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Transport Fatigue Simulation of Passengers in Suburban Service

Tatyana Grigorova, Yurii Davidich, Viktor Dolya

Department Transport Systems and Logistics, O. M. Beketov National University of Urban Economy in Kharkiv, Kharkiv, Ukraine

Abstract

Transport process has a negative impact on characteristics of passengers' life activity. Passenger gets tired during the process of transportation and it has a negative impact on characteristics of passengers' life activity. Long transportation leads to passenger free time reduction, that also has estimation cost. From the society perspective, the optimal technological parameters of passengers' transportation in a suburban public transport can be determined considering the transport enterprises incomes from the passengers' transportation, transport companies costs on the organization of transportation and value costs of society as a result of the transport process. The investigation aim is to measure transport fatigue changes arising among passengers from suburban transport using. Transport passengers fatigue is determined by examining changes in their regulatory system's activity index while transportation elements. It is described as a function of time and traffic conditions during transportation, passenger's age. The model's result can be used in the organization of transport services suburbanites.

Keywords

Passenger, Transportation Fatigue, Conditions of Transportation, Process

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1. Introduction

The main factor, when analyzing the demand and market of transport services, is the determination of initial requisites which define the passenger behavior [Krystopchuk 2009]. The production of goods and services is effectiveness to that extent in which the consumer takes and pays for the number of market values which he produced. The consumer makes the decision to take some services and it is based on the correlation between usefulness and wasted expense. In spite of all this the conception of "value" and "usefulness" doesn't formalize well. The question of social – phychological estimation of person's motivation to use transport services is much more investigated [Krystopchuk 2009, Kotler 1998]. A lot of authors in their works pay attention to the question of passengers choice of their way of movement (path choice) [Dolya 2011, Spiess, Florian 1989, Cepeda, Cominetti, Florian 2006, Wu, Florian, Marcotte 1994, Ponkratov, Faletska 2014]. For all this it is noted that one of the criterions of an unconscious choice of movement way is passenger transportation fatigue [Dolya 2011, Ponkratov, Faletska 2014]. When improving transportation process the demand for service increases. The demand determines the offer of services, and the situation on the market depends on the correlation between the demand and the offer as a result optimization of passenger transportation process in suburban service is to be made with the regard to interests of transportation facilities and passengers as well.

2. Formulation of the Problem

The aim of investigation is to measure transport fatigue changes arising among passengers from suburban transport using.

* Corresponding author
E-mail address: tagrigorova@yandex.ru (T. Grigorova), davidich@mail.ru (Y. Davidich), kafedra_tsl@ukr.net (V. Dolya)

3. The Results

The criterion efficiency for improvement of passenger transportation system in local public service is to take into consideration the interests both passenger and transport service department. It can be formalized as follows:

$$E = I_E - E_E - C_S \longrightarrow \max. \quad (1)$$

In which:

a) E – the effect of modernization of passenger transportation system in local service;

b) I_E – income of transportation department which they get transporting passengers;

c) E_E – expenditure of transportation enterprises when organizing the transportation process;

d) C_S – cost expression of society's expenditure as a result of transportation process.

Income and expenditure of transportation enterprises are determined by applied transportation technology. Cost expression of society's expenditure as a result of transportation process can be determined from the ergonomics point of view. The investigation of transportation parameters and passenger's transportation fatigue variation has been made. To estimate the transportation fatigue of person's functional state an integral criterion (regulatory system's activity index) was used [Dolya, 2011]. It reflects the whole reaction of organism on the influence on environmental factors. This index characterizes the information of channels intension in human organism and it reaction on the environmental factors influence. [Baevsky 1984, Dolya 2011]. It is determined by treating the human electrocardiogram (ECG) and measured on a scale, which can determine the state in which it is [Baevsky, 1984; Dolya, 2011]: up to 3 points - normal condition; from 3 to 6 points - a state of tension; from 6 to 8 points - an overvoltage condition; 9 to 10 points - a state of exhaustion.

A survey conducted on suburban routes city Kharkiv (Ukraine). In conducting the survey accountants came to the residence of the passenger before leaving the house. In passenger recorded his age and joined him Electrodes computer system "Kardiosens." After coming to a stop and the door of the vehicle when traveling in passenger sitting electrocardiogram was recorded using a computer system "Kardiosens." At the same time determined parameters trips and fixed brand vehicle.

Processing results of the survey was to determine the travel time (T), the age of the passenger (A_p), The cost of a new bus (C), corresponding brand, its nominal passenger (R) and technical Speed at trip (V). In addition, the determined values of the regulatory systems of passenger trips before (I^a) and after (I^b) its completion. To do this, was used special software computer system "Kardiosens". Results of calculations shows in Table. 1.

Table 1. Results of calculations processing.

I^a	I^b	T, с	V, км/ч	A_p	C/R, тис. $/мест
6,8	4,3	39	38,8	21	0,75
4,3	3	33	48,4	23	0,88
5,3	6,4	30	52,5	23	3,33
5,6	5,6	35	45,25	21	1,79
7,1	2,7	27	57,68	48	1,03
4	3,4	34	25,46	20	0,63
4,4	5,5	37	42,5	18	0,92
4,2	4,1	14	37	21	0,83
4,7	5,2	13	45	25	0,97
5,9	6,6	20	46	43	0,97
4,8	5	17	49	20	0,97
4	3,4	19	12,6	60	1,03

From all of the methods that allow describing change of regulatory systems activity of suburban passenger transport passengers, was chosen methods of regression and correlation analysis [Halushko, 1976]. Develop regression models was conducted using the guidelines in which the number of observations in 6-7 times the number of factors included in the model [Frenkel, 1966]. Regression coefficient is calculated according to the method of least squares [Mytropolskiy, 1971]. Characteristics of the model parameters were determined by known methods of statistics [Huter, Ovchynskyy, 1970]. The significance of the factors included in the model, determined using Student's T test [Dreyner, Smith, 1973]. To determine the ability of information used Fisher's criterion [Zavadsky, 1978]. To assess the closeness of the connection between dependent and independent variables used correlation coefficient [Halushko, 1976].

During suburban service transportation research, based on the transportation process parameters, the electrocardiogram indictor was identified. The regressive and correlative analyses methods were used [Halushko, 1976]. As a result of calculations a model of passenger regulatory system activity index changes when sitting during the transportation at vehicles:

$$I^a = 0,06 \cdot ((I^b)^{1,1} \cdot (2 \cdot log(A_p))) - 1,06 \cdot ((32,57 / T) / (-0,9 \cdot \sqrt{C / R})) \quad (2)$$

In which

a) I^a – an index of regulatory systems activity after the transportation, points;

b) I^b – an index of regulatory systems activity before the

transportation, points;

c) A_p – the age of passenger, years;

d) T – the duration of transportation, min;

e) *C/R* – correlation between the cost of a new bus and nominal seating capacity, *$/* pas.

The calculation results of the model parameters variation of regulatory systems activity when traveling seated in Table. 2-4.

Table 2. The boundaries of varying factors

Factor	Designation dimension	The boundaries of variation
Activity index of regulatory systems before the trip sitting	I^b, points	1-8, 9
Age of passengers	A_p, years	18-60
Travel time while sitting	T, min.	2-30
The ratio of the cost of a new bus to nominal capacity	*C/R,* thousands doll/passengers	0,63-3,33

Table 3. Characteristics of the model change of regulatory activity of passengers when traveling, sitting in the cabin car commuter vehicle.

Factor	coefficient	Standard error	Student test	
			calculated	tabular
$(I^b)^{1,1} \cdot (2 \cdot log(A_p))$	0,06	0,007	9,8	2,02
$(32,57/T)/(-0,9 \cdot \sqrt{C/R})$	1,06	0,007	9,88	2,02

Model statistical significance was performed using Fisher's exact test, the multiple correlation coefficients and the average approximation error, the values of which are given in the Table. 5.

Table 4. Confidence intervals coefficients.

Factor	Lower limit	Upper limit
$(I^b)^{1,1} \cdot (2 \cdot log(A_p))$	0,02	0,18
$(32,57/T)/(-0,9 \cdot \sqrt{C/R})$	0,63	2,76

Table 5. Results of statistical evaluation model

Indicators	Value
F-test:	
Tabular	2,09
calculated	552,99
Multiple correlation coefficient	0,99
The average error of approximation, %	8,43

The resulting model shows influence on passengers fatigue following factors: transportation parameters, the passenger and the ergonomics of transport facilities, new bus and nominal seating capacity. The statistical significance estimation of a given model was carried out with the use of multiple correlation coefficient and approximation of mean error. Calculations showed that the significance of multiple correlation coefficients being equal to 0,99, corresponds the close connection between the dependent variable and selected factors. Model adequacy was estimated with the use of error approximation meaning. Its meaning, being equal to 8.43%, corresponds to permissible limits.

The analysis of the received model was carried out with the use of diagrams demonstrating the change of regulatory systems activity index. When constructing the diagrams all the meaning were equal to average value exept the only factor its meaning varied. The results of calculations are given in figures 1-4. Their analysis made it possible to draw the following conclusions.

The influence of index of passenger regulatory systems activity before the transportation is essential. It defines person's initial state before the transportation. The more the meaning of the given index is before the transportation, the more its meaning is after the transportation.

Feed forward between passenger's age and an index of passenger regulatory systems activity is observed. With an increase of passenger's age adaptive properties of organism decrease which leads to growth of transportation fatigue. It can be explained by the decline of person's system of organs in dependence from the age which is natural process. Therefore, the older the passenger is, the more influence upon his adaptive properties the trip conditions exert.

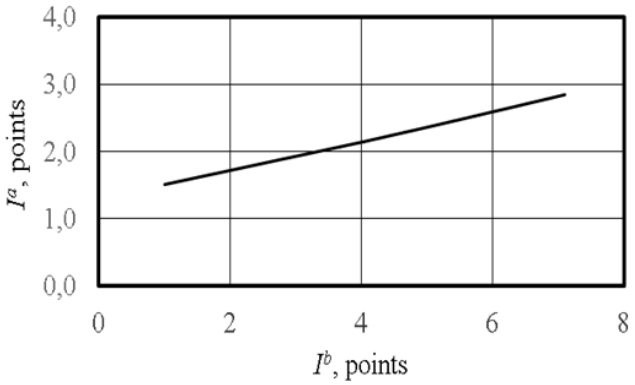

Fig. 1. Dependence of change of index in passenger regulatory systems activity during the trip in dependence of index of regulatory systems activity before the trip.

There exists a feed fack between the duration of the trip and an index of passenger regulatory systems activity. By taking

a comfortable position a person reduces physical load on organism. The longer the person travels the less his tiredness is, and the more the state of his organism normalized.

Ergonomics of transport vehicle in the capacity of which the cost relation to nominal capacity influences positively the human organism. With the ergonomic improvement of a transport vehicle's salon the tiredness during the trip decreases.

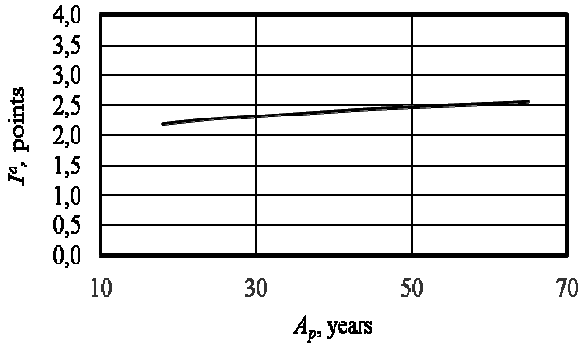

Fig. 2. Dependence of change of index in passenger regulatory systems activity sitting during the trip in dependence from passenger's age.

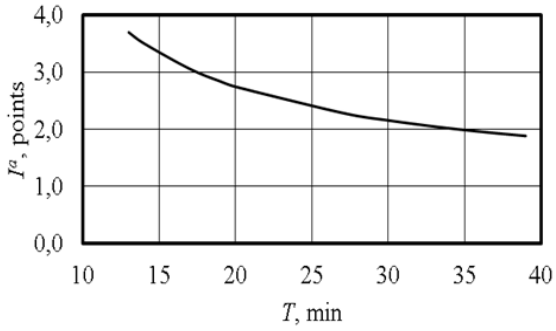

Fig. 3. Dependence of change of index in passenger regulatory systems activity sitting during the trip in dependence from the trip duration.

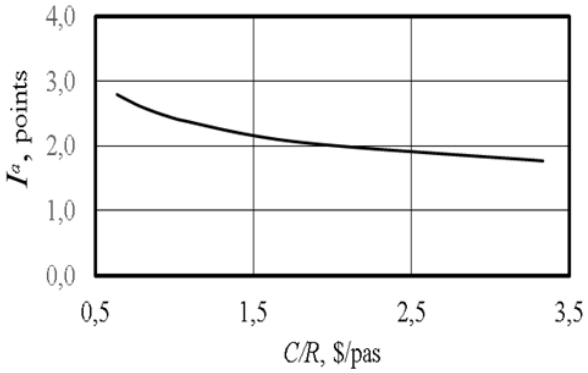

Fig. 4. Dependence of change of index of passenger regulatory systems activity sitting during the trip depending on relation of a new bus cost and nominal capacity.

4. Conclusions

The influence the transport process parameters on the passenger transport fatigue can be estimated by the change in meaning of index in passenger regulatory systems activity during the transportation. It is indicated that the change of an index in passenger regulatory systems activity during the transportation, is decreased within sufficient accuracy by non-linear regressive equation, in which independent variables appear the index meaning of passenger regulatory systems activity before the trip and the cost relation of a new bus to its nominal capacity.

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