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ANALYSIS OF THE TRANSPORT FLOWS SERVICE TIME OF THE VEHICLES AND THE ASSESSMENT OF THE IDETERMINANCY OF EXTERNAL IMPACT

Aldona Jarašūnienė

Transport Research Institute, Vilnius Gediminas Technical University,
Plytinės g. 27, LT-2016 Vilnius, Lithuania
E-mail: ajarasuniene@yahoo.com

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Abstract. To increase the attraction of Lithuania as a transit country striving to promote carriers' border crossing activities and facilitate customs clearance procedures as well as freight delivery to clients it is necessary to identify the main obstacles, to analyse them and to select adequate measures and means for their elimination. Therefore, on the basis of the analysis of the transport flows service time, as well as basing on the assessment of indeterminacy of external impacts, it would be possible to deduce the main causes of idle time of transport means at customs, to estimate the dependence of service time in proportion to transport flows. Basing on theoretical estimation in this article the estimation of service time of international transport and the management of transport flows are described.

Keywords: transport flow, theoretical research, estimation of service time of international transport.

1. Introduction

Transport should be an important guarantee of ensuring sustainable public mobility and transportation of goods, supporting the dynamic development of national economy. The most complex issue is to identify precisely the problems of freight transport and to select properly as well as to adjust different means and advanced technologies. In the course of working out the means related to the perfection of freight transport it is necessary to consider all possible consequences of their realization upon the transport sector as well as upon other sectors of national economy (consequences of technological, economical aspects, as well as of social, ecological and even political aspect) [1–5].

Therefore, regarding advanced technologies, information systems and other means ensuring freight transportation development as well as the acceleration of freight interoperability, it is necessary to create and develop new technologies, to model the development of Lithuanian transport system in general, to elaborate a steadily operating system of modelling and forecasting of transit transport and freight flows. It is important to establish new technologies at transport terminals thus enabling direct reloading of goods from one transport mode to another [6].

With the aim to increase the attraction of Lithuania as a transit country it is necessary to identify the main obstacles in the field of border crossing and formalities of customs procedures.

While analysing this situation it is important to explore the incoming and outgoing transit transport flows, to identify their theoretical distribution in proportion to customs and transport pressure on customs as well, to research the influence of international transport flows service time and to assess the indeterminacy of external impacts.

Basing on the formulation of estimation of service time for international transport and on the assessment of indeterminacy of external impacts it will be possible to perform detailed research into the flow distribution of incoming transport means according to the time and their distribution in separate customs lanes [7]. It will also allow to identify the idle time of transport means and to measure the dependence of carriers' service time in proportion to transport flow.

2. Estimation of Service Time of International Transport

Basing on the experiment we see that flows of cars entering a customs post are distributed to identify the exponential law. Thus at every moment the average quantity of cars at platform $\bar{n}$ will be formulated by the average speed of arriving cars, by the average service time and the dispersion of service time:

$$\bar{n} = \frac{\lambda}{\mu} + \frac{\lambda^2 \sigma_{t_s}^2 + (\lambda/\mu)^2}{2[1-(\lambda/\mu)]}, \qquad (1)$$

there $\sigma^2_{t_s}$ – dispersion of t_s service time. From (1) equation it is seen that if senses λ and μ are fixed, the average quantity of arriving cars increases due to increasing dispersion $\sigma^2_{t_s}$. If λ and μ are invariable, the average the quantity of cars at platform is accordingly $\sigma^2_{t_s} = 0$. When the speed λ of arriving cars and service time μ are the same, then:

$$\bar{n} = \frac{\lambda}{\mu} + \frac{(\lambda/\mu)^2}{2[1-(\lambda/\mu)]}. \tag{2}$$

If the service time of arriving cars is distributed by the exponential law and if it has a negative sense and average sense μ, then $\sigma^2_{t_s} = 1/\mu^2$, in this case the equation (1) will be:

$$\bar{n} = \frac{\lambda/\mu}{1-\lambda/\mu},$$

From (1) equation we see that the average quantity of cars is increased when the average quantity service time $(\lambda - \mu)$ exists.

From this equation we see that according to the established distributing law of service time the number of cars at the platform can be decreased only decreasing quantity λ/μ. This proportion decides the average quantity of cars at the platform. For example if λ/μ decrease, quantity $1-(\lambda/\mu)$ increases, but the quantity of cars at the platform decreases [6].

3. Assessment of the Ideterminancy of External Impact

Let us analyse the objective of the optimal management of transport flows (3)–(7).

$$J_0(X, U, t) \rightarrow \max; \tag{3}$$

$$\Delta X(t) = \varphi(U, t), \quad t = \overline{0, T-2}; \tag{4}$$

$$l(t, \xi) \le U(t) \le f(t, \xi), \quad t = \overline{0, T-1}; \tag{5}$$

$$X(T) \le g(t, \xi), \quad t = \overline{1, T}; \tag{6}$$

$$\left.\begin{array}{l} X(t) \ge 0 \\ U(t) \ge 0 \end{array}\right\}, \quad t = \overline{0, T}. \tag{7}$$

And the set of initial states $X(0)$ – is put:

$$X(0) = X^0,$$

here (1) – criterion of management efficiency;

(2) – management of the movement of a managed object;

(3) – permissible management range;

(4) – limitations for phasic coordinates;

(5) – non-negativity of phasic variable and managing parameters.

By the stochastic model (3)-(7) it is possible to define a great class of transport flows optimal management objectives.

For the solution of the objective we shall use a two stage scheme of optimisation. Here in the first stage it is stated that $\xi = 0$ and the solution is sought of a determined objective (programme trajectory), but in the second stage it is considered that ξ is a small deviation and a minimisation objective of the occurring deviation from the programme trajectory is solved [6].

Thus for the search of the programme solution the initial objective will be written as follows:

$$\begin{aligned} & J_0(X, U, t) \rightarrow \max; \\ & \Delta X(t) = \varphi(U, t); \\ & l(t) \le U(t) \le f(t); \\ & X(t) \le g(t). \end{aligned} \tag{8}$$

The solution of this discrete optimal management objective may be obtained using the discrete maximum principle or traditional methods of network solution which as a rule tend towards the solution of a static objective in a relevant deployed network [8].

Let us presume that the solution of the objective (8) has been obtained and it is of the following shape $\tilde{X}(t)$ and $\tilde{U}(t)$.

Now, assuming that interferences ξ are sufficiently insignificant, we shall seek for the solution of the objective (3)–(7) in the shape of:

$$\begin{aligned} & X(t) = \tilde{X}(t) + y(t); \\ & U(t) = \tilde{U}(t) + v(t), \end{aligned} \tag{9}$$

here $y(t)$ and $v(t)$ are small successions as well as in ξ. Having inserted (10)

$$X(t+1) = X(t) + B^{+}U(t) + B^{-}U(t+1), \quad t = \overline{0, T-2}; \tag{10}$$

into the initial issue (3)–(7) and having deployed the functions φ, l and f into the line according to y, v, ξ and leaving only linear members we shall obtain:

$$\begin{aligned} & \Delta y(t) = a(t)v(t); \\ & y(t) = g(t)\xi + \bar{g}(t); \\ & \bar{l}(t) + \theta(t)\xi \le v(t) \le \delta(t)\xi + \bar{f}(t); \\ & \bar{g}(t) = g(t) - \tilde{X}(t); \\ & \bar{f}(t) = f(t) - \tilde{U}(t); \\ & \bar{l}(t) = l(t) - \tilde{U}(t); \end{aligned} \tag{11}$$

$$\alpha = \left(\frac{\partial \varphi}{\partial \xi}\right), \ \theta = \left(\frac{\partial l}{\partial \xi}\right);$$

$$\gamma = \left(\frac{\partial g}{\partial \xi}\right), \ \delta = \left(\frac{\partial f}{\partial \xi}\right).$$

Here all the derivative programme trajectories are calculated along the system (i.e. at the zero meanings of ξ, v, y). In the second stage for various objectives the functional, which has to be minimised, may be of different expression. In general shape we shall put it as follows:

$$J_1(y, v, t) \to \min. \tag{12}$$

Further, in the second stage, we shall solve the objective identifying the correcting management $v(x,t)$ and the reaching minimum to functional (12) to the conditions (11). For finding $v(x,t)$ it is necessary to know how to measure present solution diversions from that of the programme, at least at relevant discrete moments and to select correcting impacts according to the results of this measurement. The objective is solved by the mechanism of reversible synthesis. However, in general, there are no regular methods of making the reversible mechanism. We shall apply the above said general solution sequence for the 3–6 objectives. After restoring (9) into the conditions and after linearization, we shall obtain:

$$y(0) = 0; \tag{13}$$

$$\bar{l}(t) + \theta(t)\xi \le v(t) \le \delta(t)\xi + \bar{f}(t);$$

$$y(t+1) = y(t) + B + v(t) + B - v(t+1);$$

$$y(T) = y(T-1) + B + v(T-1);$$

$$y(t) \le \gamma(t)\xi + \bar{g}(t).$$

Further we shall state that the quantities $\theta(t)$ and $\delta(t)$ for each t cannot have a meaning with various symbols and the quantities $\theta(t)\xi$, $\delta(t)\xi$ and $\gamma(t)\xi$ may be positive and negative as well.

Let us take the criteria of the second stage for the objectives 3-6.

1 Objective.

$$y_n(T) \to \min. \tag{14}$$

2 Objective.

$$\left| \sum_{t=0}^{T} (R(t),\ v(t)) \right| \to \min. \tag{15}$$

3 Objective.

$$Y_n(T) \to \min \tag{16}$$

if $\theta(t) = \delta(t)$, for all branches of a lot $\Omega(t)$.

4 Objective.

$$\left| \sum_{t=0}^{T-1} \left[\left(C(t),\ v^2(t) \right) - \left(R(t),\ v'(t) \right) \right] \right| \to \min;$$

$$v^1(t) + v^2(t) = v(t); \tag{17}$$

$$v^1(t) \le \delta^1(t)\xi,\ v^2(t) \le \delta(t)\xi.$$

Further, basing on theoretical research, it will be possible to make the analysis of the distribution (according to time) of flows of cars entering a customs post as well as the analysis of their distribution into separate customs lanes. It will also be possible to identify the idle time of transport means caused by customs procedures, to identify the dependence of the time of services given to carriers in proportion to the amount of transport flow, to calculate and to assess the optimal selection of transport amount for inspection in customs during a certain period of time.

4. Practical Assessment of the Theoretical Research of Transport Flows

Basing on the experiment we see that flows of international transport entering a customs post are distributed to identify the exponential law.

The described optimization service process model of international transport at a customs post implies to beat out the meaning of a technological process and to modell different parameters of this process.

The theoretical research into freight transport flows allows to make a detailed analysis of freight flows enabling the elaboration of the recommendations for the improvement of customs inspection procedures. Basing on this the analysis of freight structure and the distribution according to countries will enable to prepare the most influential forecasts of freight transport for separate customs-houses.

The stochastic management model obtained as a result of the theoretical research into freight transport flows enables the determination of a great group of optimal freight flows management issues, such as the issue on maximum dynamic flow in the network, which can allow to calculate maximum transport rate at a customs post; the objective of minimum cost, defining the extent of transported flow filling in the dynamic set of the pane, the objective the essence of which is the determination of minimum quantity of international transport means allowing efficient scheduling of transport traffic.

5. Conclusions

1. In the course of working out the means related to the perfection of freight transport it is necessary to consider all possible consequences of their realisation upon the transport sector as well as upon other sectors of national economy (consequences of technological, economical aspects, as well as of social, ecological and even political aspect).

2. It is important to define and to analyse transit transport flows, to identify their theoretical distribution in proportion to customs-houses and to investigate how busy they are with transport means.

3. Basing on the assessment of formulation of the objectives of management of transport flows and on the indeterminacy of external impacts, it is possible to carry out a more detailed analysis of the distributions (according to time) of flows of transport means entering customs, as well as their distribution into separate customs lanes. It also enables the definition of dependency on the extent of transport flows, as well as allows the calculation of choosing optimum transport amount for the inspection in customs-houses during a certain period of time.

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