized by l_p. and routes optimized by T^{tp}. Obtained results are summarized in Table 2

Table 2. *Comparison of the basic parameters of operation of T^{tp}-optimized routes with the routes optimized by l_p at different times of day for the working day.*

Time of day	Basic route parameter	Parameter value when optimizing by l_p	Parameter value when optimizing by t_p	Δ
7:00	T^{tp}, (hrs.)	1.30	1.30	0%
	l_p, (km.)	16.01	16.01	0%
9:00	T^{tp}, (hrs.)	2.07	1.80	-13%
	l_p, (km.)	16.01	19.15	20%
11:00	T^{tp}, (hrs.)	1.74	1.55	-11%
	l_p, (km.)	16.01	19.15	20%
13:00	T^{tp}, (hrs.)	1.68	1.48	-12%
	l_p, (km.)	16.01	19.15	20%
17:00	T^{tp}, (hrs.)	1.87	1.65	-12%
	l_p, (km.)	16.01	19.15	20%
19:00	T^{tp}, (hrs.)	1.85	1.64	-11%
	l_p, (km.)	16.01	19.15	20%
21:00	T^{tp}, (hrs.)	1.62	1.50	-7%
	l_p, (km.)	16.01	19.15	20%
22:00	T^{tp}, (hrs.)	1.30	1.30	0%
	l_p, (km.)	16.01	16.01	0%

Table 3. *Determination of Z_p parameters for routes modeled by T^{tp} and l_p parameters, selected as criteria of optimization.*

Route number	At t_p		At l_p	
	Costs per run, Z_p (c.u.)	Time of the run, T^{tp}, hrs	Costs per run, Z_p (c.u.)	Time of the run, T^{tp}, hrs
1	43.17	1.19	47.4	1.31
2	51.18	1.53	56.1	1.68
3	56.54	1.58	62.1	1.73
4	61.86	2.11	67.9	2.32
5	66.45	1.96	72.9	2.16
6	88.19	2.12	96.86	2.33
7	100.40	2.53	110.2	2.78

It can be concluded that the route scheme optimized by the T^{tp} parameter between 9:00 a.m. until 22:00 p.m. is variable in time, and in the interval from 22:00 p.m. to 9:00 a.m. coincides with the trajectory of movement obtained in route modeling by l_p parameter. A T^{tp} change graph over time during the day has been constructed for the routes optimized by T^{tp} and l_p, which is shown in Figure 1.

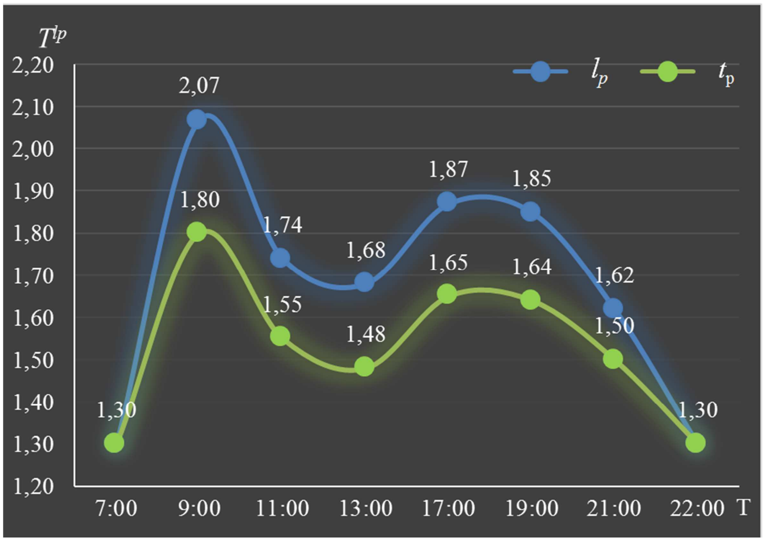

Figure 1. *T^{tp} changes over time during the day on a weekday, for routes optimized by T^{tp} and l_p.*

The obtained results determined that the optimization of the transport process is possible by t_p and l_p. Wherein modeling of routes with the definition of *tp* as a criterion for optimization has proved that Z_p costs are not static in time, Figure 2.

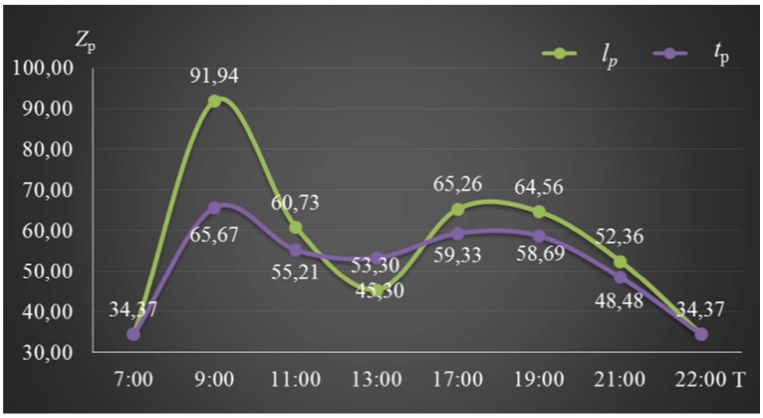

Figure 2. *The cost changes for the functioning of a route network overnight with its modeling by T^{tp} and l_p parameters.*

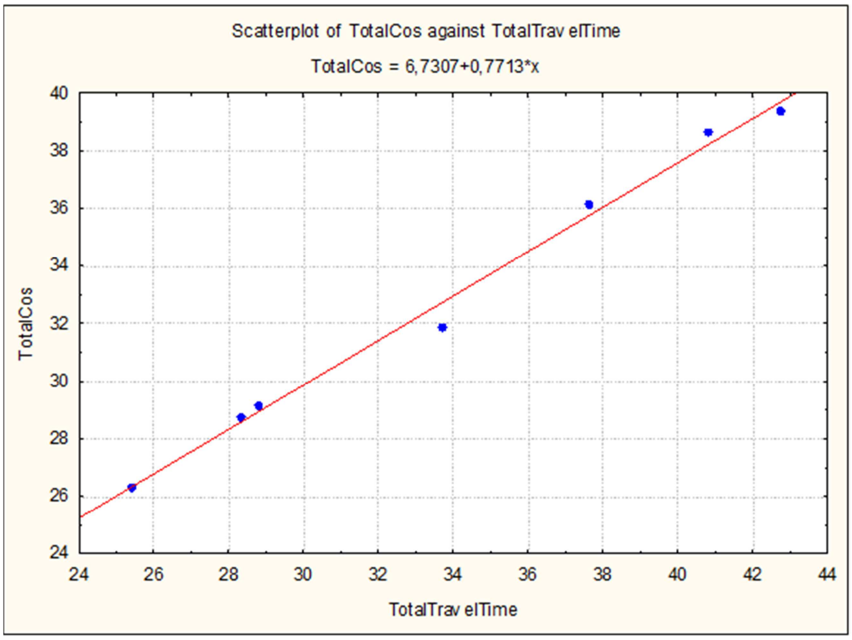

Figure 3. *Graph of the dependence of Z_p on T^{tp}.*

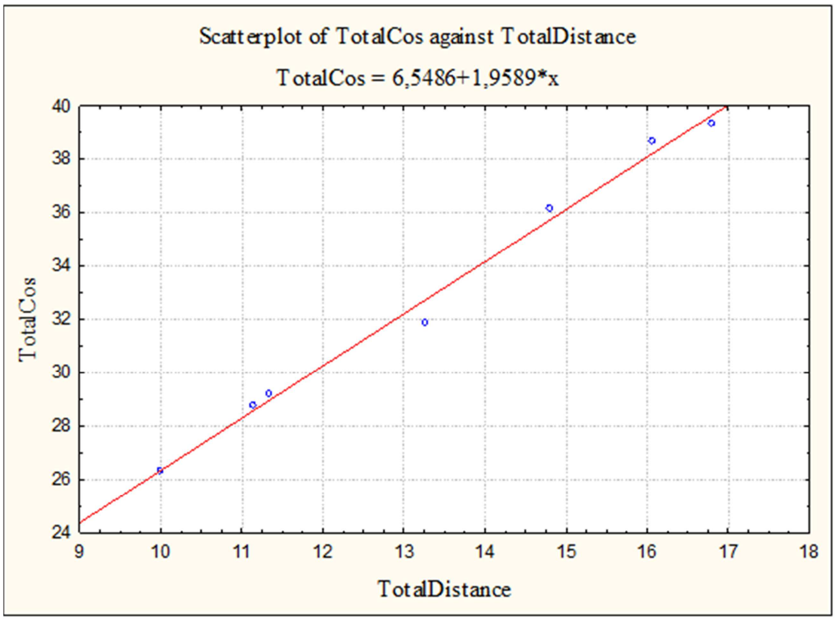

Figure 4. *Graph of the dependence of Z_p on l_p.*

Using the ArcMap software, route modeling was performed to set run cost values (Z_p) for each of the modeled routes. The modeling was conducted in two stages, indicating the T^{lp} and $l_р$ as the optimization criteria. The values of the basic indicators of Z_p of the routes are obtained, which is shown in the Table 3.

Using the obtained values of the basic parameters of the functioning of routes from the Table 3, it is possible to define the functions of the response (mathematical models) $Z_р$ from T^{lp} and $l_{р}$..

Figure 3 and Figure 4 show the distribution graphs $Z_р$ from T^{lp} and $l_р$ built using the Statistika software.

4. Results

Based on the values of the basic parameters of the functioning of routes from Table 3, the response functions (mathematical models) $Z_р$ from T^{lp} and $l_р$ were defined.

The obtained mathematical models have the following form:

$$Z_{pl} = a_l + Z_{\text{км}} \cdot l_{\text{р}}, \tag{1}$$

where: Z_{pl} – costs per run during the modeling with the definition of $l_р$ as an optimization criterion, (c.u.);

a_l– calibration length coefficient, (c.u.);

$Z_{\text{км}}$ – costs per one kilometer on the route, (c.u./km.);

$l_р$ – length of the run, (km.).

$$Z_{\text{рТ}} = a_t + Z_{\text{год}} \cdot t_{\text{р2}}, \tag{2}$$

where: $Z_{\text{рТ}}$ – costs per hour during the modeling with the definition of T^{lp} as an optimization criterion, (c.u.);

a_t– calibration time coefficient, (c.u.);

$Z_{\text{год.}}$ – costs per one hour of the trip on the route, (c.u./hrs.);

$t_{\text{р2}}$ – time of the run of the vehicle, (hrs.).

Let us assume that there exist such conditions for which $Z_{\text{км}} = Z_{\text{рТ}}$. This assumption provides the possibility of determining the following equation (3)

$$a_l + Z_{\text{км}} \cdot l_{\text{р}} = a_t + Z_{\text{год}} \cdot t_{\text{р2}}, \tag{3}$$

From equations (1) and (2) the conclusion is that if (1) > (2) it is expedient to use the modeling of the trajectories of movement with the definition of $t_р$ as an optimization parameter and vice versa.

Equation (3) provides an opportunity to propose assertions (4)

$$Z_{\text{р}\,opt} = \begin{cases} a_l + Z_{\text{км}} \cdot l_{\text{р}}; & t_{\text{р2}} \le \dfrac{Z_{\text{км}} \cdot V_{\text{c1}} \cdot t_{\text{р1}} - a_t + a_l}{Z_{\text{год}}} \\ a_t + Z_{\text{год}} \cdot t_{\text{р2}}; & t_{\text{р2}} > \dfrac{a_l - a_t + Z_{\text{км}} \cdot V_{c1} \cdot t_{\text{р1}}}{Z_{\text{год}}} \end{cases}, \tag{4}$$

where: $Z_{\text{р}\,opt}$– optimal costs per run;

$t_{\text{р1}}$– time of the run at optimization by time;

V_{c1}– connection speed when optimizing by time.

The equation (4) describes the conditions for the onset $Z_{\text{р}\,opt}$, which provides a thorough definition of the optimization factor for trajectories of freight routes on the example of Paris city.

5. Discussion

The obtained results of the study define the approach to determining the criterion of optimization of the trajectory of vehicle's movement by the territory of the city. The basic criteria for optimizing the scheme of the movement are the time and length of the route trip. It can be determined that increasing the efficiency of urban freight transportation reduces the environmental burden on the city, the cost of transportation and, as a consequence, the transport component in the final value of the goods for the end user in the city.

6. Conclusion

In the given work for the first time the technology of estimation of the information on the intensity of traffic of vehicles on the arcs of the road network for the decision on determining criteria of optimization of the scheme in the territory of cities is determined.

For the first time, technology for assessing information on the intensity of the traffic of vehicles on the links of the route network was determined for making a decision on determining the criteria for optimizing the scheme of freight transport in the territory of cities.

The proposed approach provides the opportunity to take into account the characteristics of the city's transport network in real time or on the basis of accumulated statistical information, which has improved the known similar approaches.

The strengths of the study consist in the possibility of improving the efficiency of the criterion of optimization of freight traffic between the length of the route and the time of the trip, taking into account the intensity of the traffic flow along the arcs of the road network. The determined modeling takes into account: 1) the possibility of introducing transport parameters, namely: the features of the network arc, the characteristics of the load and the vehicle, loading/unloading characteristics, start/end of the work shift and breaks; 2) forecasting parameters of the transportation process such as: time in the run and movement time, number of working shifts, mileage, total service time of the order, total amount of costs per run, expenses per one kilometer of the run, expenses per hour and others. This will allow taking into account the optimization of the efficiency of the transportation process by minimizing the number of vehicles and their mileage, time of travel and total run costs.

The weaknesses of the study include the inability to guarantee static indicators such as time and total costs per run of a freight vehicle, because the intensity and speed of the traffic flow changes every minute. As a result, it is impossible to simulate real-time traffic patterns of a freight vehicle because the software architecture does not provide client-server relations between the vehicle and the route planning center; this is due to the inability to redesign the task given to the vehicle in real time, taking into account changes on the route..

Further development of the proposed study will allow taking into account the characteristics of the transport network of the city in real time. The accumulated information also can be used for the purpose of planning of statistical schemes and schedules of traffic of vehicles. This provides an opportunity to improve the efficiency of freight traffic in the metropolis, as well as improve the financial flows of the carrier through optimization of the transport process.

There are difficulties in applying the results of research related to the complexity of co-operating of software and information about the traffic flow through the arcs of the road network. After all, the non-use of traffic flow information can lead to an increase in the total travel time and increase the cost of the run.

References

[1] Kostiantyn, D. (2017). Influence of the Seasonal Factor on the Long-Distance Passenger Correspondence. *American Journal of Data Mining and Knowledge Discovery*, *2* (4), 96-101.

[2] Dolya, C., Lyfenko, S., Nesterenko, S., & Vyatkin, K. (2017). Influence of features of the transport network pattern on the haul cycle length between its nodes on the example of the transport network of Ukraine. *Technology audit and production reserves*, *5* (2 (37)), 54-58.

[3] Dolya, C. V. (2017). Gravity Model Formalization for Parameter Calculation of Intercity Passenger Transport Correspondence. *SCIENCE & TECHNIQUE*, *16* (5), 437-443.

[4] Dolia, K., Davidich, Y., Dolia, O., Lyfenko, S., & Uhodnikova, O. (2017). Modeling of polygons of maximum passenger route transport accessibility by the example of the transport system of Ukraine. *Technology audit and production reserves*, *6* (2 (38)), 28-33.

[5] Kostiantyn, D. (2017). Variativity of the Transport System at Intercity Passenger Transport from the Demand. *International Journal of Data Science and Analysis*, *3* (6), 77.

[6] Dolya, C., Lyfenko, S., Nesterenko, S., & Vyatkin, K. (2017). Influence of features of the transport network pattern on the haul cycle length between its nodes on the example of the transport network of Ukraine. *Technology audit and production reserves*, *5* (2 (37)), 54-58.

[7] Dolya, C., Botsman, A., & Kozhyna, V. (2017). Investigation of approaches to modeling of intercity passenger transportation system. *Technology audit and production reserves*, *4* (2 (36)), 24-28.

[8] Dolya, C. (2017). Modeling of intercity passenger transportation system. *Technology audit and production reserves*, (2 (2)), 37-43.

[9] Grigorova T., DavIdIch Yu., Dolya V. (2015). Assessment of elasticity of demand for services of suburban road passenger transport. Technology audit and production reserves. 3. 2 (23). 13–16.

[10] Dolya, C. (2017). Modeling of passenger transport correspondence between regional centers in Ukraine. *Technology audit and production reserves*, *1* (2 (33)), 44-48.