

Creating OD matrix using cordon survey: case study – City of Varaždin

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Abstract

Nowadays, cities have a problem with transport planning. Transport planning is a time-consuming process and a data-eating process. For the purpose of transport planning, it is necessary to collect up-to-date data, not only transport data (number of vehicles, bus lines, passengers carried, etc.), but also demographic data, urbanization data and economic data. The most frequently changed data are those from transport, which means it is necessary to implement a strategic process to collect these data. This process is not only time-consuming but also money-consuming. Without transport data it is not possible to make smart mobility plans for citizens. The most important function of transport data collection is building of an Origin-Destination Matrix (OD Matrix). There is a wide range of methods for collecting and building of this OD Matrix. This paper explains the building of OD Matrix using innovated cordon survey in road transport. Cordon survey is a field method to collect information about travel preferences of road drivers. Cordon survey has been performed on strategic points entering the City of Varaždin. The cordon survey was carried out during two-hour intervals in early morning, late morning and afternoon.

Keywords: OD matrix, cordon survey, transport planning.

1 Introduction

The mobility of citizens represents today one of the major variables of life quality evaluation. This refers especially to everyday travelling, mainly to daily commuting (business and education). Unfortunately, public passenger transport in the Republic of Croatia has not accompanied the trends of transport demand and has completely failed as a public service. Since the population has the need for commuting, an alternative to inadequate public transport had to be found.



The alternative was found in passenger cars. Thus, the number of passenger cars on roads increased suddenly over a short period of time, and a large number of bottlenecks appeared. Public transport has continued to be used by those groups of citizens who have no other choice, such as schoolchildren and students. Such development created a big problem in efficient planning and managing of the traffic system. Therefore, the need to consider the traffic system management reappeared. Transport planning is a time-consuming process and a data-eating process. For the purpose of transport planning, it is necessary to collect up-to-date data, not only transport data (number of vehicles, bus lines, passengers carried, etc.), but also demographic data, urbanization data and economic data.

It is, therefore, necessary to carry out regularly statistic surveys of traffic and non-traffic (demography, physical planning and economy) data. Especially important is that the surveys are repeated cyclically within certain periods of time in order to be able to update the traffic models.

The task of the gathered data is to enable the construction of the maximally precise traffic model. One of the most important results of data gathering should be the OD matrix. It represents the journey between the origin and destination and enables the creation of traffic flows.

During data gathering to create the OD matrix, there is a large number of methods. This paper will explain the cordon survey. The cordon survey represents a survey procedure of road vehicles. It is important to determine the places and the time at which the cordon survey is to be carried out. The cordon survey itself is performed so that a police officer “excludes” randomly a vehicle from the free flow and the interviewer conducts the survey. The results of the cordon survey make it possible to create the OD matrix.

2 Catchment area

The Varaždin County is located in the north-west of the Republic of Croatia. The Varaždin County covers an area of 1,262km² which 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/km² which is double the total population density in Croatia [1].

The Varaždin County has 302 settlements and about half of the population live in the settlement with less than 1,000 inhabitants. The next interesting point is extreme dispersion of the settlement across the entire County, and especially in marginal western and southern parts.

The traffic network of the County has 92 kilometres of railway lines, 209.6 kilometres of state roads and 952 kilometres of county roads [2].

The City of Varaždin is the main centre of the Varaždin County. The City of Varaždin covers an area of 58.43km² which represents 4.63% of the total area of the County. It has 46,946 citizens which represents 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/km². The City of Varaždin is divided into 10 administrative units [3].



3 Methodology of implementing the cordon survey

3.1 In general about the research

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 the OD matrix for the area of the City of Varaždin. Generally speaking, the survey is the basic tools for including the citizens in the decision-making processes. In this way the citizens have also 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 of the maximal number of participants filling in the questionnaire, (9) pre-test, analyze and enter the changes in the survey, (10) analyze 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 establish OD matrices in the region 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 one-year 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. This research opted for a survey on a sample of free traffic flow on the roads entering/leaving the City of Varaždin. Special attention was paid to informing of the citizens before carrying out the survey, in order to make them familiar with the aim and the purpose and the reason why they should participate in the survey. The pre-testing was done in the area of the City of Lepoglava in the West of the Varaždin County [5]. The survey is followed by a statistical analysis, determining of the OD matrix, 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 respondents 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 respondents 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 area 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 [6].

3.2 The survey

The survey on the territory of the City of Varaždin included participation of the Faculty of Transport and Traffic Sciences, and the Faculty of Organization and Informatics together with the Association for Railways, School of Mechanical Engineering and Transport Varaždin, Ministry of the Interior Police administration and Varaždin County [7]. In the field the survey is performed by a police officer and an interviewer and in the survey centre by a coordinator. It is particularly necessary in the beginning to define the job of the police officer and the work of the interviewer, and to coordinate their work.

In the procedure of the survey the police officer randomly (by random selection) excludes from the free traffic flow a road vehicle. After having excluded the vehicle from the traffic and after the vehicle had stopped safely, the interviewer starts with the interview. The interview can be rejected. The total duration of the interview did not exceed one minute.

While the passenger car is stopping, the police officer shall behave according to the rules defined by the Ministry of the Interior, and these include:

1. While performing their work the police officer shall wear official uniform and a reflective vest;
2. In performing their duty the police officer shall behave politely towards the citizens, greet them and address them using words such as: madam, or sir;
3. Before starting to stop the passenger cars, the police officer shall set up a road sign of danger at a distance of 100 to 150 metres along the right edge of the road before the stopping place; and



4. When in the traffic control on roads the police officers stop traffic participants, they have to use the “Stop Police” sign and perform the stopping on the road section along the right kerb in the direction of the traffic flow so that other traffic participants can notice on time the stopped vehicles, taking care not to disturb the traffic or endanger their own safety or the safety of other traffic participants.

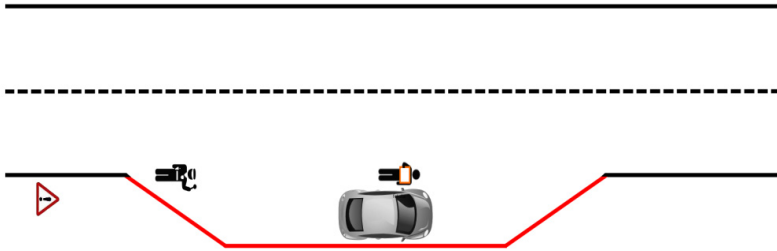


Figure 1: Scheme of stopping the passenger car.

The duties and rules of behaviour of the interviewers are also regulated:

1. perform with responsibility and on time all the entrusted tasks,
2. arrive ready to the survey location,
3. manage the questionnaire well,
4. at the end of the survey return the filled in questionnaires to the controller,
5. for every ambiguity regarding the procedures or unexpected cases in the field, contact the controller, who shall be at disposal all the time,
6. shall explain the question to the respondent in case of ambiguity which leads to better survey,
7. wear a reflective vest, and
8. shall not change any information given by the respondent.

The duties of the controller of the interviewers are:

1. preparation and organization of survey implementation,
2. providing information about the changes in the questionnaire,
3. selection of the interviewers,
4. cooperation with interviewers during the survey at an agreed location or by mobile phones,
5. solving all the problems the interviewers may encounter in the field,
6. checking whether the interviewer has correctly entered the time of survey and other data,
7. checking whether the survey has been performed at all the selected locations, and
8. keeping the questionnaires until a certain time when the survey is to be repeated.

3.3 Places and time of survey

Taking into consideration the position of the Varaždin County, and especially of the City of Varaždin, the locations for the cordon survey were selected. The selection criterion was to cover with a minimal number of positions the biggest incoming, outgoing and transit road flows in the City of Varaždin. Based on this, five (5) locations were selected: Airport (D2 from the east), Varaždin Breg (D3 from the south), Hrašćica (D2 from the west), Drava bridge (D3 from the north) and Nedeljanec (D35 from the southwest). The time of the cordon survey implementation was from 5 to 17 in two-hour shifts. The shifts were the early morning one, the noon one and the afternoon one.

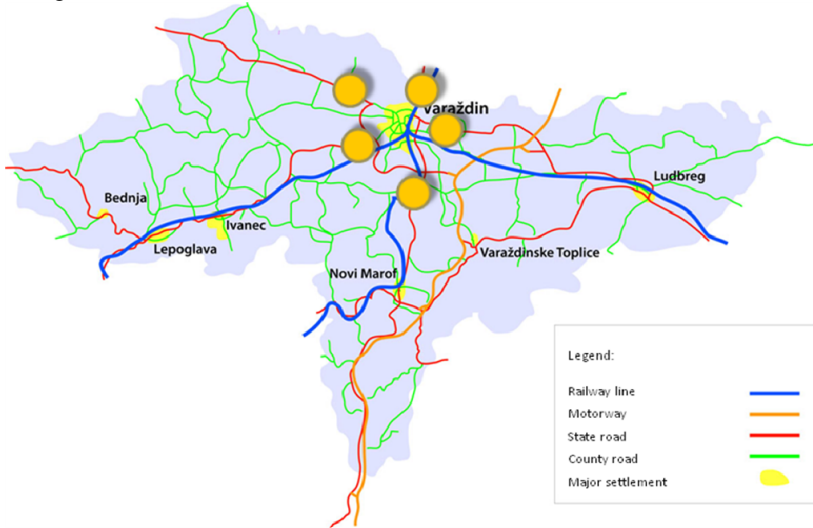


Figure 2: Positions of cordon survey.

It should be also emphasised that parallel with the implementation of the cordon survey the traffic count was performed as well.

3.4 Cordon survey questionnaire

Since the cordon survey is performed in a free flow and the respondent is selected randomly, the questionnaire has to be short and clear. During structuring of the questions care was taken about the relatively small number of questions and relatively short time necessary to answer the questions [8]. Therefore, the following questions were included in the questionnaire:

1. Where are you coming from?
2. Where are you going to?
3. The purpose of travelling?
4. How long have you been travelling?
5. Number of journeys per week?
6. If there was adequate public transport, would you use it?

7. Do you know what the term “Integrated passenger transport” means?”
8. Number of passengers in the vehicle, and
9. Code of the city on the license plate.

The answers to the first two questions required the place and exact address where from / to you are going. This was followed by the question about the purpose of travelling which required circling one of the following answers: (a) school/faculty, (b) to/from work, (c) business (business trip), (d) shopping, (e) personal (bank, hospital and similar), (f) leisure time (theatre, gym,...) and (g) other. In case the respondent did not choose any of the answers from (a) to (f), the purpose of the trip was added under (g). Then followed the question about the duration of the journey, taking minutes as the measuring units. Then there was a question about the number of trips within a week. Then followed the questions about the public passenger transport. The first of these referred to the possibility if public passenger transport existed would the respondent use it, and the other referred to whether the respondent was familiar with the term “integrated passenger transport”. In case the answer to this question was NO, the interviewers explained what integrated passenger transport was. The last two questions were filled in by the interviewers themselves, and these were about the number of passengers in the vehicle and the license plate on the vehicle.

4 Cordon survey OD matrix

4.1 Analysis of cordon survey results

The cordon survey was carried out on 22 March 2011 at five selected locations. A total of 409 questionnaires were collected. It is interesting to note that nobody rejected the survey. There are two possible reasons for this: (1) the police officer excluded randomly vehicles from the free traffic flow which creates in people a certain feeling of fear and they accept the survey without considering any other option, and (2) since a campaign was carried out beforehand, informing the public, the drivers knew that they could be stopped for the purpose of a survey. The share of questionnaires per locations is presented in Table 1.

Analyzing the purpose of travelling per sub-questions the answers were as follows: (a) school/faculty 2%, (b) to/from work 46%, (c) business (business

Table 1: Share of the cordon survey per locations.

Location	Number	Share
Airport	75	18%
Drava bridge	74	18%
Hrašćica	102	25%
Nedeljanec	77	19%
Varaždin Breg	81	20%
Total	409	100%



trip) 14%, (d) shopping 8%, (e) personal (bank, hospital and similar) 24%, (f) leisure time (theatre, gym,...) 1% and (g) other 5%. Figure 3 gives a graphic presentation of the share per travelling purpose.

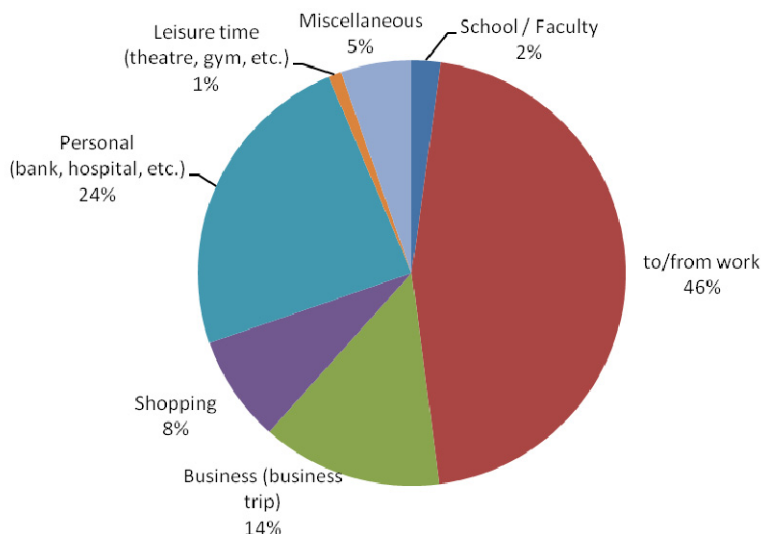


Figure 3: Share per travelling purpose.

The average travelling time amounted to 24.91 minutes, minimal time amounted to 2 minutes, and maximal time amounted to 180 minutes. The travelling time mode was 15 minutes whereas the travelling time median was 20 min. These times are in correlation with the question about the license plate on the vehicle. The license plates of the Varaždin County (VŽ) were on 77.26% of cars. The license plates of the neighbouring Međimurje County were on 14.43% of vehicles, followed by the Krapina-Zagorje County with 1.47% of vehicles and the City of Zagreb and Zagreb County with 3.18%.

The average number of trips within a week amounted to 8.75, the minimal number of trips was 2 and the maximal number was 40. The mod and median of the number of trips is 10. The average number of passengers in a vehicle (occupancy rate) is presented in Table 2.

Table 2: Average occupancy rate of cars per locations.

Location	Occupancy rate
Airport	1.37
Drava bridge	1.28
Hrašćica	1.44
Nedeljanec	1.49
Varaždin Breg	1.56
Total	1.43

Questions regarding the possibility whether there was an adequate service in public passenger transport, would the respondents use it, 44.74% of the respondents answered affirmatively, whereas the question about knowing what the term integrated passenger transport means was answered affirmatively only by 20.29% of respondents. These two answers open up two possibilities. The first possibility is the improvement of the public passenger transport since people are aware of the advantages but they do not use public transport due to its poor organization. The second possibility is that people have heard of the term integrated passenger transport and that there is a lot of space to inform the people about the advantages of integrated public passenger transport.

4.2 Creation 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 [9]. Using cordon questionnaires the respondents answered the questions about where they were coming from and where they were going to. 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 respondents in the cordon survey. A total of 409 respondents were interviewed at five locations and based on their answers 103 unique origins were obtained, 74 unique destinations, and 143 places of the start and end of the journey. Table 3 shows the general form of an OD matrix.

Table 3: General form of OD matrix.

	1	...	j	...	n	Σ
1	T_{11}					O_1
...						
i			T_{ij}			O_i
...						
m					T_{mn}	O_m
Σ	D_1		D_j		D_n	$\Sigma D_j = \Sigma O_i$

The cordon survey in the area of the City of Varaždin forms a 143 times 143 OD matrix. Because of the complexity of presenting the matrix of 143 times 143, it is not presented in the paper. The matrix was filled in by searching the origins and filling in the matrix with destinations.

4.3 OD matrix analysis

By analyzing the OD matrix for the City of Varaždin it may be concluded that in the implementation of the cordon survey 28.16% of respondents had the City of Varaždin as the origin of their journey whereas 51.05% of the respondents 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 1% at origins, and these are: Trnovec (5.79%), Sračinec (5.53%), Čakovec (5.26%), Hrašćica (3.68%), Vidovec (2.89%), then Ivanec and Novi Marof (2.37%), Pušćine (2.11%), Bartolovec (1.58%), then Petrijanec, Tužno and Varaždin Breg (1.32%) as well as Kučan Marof, Ludbreg, Nedelišće, Seketin, Vinica and Zamlaka (1.05%).

Also interesting are the places that have a share greater than 1% at destination, and these are: Čakovec (6.32%), then Novi Marof and Sračinec (4.21%), Zagreb (2.89%), Trnovec (2.11%), Ludbreg (1.84%), Bartolovec (1.58%), then Ivanec and Petrijanec (1.32%) as well as Lužan and Varaždin Breg (1.05%).

The obtained OD matrix can be used for further traffic planning procedures.

5 Conclusion

Traffic planning represents an efficient approach to solving traffic problems. During the recent years an increase in individual road traffic has been especially noted, as well as strong stagnation of public passenger transport in the Republic of Croatia. For the traffic planning to offer a solution of the problem, the traffic and non-traffic (demography, physical planning and economy) data need to be gathered. Naturally, it is understood that the data need to be up to date.

OD matrices are a necessity in creating the traffic plans. Therefore, a large number of methods for gathering data in order to establish OD matrices has been developed. One of the possible data gathering methods to establish OD matrices is the cordon survey. Cordon survey is a field method of interviewing road vehicle drivers. Such a survey was performed for the first time in the area of the City of Varaždin, and the recommendation was to perform such surveys at least in one-year cycles.

The survey was carried out on a free traffic flow on the roads entering / leaving the City of Varaždin at five strategic locations. A police officer was in charge of excluding vehicles from the free traffic flow and then the interviewer asked the questions. During the preparation of the cordon survey, special attention was paid to informing the citizens in order to make them well informed about the objective and the purpose, as well as the reason why they should participate in the survey. During the implementation of the cordon survey nobody rejected the interview.

Based on the result of the cordon survey, an OD matrix for the City of Varaždin has been established.

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