

# Analysis of the mobility of railway passenger transport in small urban areas

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## Abstract

In the organization of city traffic there is a historical link between the various transport modes, particularly between the road and rail systems (tram, metro and railways). Each particular system operates autonomously and independently of one another, while at locations of mode changing (stops) time integration of various modes into a single integrated system is performed. Rail systems are the backbone of an integrated system because of the capacity and speed they can provide. Railways are particularly interesting because they integrate urban, suburban, regional and intercity traffic. Railways are traditionally monopolistic, but, since 1990, the European Union has implemented legal, organizational, technological and technical measures in order to achieve full liberalization of railway transport. The liberalization of railway transport is particularly successful in freight, while in passenger traffic the change is slower; particularly interesting are the changes in the regional railway traffic in Germany and in intercity traffic in the Czech Republic. How well railways are successfully integrated into urban transport systems can be evaluated in several ways, but the most important method of assessing is by a survey of users – passengers. The whole integrated system is established with the aim of enabling higher levels of mobility for the user – passenger. Today, mobility in cities is a *conditio sine qua non* of the population. Therefore, the public transport system must be evaluated through surveys. This paper analyses the mobility of passengers by railway in the area of the small town of Varaždin (Croatia). In addition to standard questions about the provision of services (demography, the beginning and end point of travel, duration of travel, types of tickets), questions were asked about changing the mode of transport in the last 5 years. This set of questions produces data on how many new passengers came to the railway and what are their reasons for changing their habits.

*Keywords: railway, mobility, passengers, survey.*



## 1 Introduction

In recent years, there have been intensive talks about the mobility of the population. The last published White Paper – Roadmap to a Single European Transport Area specifically emphasized the development of the mobility plans. Certainly, any sustainable mobility in addition to good economic calculation must be based on ecology. Therefore, it is reasonable mobility of passengers to design the integrated transport system. Integrated transport system allows the use of the comparative advantages of each transport mode in relation to the other. For passengers integrated system provides two features: (1) one transport ticket and (2) one harmonized timetable. In such a system railway represents the backbone. For example, when there is a high enough demand for transport if there is a railway system, it is used. When demand decreases and the railway offer too much capacity it is reasonable that the same line can be serviced by busses. For passenger in such a system it doesn't matter if he or she is using a train or a bus on the same route because they are ultimately interested in travelling from A to B.

Varaždin County, including the City of Varaždin, does not have an integrated passenger transport system, although in the past five years a number of studies were made that address the introduction of the new system.

The railway is the oldest organized land carrier and today represents the *old lady* but liberalization is violently knocking at the door. Therefore railways, particularly in passenger transport, may constitute an aggravating circumstance of introducing new ways of managing public transport and ultimately mobility.

Therefore this research performed a survey of passengers who use rail transport for arrival and departure from the territory of Town of Varaždin. Besides the standard questions in the survey, part of the survey is devoted to the so-called swing users. Swing users are travellers who have changed their transport mode in the last five years and we try to determine the reasons for their decision. The survey gives a clear picture of the state of mobility of passengers.

The survey results of swing users are interesting because they can assist in the creation of new mobility schemes and increasing modal shift and then the share of passengers in public transport passengers.

## 2 Research area

The City of Varaždin is the main centre of Varaždin County. It covers an area of 58.43km<sup>2</sup> that represents 4.63% of the total area of the county. It has 46,946 citizens that represent 26.68% of the citizens of the county, i.e. 1.1% of the citizens of the Republic of Croatia. The population density is 1,759.6 citizens/km<sup>2</sup>. The City of Varaždin is divided into 10 administrative units [1].

Varaždin County is located in the north-west of the Republic of Croatia. It covers an area of 1,262km<sup>2</sup> that is 2.23% of the total area of the Republic of Croatia. It has 175,951 inhabitants which is 4.11% of the total population in Croatia. The average population density is 139.42 inhabitants/km<sup>2</sup>, double the total population density in Croatia. Varaždin County has 302 settlements and



about half of the population lives in settlements with less than 1,000 inhabitants. The next interesting point is the extreme dispersion of settlements across the entire county, and especially in marginal western and southern parts [2].

The central traffic junction in the Town of Varaždin and Varaždin County is the Varaždin Railway Station with a railway line branching off northwards to Čakovec i.e. Međimurje County with a total length of 9 km and a maximum speed of 100 km/h. There are also the railway line towards Lepoglava and further to Golubovec, i.e. Krapina-Zagorje County, 32 km long and a maximum speed of 60 km/h, the railway line towards Ludbreg and further to Koprivnica, that is, the Koprivnica-Križevci County, 42 km long with a maximum speed of 100 km/h, and the railway line towards Budinščina, that is, the Krapina-Zagorje County, 32 km long with a maximum speed of 70 km/h. Figure 1 gives a graphic presentation of the railway lines in the research area of Town of Varaždin. Passenger carriage operates mainly trains with classical wagons (B) and Diesel railcars HŽ 7121 or HŽ 7122.

Passenger carriage has seen an average annual growth rate of 2.4% over the last three years and in overall carried passengers the region accounts for about 18.6% of the total for the Republic of Croatia [3].



Figure 1: Railway lines of Varaždin County.

### 3 The methodology of conducting the survey

The main aim of the citizens' survey is the gathering of information that is relevant for the research task. In this case, the research task was to define mobility in railway passenger transport for the area of the City of Varaždin. Generally speaking, the survey is the basic tool for including citizens in the decision-making processes and also a good tool to measure the quality of service. In this way the citizens also have the feeling that they participate in improving their living environment, i.e. that their opinion is also taken into consideration.

The implementation of an efficient citizens' survey requires several steps that need to be undertaken in the following chronological order: (1) define a clear research objective, (2) decide on the frequency of the study, (3) train the personnel responsible for the research, (4) define the population or the research sample, (5) determine the data gathering method, (6) identify the data gathering areas, (7) develop standard questions, (8) develop methods to have the maximum number of participants filling in the questionnaire, (9) pre-test, analyse and enter

the changes in the survey, (10) analyse the survey statistically, (11) make the conclusions, and (12) publish the results [4].

In this research the clear aim is to gather a relevant quantity of data which are needed to estimate mobility in the area of the City of Varaždin. This research was carried out for the first time in the City of Varaždin, and the recommendation is to carry out such surveys at least in annual cycles. The personnel carrying out the survey has to be adequately trained. This refers especially to the approach to citizens and entering the responses into the questionnaire. The survey is followed by a statistical analysis, determining the level of mobility, making conclusions and informing the public about the survey results.

On the territory of the Republic of Croatia there is a certain reserve against participating in surveys. There are a number of reasons because of which the passengers do not want to answer the survey questions, and some of these are: (1) failure to understand the purpose and aim, (2) the survey serves for the control (negative evaluation), (3) bad experience from previous surveys, and (4) surveying has no purpose.

When starting the survey process the public should be best informed about the objective, and the purpose of the survey. The public should be clearly informed about the survey procedure. Thus, it is necessary to emphasise that the objective of the survey is the gathering of the necessary data about the traffic values with the aim of improving the entire traffic system. Therefore, the cooperation with the bodies of local government and self-government, radio, newspaper, and television field teams and innovative information channels, such as Facebook and Twitter is necessary. In the public mind the surveys serve to control someone; therefore, it is necessary to continuously emphasise that the survey is anonymous and participation in it is optional. In the last ten years various surveys were carried out, mainly in the domain of promoting certain products and services, and to the passengers it seemed that they were wasting their time for others, i.e. they did not see the benefit for them of fulfilling the survey. It is precisely because of this that one should work intensively on making the public informed prior to carrying out a survey.

For the surveys to be successfully carried out in the future, after the survey the results should be made public over the same channels that had been used for information about the preparation of the survey. In this way the habit of participating in the survey will be created, and the public will understand that their participation in the survey can improve their quality of living.

In the area of traffic a survey is a very powerful tool; therefore, the public needs to be sensitized. Without surveys, namely, it is almost impossible to make plans in the field of traffic. Therefore, the public should be continuously informed about the objectives and purposes of the survey in the field of traffic issues and make them familiar with the entire process of surveying. When a traffic project which includes a survey has been completed, it has to be emphasized in presenting the project that the public with their opinions and suggestions participated in creating the project [5].

The survey on the territory of the City of Varaždin included the participation of the Faculty of Transport and Traffic Sciences University of Zagreb and with permission from HŽ Passengers transport Ltd. In the field, the survey is performed by an interviewer – students. All interviewers were trained to conduct survey according to standards of good conduct.

The survey was conducted in trains from/to the Town of Varaždin, with two interviewers (one team) for each train. They wore reflective vests (for security reasons) and name and company tags. Train personnel were informed about the purpose and how the survey was to be performed. A controller was at the Varaždin railway station during the whole survey period.

The controller has the following duties and obligations:

1. The preparation and organization of survey implementation;
2. The distribution of the interviewers;
3. Cooperation with interviewers during the survey at an agreed location or by mobile phones;
4. Solving all the problems the interviewers may encounter in the field;
5. Checking whether the interviewer has correctly entered the time of survey and other data;
6. Checking whether the survey has been performed at all the selected locations, and
7. keeping the questionnaires until a certain time when the survey is to be repeated.

The interviewers have the following duties and obligations when they conduct the survey:

1. To arrive prepared and on time to the survey location – train;
2. To manage the questionnaire well;
3. To not change any information given by the respondent;
4. To explain the question to the respondent in case of ambiguity, which leads to a better survey;
5. For every ambiguity regarding the procedures or unexpected cases in the field, to contact the controller, who shall be at disposal at all times, and
6. at the end of the survey return the filled questionnaires to the controller.

In addition, a passenger can refuse the survey. The total duration of the interview did not exceed 10 minutes.

#### **4 Analysis of survey**

The survey had 17 questions. The answers to two questions were given if the condition was met. The condition was that the respondent changed his or her transport mode in the last five years. The survey was conducted during one working day (Wednesday), from 5AM to 5PM on trains to/from Varaždin and 175 passengers were interviewed. 46.23% of the respondents were male.



#### 4.1 Analysis of standard question

According to current occupation there were 17.71% high school students, (elementary school students are transported by special bus lines), 22.86% were university students, 46.29% employed, 8.57% retired and 4.57% other. In total 34.86% of passengers have their own car, and 69.14% of them have the possibility of occasional use of a car.

When we sum high school students and university students, we get 40.57% of all passengers. These passengers are highly subsidized and they are very dependent on state decision on subsidized busses or trains. Therefore, railway management must have excellent negotiation skills to keep such services running.

Also, the fact that more than one third of passengers are car owners, but use railway for their mobility, is very interesting. Main reasons is that the roads to and from town are quite congested. There also exists the very large problem with the amount of parking spaces and the cost of parking in the Town of Varaždin.

According to the reasons for travelling, 37.14% of passengers went to school/university, 33.14% went to/from work, 6.86% were on a business trip, 19.43% travelled for private reasons (banks, hospitals and etc.), 2.29% due to free time (theatre, gym, etc.) and others purposes 1.14%. Notably, none of the passengers chose the answer that reason of travel is shopping.

The question on the purpose of the trip is followed by the question about how many times a week the passenger chooses a particular mode of transport. Transport mode was categorized into: (1) Passenger car/Motorcycle, (2) Public transport, and (3) Bicycle/Walking. The frequency is divided between the five possible periods: (1) once per week or less, (2) two times per week, (3) three times per week, (4) four times per week, and (5) five times per week or more. Figure 2 shows the distribution of time frequency of using transport modes and type of transport modes.

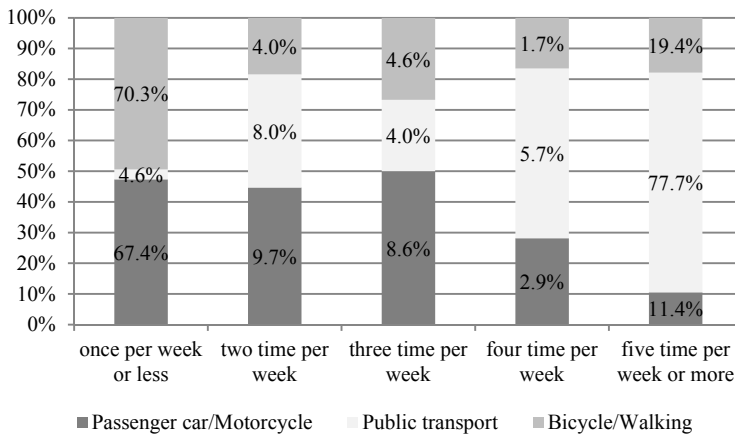


Figure 2: Share of time frequency of using and type of transport modes.

According to the types of tickets used for travel, monthly passes prevail with 49.71%, followed by individual tickets with 34.59%, 8.57% yearly passes and other types of tickets with 7.43%.

Almost half of tickets sold are monthly passes; this is a good sign that shows the passengers are connect to railway travel and choose to use public transport daily and on a regular basis.

Average travel time lasted 54 minutes, minimum travel time lasted 5 minutes and a maximum travel time lasted 390 minutes. Mode (stat) and median of travel time was 30 minutes.

The number of trips was defined as one direction – one trip, if the respondent went and came back on that day it was seen as two trips. The average number of trips is 7.7, while the mode (stat) and the median number of trips is 10.

This means that during the working day railway has permanent passengers. There was also the question would they use public transport for other travel purposes. In this case, 92% of respondents answered affirmatively.

Also the survey posed the question: Do you know what does the term “Integrated Passenger Transport – IPT” mean? – only 28% of respondents answered affirmatively. To the respondents who answered negatively the interviewer briefly explained the concept of IPT.

## 4.2 Analysis of swing users

For the first time in Croatia this survey raised the question about swing users. Swings user are those passengers that have for some particular reasons change the routine about every day travel respectively mobility. Thus these users are interesting because they can point out the main reasons of modal shift of every day users. Because of that we can make plans to change mobility in order that more people use public transport especially on railway lines where that is possible.

The specificity of the survey was the question about changing the mode of transport in the last five years. An even 43 or 24.57% or one-fifth of respondents changed their usual transportation mode. Reason given for the change of transport mode was a multiple-choice question plus the option to enter additional reason. They were offered four basic reasons: (1) more connections (frequency), (2) comfort, (3) a better price, and (4) ecology. Respondents cited the following reasons for changes the transport modes: timetables, speed, car sales, relocation, proximity to the station, speed, change of job, and subsidized fares.

Table 1: Distribution of answer for reasons for swing users.

More connections	Comfort	Better price	Ecology	Additional entry
8	5	30	2	9

Swing users were asked how often and which modes of transport they used before they made the transition from one mode to another. Figure 3 shows share

of time frequency of using transport mode and type of transportation mode before swing of transport mode.

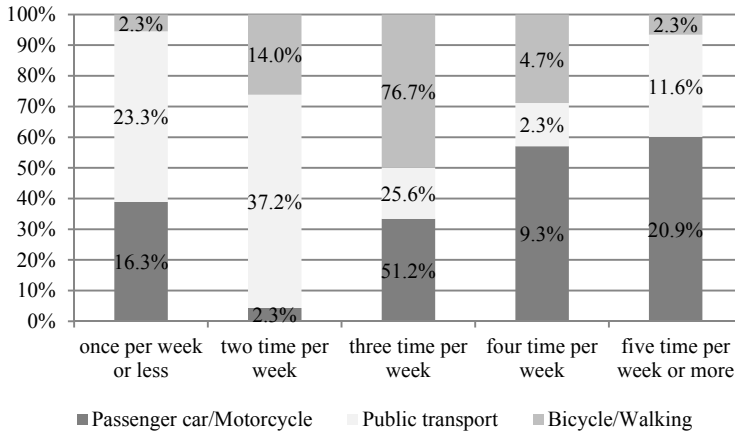


Figure 3: Share of time frequency of using and type of transport mode before swing.

When we compare the mode of transport of swing users it is interesting that they have moved from private cars to public transport and bicycles. Most of users changed the mode because of prices, so people decided to calculate more precisely how much money they will spend on every day travel.

### 4.3 Analysis of OD matrix

One of the major tasks in traffic planning is the determination of the start and the end of a journey. The start of the journey is called origin, whereas the end of the journey is called destination [6]. Through the survey the passengers answered the questions about where they were coming from and where they were going. This means that they indicated the origin and the destination of travelling. Based on these two questions one can establish an OD matrix for the passengers in the survey. A total of 175 passengers were interviewed in the trains to and from the City of Varaždin and based on their answers 34 unique origins were obtained, 30 unique destinations, and 45 places of the start and end of the journey.

The survey in the trains forms a 45 times 45 OD matrix. Because of the complexity of presenting the matrix of 45 times 45, it is not presented in the paper. The matrix was filled in by searching the origins and filling in the matrix with destinations.

By analyzing the OD matrix in the trains to and from the City of Varaždin it may be concluded that in the implementation of the survey 29.14% of passengers had the City of Varaždin as the origin of their journey whereas 42.29% of the passengers indicated the City of Varaždin as the destination of their journey.



This result corresponds to the fact that the City of Varaždin is the centre of the Varaždin County and is the biggest city of the North-western Croatia.

Then, interesting are the places that have a share greater than 2% as origins, and these are: Ivanec (10.29%), then Čakovec and Lepoglava (6.86%), Novi Marof (4.57%), then Golubovec, Koprivnica and Ludbreg (4.00%), as well as Konjščina, Mađarevo, Vidovec and Zagreb (2.29%).

Also interesting are the places that have a share greater than 2% as destination, and these are: Čakovec (11.43%), Novi Marof (7.43%), Ludbreg (4.57%), then Ivanec and Koprivnica (4.00%), then Lepoglava and Zagreb (3.43%) and Golubovec (2.29%).

Of course, from the OD matrix we also have data about the length of trips. The average distance is 35 kilometres, the minimum distance is 3 kilometres and the maximum travel distance is 357 kilometres. Mode (stat) trip distance is 20 kilometres while the median distance travel is 23 kilometres.

When we relate mode (stat) and median of travel time and length of trip it is possible to calculate mode (stat) and median of speed. Therefore, mode (stat) of speed is 40 km/h and median is 46 km/h. This are excellent results.

## 5 Conclusion

Today the organization of passenger transport represents a challenge. The challenge consists in maintaining a functional system that is economically and environmentally friendly, and fully satisfying to the users – passengers. Therefore the White Paper – Roadmap to a Single European Transport Area clearly defines the need to develop mobility plans and as one of the solutions propose integrated transport system. The spine of an integrated transport system is the railway.

Therefore, this research deals with a survey of users in rail transport to / from Town of Varaždin. The survey consisted of two parts. The first part included the standard questions about the passengers (gender, age, education ...) and then a standard traffic questions (departure and arrival of travel, number of trips, travel time, type of fares ...). The second part of the survey concerned on the swing users. Swing users are passengers who have changed the transport mode in the last five years, choosing the railway.

When we total high school students and university students, we get 40.57% of all passengers. These passengers are highly subsidized and they are very dependent on state decision on subsidized busses or trains. Therefore, railway management must have excellent negotiation skills to keep such services running. Also, very interesting is the fact that more than one third of passengers are car owners but are using the railway for their mobility. Almost half of tickets sold are monthly passes; this is a good sign that shows the passengers are connect to railway travel and regularly use public transport for every day trips. The survey in the trains forms a 45 times 45 OD matrix. In the survey 29.14% of passengers had the City of Varaždin as the origin of their journey whereas 42.29% of the passengers indicated the City of Varaždin as the destination of their journey.

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When we compare mode of transport of swing users it is interesting that they have moved from private cars to public transport and bicycles. Most of the users changed the mode because of prices, so people decided to more precisely calculate how much money they will spend on every day travel. The survey results of swing users are interesting because they can assist in the creation of new mobility schemes and increasing modal shift, and then the share of passengers in public transport passengers.

Of course, it would be good both for the railway undertaking as well as for the local community to introduce an annual passenger survey in public passenger transport.

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