MARKETING APPROACH TO THE STUDY OF URBAN PASSENGER FLOWS

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ABSTRACT

The article is devoted to the organization of passenger flows of public transport in Yaroslavl. A new method for the study is proposed, based on the marketing concept. The field portion of the program was accomplished in May 2012. The results of the study on the transport situation allowed offering correction methods that optimize the route network of the city.

Despite localization of problems under review, which was determined by the necessity to apply and verify the methods in real situation, the approaches and techniques suggested by the researcher can be generalized and used for other locations.

ENGLISH SUMMARY

Background. *Many cities face a very real problem how to optimize a route network of public transport. And that problem evidently should be solved not in a distant future but right now.*

The first task, associated with it, is the study of the demand for intercity passenger transportation by all modes of public transport.

Analyzing works of 2004–2013 years, it can be concluded that the study of the demand is made incorrectly. The approach that we will call «traditional» [e.g., 2, 3, 6, 7, 10, 14] is as follows. In each unit of rolling stock or in a vehicle a record-keeper is placed, fixing the number of passengers getting on and getting off at each stop. In a number of cases [5, 8, 11] it is proposed to place a record-keeper at the stop and fix the number of passengers, who get off from each tram, trolleybus or bus and the number of passengers who get on.

This method is quite common, but has some significant drawbacks.

Firstly, it is a very labor-intensive. For example, in Yaroslavl there are 950 units of public transport working about 18 hours a day at city routes. It will make about 34200 person-hours per day (there should be at least two record-keepers in each vehicle).

Secondly, the traditional approach does not account for transfers of the same passenger to the transport of another route (although there are works, which propose to track transfers – for example, [1]). This in turn leads to the fact that the data collected can be applied either to resolve the problem of the graphs of motion, or to select a model of a vehicle according to the conditions of the route. It is impossible to change the same route itself or to create a new one – for this information is missing.

In general, this approach is consistent with production or product business concept [15, 17]. According to Levitt [16], it will sooner or later lead to a sharp outflow of customers and, as a consequence, to bankruptcy. This is, in fact, already happening in many cities, including Yaroslavl: municipal carriers are unprofitable and exist only because of subsidies.

Objective. *The objective of the author is to investigate problems related to the organization of passenger flows of public transport in Yaroslavl and to propose a new method for the study, based on the marketing concept.*

Methods. *The author uses analytical method, comparison, modeling, mathematical calculations.*

Results.

Marketing management

It is clear that in modern conditions the organization of public transport must comply with the marketing concept of business operations [15, 17]. The concept of marketing management suggests that the company is appealed to produce and to sell a product that fully meets any needs of population. With regard to the urban public transport such a need can be described by a number of parameters:

- *Point (stop) of departure;*
- *Point (stop) of destination;*
- *Departure time.*

The fare of one travel in the city public transport is determined by authorities and carriers cannot set it independently. A type of a vehicle (tram, trolleybus, bus) and a model are of secondary importance for a passenger, as well as a route of movement – the main thing that passengers are transported from point of departure to a point of destination with minimal time expenditures and fewer transfers.

In accordance with the marketing concept of business a proposal of a company should fully meet the demand, and hence baseline information should be obtained from passengers. Similar ideas were expressed earlier [4, 12], but they have not been brought to a logical end.

The procedure of obtaining baseline information is as follows. At each stop during morning rush hours n_i people are interviewed on a questionnaire:

1) To what stop will you go now?

2) What is your gender?

3) What is your age?

If the survey is conducted during evening peak hours, the first question is transformed: «From what stops did you arrive here?». In addition, at the same stop the total number of people is recorded who come to it to use public transport.

Processing of results is reduced to the construction of the table of stops correspondence within city limits (sample – Table 1).

The value $p_{i,j}$ is the number of passengers going from the stops' number i to a stop with a number j and is calculated as follows:

$$p_{i,j} = \frac{o_{i,j}}{n_i} \times h_i \,, \qquad (1)$$

where $p_{i,j}$ is a number of passengers, going from a stop number i to a stop number j;

$o_{i,j}$ is a number of respondents at the stop number i, replied that they were going to a stop number j;

n_i is a number of respondents surveyed at a stop number i;

h_i is the total number of passengers coming to the stop number i.

Precision of studies can be improved by dividing the day into intervals (for example, of one hour) and performing measurements of $o_{i,j}$ and h_i in each interval. In turn, h_i can be measured simplistically: to determine a number of passengers who came to a stop within five minutes, and then with the assumption of constancy of flow, to multiply the resulting figure by twelve. Such an option will significantly reduce the resources required to conduct the study.

Table 1

Movement of passengers between stops

		Number of destination stop, j			
		1	2	...	m
Number of departure stop, i	1				
	2				
	...			$p_{i,j}$	
	m				

Testing of conceptual schemes

The proposed method was tested in May 2012.

In the city sixteen isolated districts were taken, in each of them two to four stops were selected for the survey. There were 40 stops. The total number of surveyed passengers aged 15 years and older was 400; sampling error was ± 5 points at a confidence level of 95,4% (the population of Yaroslavl in this age is 528482 people [13]).

The number of passengers departing from each of forty stops was recorded three times: at intervals from 7^{00} to 8^{00}, from 8^{00} to 9^{00}, from 9^{00} to 10^{00} during ten minutes throughout each time interval. Thus, the study covered peak hours – typically the most problematic periods in most cities, because it is required to transport a large number of people for a considerable distance over limited time period.

It was assumed that the number of passengers and the typical direction of their departure from all stops in one district were the same. Then the total number of passengers departing from a district k to a district l, is equal to:

$$p_{k,l} = \frac{o_{k,l}}{n_k} \times h_k \times \frac{t_k}{s_k}, \qquad (2)$$

where $p_{k,l}$ is a number of passengers, going from a district number k to a district number l;

$o_{k,l}$ is a number of respondents at stops of the district number k, replied that they were going to travel to a stop in a district number l;

n_k is a number of respondents surveyed at stops of a district number k;

h_k is a total number of passengers who came to stops in the district number k, at which the study was conducted;

s_k is a number of stops in the district k, at which the study was conducted;

t_k is a total number of stops in the district k.

In addition, a new question was added to the questionnaire: «What routes of public transport do you use to go to work?». The answers helped to assess whether the existing routes coped with the carriage of passengers or passengers were forced to make transfers, use alternative routes, and so on.

On the basis of the data table 2 was constructed related to a passenger turnover between different districts of the city and an analysis of the situation with public transportation was made.

The total number of users of public transport services in peak hours is 95002 people, representing 18% of the population of Yaroslavl aged 15 and older. The sample included only 8,8% of people aged 50 years and older and 4% – in age from 15 to 20 years. That is, we can assume that pensioners, schoolchildren and students prefer to use public transport outside peak hours. It turns out that in rush hours trams, buses, and trolleybuses carry 33% of the economically active population. (During evening rush hours traffic volume will be, of course, the same.)

Analyzing the table, we can see that 17,1% of peak passenger (16281 people) work in the same district, where they live – they need short «intra-district» routes. However, there are no pure «intra-district» routes – passengers often have to use minibuses. This is especially true for such areas as Norskoe (bus of the route N6 or a minibus № 96: 3772 peak passengers), Perekop (minibuses № 85 and № 87, 2550 passengers) and area of prospect Mashinostroiteley (minibuses № 36, № 83, № 85, 2295 peak passengers).

Problem directions

Passenger transport in Yaroslavl comprises primarily small capacity buses (type PAZ-3205 and PAZ- 3204), as well as minibuses «Gazelle», used fixed-run taxi (a minibus that has a fixed route but can stop not only at recognized snf equipped stops of public transport but at every allowed place at the demand of passengers - ed.note).. Municipal transport is mainly represented by large capacity buses type LiAZ 5256 and LiAZ 5292, trolleybus type ZiU-9.

Obviously, the situation in which a significant portion of passengers is transported with socially dangerous minibuses is unacceptable in a modern city: minibuses should be replaced with large capacity transport with established sites of embarkation / disembarkation of passengers. Areas used by more than 300 persons were underlined in an initial copy of a table of pasenger turnover – in this case a possibility was implied to create a route serviced by large capacity buses, able to make at least three trips during morning rush hours at 100% load (and therefore three trips in evening rush hours).

Within direction Neftestroy – Suzdalka 904 people are carried in peak hours. The only mode of transportation here is the minibus № 47, which is served by minibuses «Gazelle» and their analogues. Obviously, for transportation of such a large number of passengers «Gazelle» has to make 25 trips in an hour. The actual number is much less – no more than six trips that, firstly, leads to overloading of vehicles (transportation of standing passengers); secondly, many passengers are forced to go «detour» with a transfer at the stop «Vyemka» (distance increases by three to four times). The solution to this problem is creation of «shortcut» routes linking these two districts, using large capacity buses.

Furthermore, we can distinguish also three directions: Kresty – Suzdalka (1000 peak passengers), Suzdalka – Neftestroy (406), Suzdalka – Kresty (467), which have the same problems.

Another problem direction is Neftestroy – prospect Lenina (631 passengers). Existing routes in general satisfy the demand (bus № 2, minibuses № 97 and № 98), but they all pass through prospect Moscovky in the area of the biggest traffic jams, as well as through the historic center of the city, too congested. The solution may be made by a launch of the route to detour traffic jams through South-Western

Table 2

Passenger turnover between different districts of Yaroslavl

		ARRIVAL DISTRICT («WORK»)																
		Neftestroy	Kresty	Suzdalka	Lipovaya gora	Spedniy and Nizhniy settlements	prospect Mashinostroiteley	prospect Aviatorov	Rezinotekhnika	Norskoe	Bragino	prospect Dzerzhinskogo	Perekop	city center	prospect Lenina	Pyaterka	Yaroslavl-Glavny	TOTAL
DEPARTURE DISTRICT («HOME»)	Neftestroy	85	273	904						255	85			1177	631		170	3580
	Kresty			1000						436			500	872	4372			7180
	Suzdalka	406	467	1623	561		47	622			885			1110	1028	466		7215
	Lipovaya gora	176		178	890			88		88	90	180		1602	88	90	90	3560
	Spedniy and Nizhniy settlements					324	306	45			108			90	504	153		1530
	prospect Mashinostroiteley	1122		1122		561	2295							1683	2244	561	561	10149
	prospect Aviatorov	259					328	82		518				259	259			1705
	Rezinotekhnika							400	1422					1284	921			4027
	Norskoe			220					217	3772	217			418	1050	198	198	6290
	Bragino	741	741	741		1482				741	1482				1482			7410
	prospect Dzerzhinskogo	1481	2962	3027							166	664	1481	773	1546			12100
	Perekop		840	420								420	2550	840			1320	6390
	city center	221	168	266	46	54	62	168				108	222	704	582	357	382	3340
	prospect Lenina	43		58			210	159		90	180	38		136	310	58	415	1697
	Pyaterka		1822	4396				2574			1605		1287	2892	2357		1287	18220
	Yaroslavl-Glavny	54	29			29	29			27	56			58	249		78	609
TOTAL		4588	7302	13955	1497	2450	3277	4138	1639	5927	4874	1410	6040	13898	17623	1883	4501	95002

ring road and Perekop. The same route will help to deliver residents in directions «Kresty – prospect Lenina» (4372 passengers), «Suzdalka – prospect Lenina» (1028 passengers).

Serious problems are observed in the vicinity of Lipovaya gora. The most massive departure direction from here is to the city center (1602 people). Most of passengers are transported by minibuses, which are overcrowded in rush hours. The primary measures include increasing the number of buses on routes № 4 and № 41, as a promising task is to move a part of the route № 41 from prospect Frunze (near the «new» Sokol) and prospect Moscovsky to Tormoznoe highway.

District of prospect Mashinostroiteley in Soviet times was characterized by low transport accessibility. This reputation is maintained: there are two directions – to Neftestroy and Suzdalka – with heavy load (2244 passengers), which are served by minibuses – buses type PAZ-3205 and PAZ –3204, and their routes go through «traffic jams dangerous» places. A new route with buses of increased capacity through prospect Lenina, Perekop and Southwest ring road can ease the situation.

Daily 9693 people go from Bragino and prospect Dzerzhinskogo to Neftestroy, Suzdalka and Kresty – more than 10% of the total number of «peaks» passengers. Basically, they are transported by minibuses, that leads to high load of vehicles, and traffic jams at prospect Oktyabrya, in the city center, at prospect Moskovsky. The problem might be solved in two ways. The first is to organize a bus route through Southwest ring road with buses of large capacity (such as LiAZ-6212 or LiAZ- 6213), the second is a combination of two trolleybus routes № 8 and № 9 in one, followed mandatory use of high capacity trolleybuses type ZiU-683.

Tram lines, mostly closed in 2004–2009, served as the transport basis for two districts – Perekop and Pyaterka. It turned out, that daily 1287 people want to get from Pyaterka to Perekop, direct routes (or at least with a convenient transfer) do not exist now. A temporary solution is transportation of passengers by bus route serving prospect Dzerzhinskogo – Perekop, a cardinal, but unlikely solution is restoration of tram traffic on Perekop.

Elimination of tram traffic at Perekop negatively affected the direction Perekop– city center (840 passengers). At the time of the survey, passengers used the bus route № 19-K. The problem of the route lies in the fact that part of it goes through a very busy prospect Moscovsky. In addition to come and to leave this prospect a bus must pass several narrow one-way streets, increasing the length of the route by two to three kilometers, and undergoing risks of accidents. The solution may be a launch of the same route through Tolbukhinsky Bridge and Bolshaya Oktyabrskaya Street.

Pyaterka district is «rich» with unsolved transport problems. 6218 people go daily to Suzdalka and Kresty. There is no direct route linking Pyaterka and Kresty; there is a fixed-run taxi № 94 served by minibuses «Gazelle», going through the city center and prospect Moscovsky to Suzdalka (4396 peak passengers). The situation can change with the launch of large capacity buses going by the street Uglichskaya, Perekop and Southwest ring road.

Another direction requiring reform is Pyaterka – Bragino (1605 people). Existing minibuses № 61 and № 78 do not meet the established needs. The solution is to increase the number of cars on the tram route № 5 while decreasing intervals of awaiting next tram (now – about 30 minutes [9]).

These examples, of course, do not exhaust the problems identified by the study; they only illustrate the essence of the method and its effectiveness. As for the overall assessment of the urban public transport network, it has a lot of areas that are well served by the existing routes, and there is no need to conduct any reforms related to them.

Conclusion. *A method of conducting of studies of passenger flows was suggested. It was tested and its advantages were confirmed: labor costs for field part with comparable accuracy amounted to only about 60 man-hours (the traditional method would require a minimum of 11400 man-hours), based on the results of surveys and analysis nearly three dozen proposals were put forward to reform route networks, more than half of which could not be prepared in a conventional manner.*

The new method is well suited for making strategic decisions in the transport medium: it allows us to estimate the number of people moving from district to district or from one stop to another, and to build on the basis of these data, a network of routes, to determine the most suitable vehicle type for each route. The old way of study only helps clarify and make more optimal schedule of rolling stock on a particular route.

Unused methodological resources, awaiting their application, are: surveys in off- peak hours, and on weekends for scheduling and determination of routes, that should operate exclusively on weekends or only on weekdays.

Keywords: *public transport, passenger management, flight network, optimization, marketing approach.*

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