FEASIBILITY STUDY ON TRAFFIC RESTRICTION STRATEGIES IN THE OLD TOWN OF VILNIUS CITY

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Abstract. The paper presents the results of feasibility study on traffic restriction strategies in the Old Town of Vilnius city. The annually growing traffic flows in the narrow streets of Old Town increase the environmental, traffic safety, economic and social problems. The article covers analysis of the worldwide land use and transport strategies, the surveys of traffic flows in the Old Town of Vilnius and the analysis of survey results, gives the strategic proposals related to traffic organization and the substantiation of these proposals.

Keywords: land use strategy, transport strategy, Old Town of Vilnius, transit traffic.

1. Introduction.

The growth of traffic flows in the largest Lithuanian cities became a difficult dilemma. Social and economic sustainability in the cities is closely related to the character of communication system, i.e. which means of communication a priority should be given to and which model (American or European) the traffic organization solutions should be based on.

The aim of this article is to make the analysis of traffic restriction and organization possibilities in the Old Town of Vilnius City and to give strategic proposals on how to improve the existing situation. With this aim the article describes the worldwide traffic restriction and organization measures, the surveys of traffic flows and the analysis of survey results, gives the proposals related to traffic organization and the substantiation of these proposals.

2. Problem formulation

The annually growing traffic flows in the Old Town of Vilnius increase the environmental, traffic safety, economic and social problems [1-2]. The Old Town has been included into the UNESCO World Heritage List and it is a sensitive zone of the city from the transportation point of view, since it is located in a hollow, the prevailing streets are narrow and poorly aerated and the traffic is very intensive. Vehicle-generated noise in the city centre also cause a negative impact on the working capacity of the residents and on their rest at night due to the frequently exceeded permissible noise levels at these streets.

The most problematic core of Old town covers 92 hectares of the very central part of the Vilnius city. Based on expert and statistical forecasts the car ownership in Vilnius in the year 2020 will make about 600 cars per 1000 inhabitants [2-3]. Due to specific transportation system and such a large number of cars in the city, the transport infrastructure will be inevitably oversaturated and traffic conditions in the Old Town will get more and more difficult each year.

3. Worldwide practice

There are various ways and means studied and implemented all over the world to change the transport needs of inhabitants, modal distribution between transport modes and, herewith, to reduce environmental pollution [5]. The two main groups of strategies used for this purpose could be distinguished: land use strategy and transport strategy. The character of using these strategies is divided into technological, social, political and economic (administrative) subgroups.

Land use and transport strategies cover the planning of transport infrastructure and transport services, control, pricing and rendering of information. The aim of land use strategy is related to the reduction of the travel need (for example, a concept of sustainable and compact city), however, the implementation of transport strategies is aimed at harmonizing the communication system as much
as possible (for example, charging in order to reduce traffic flows, increasing the efficiency and occupation of vehicles). Implementation of the land use strategy helps to reduce travel length, to contribute to the change in human behaviour and efficient use of transport infrastructure. When implementing the transport strategy a modal distribution, human behaviour in selecting the travel mode and the living place is changed, the transport infrastructure is used more efficiently. From a long-term point of view these different strategies and their realization measures interact, therefore, they must be coordinated.

Experience of such cities as London, Stockholm, Oslo, Singapore, Riga and Tallinn shows that the most efficient way of traffic flow management is road pricing. More strict traffic restrictions with the help of prohibiting signs is not so attractive, since for a certain time the traffic is limited for all the users, the number of violators increases and this is not beneficial for the businesses located in the Old Town. On the other hand, the Old Town of Vilnius is large and it would be not wise leaving the central part of the city without transport communication [6-8].

4. Traffic surveys

Complex traffic surveys in the Old Town of Vilnius City were carried out on September 29 (Thursday) and October 22 (Saturday), 2005. The students of Vilnius Gediminas Technical University, Department of Urban Engineering made the surveys of traffic flows on 7 main entrance streets to the Old Town. Besides, a major part of the day the traffic and pedestrian flows were surveyed as well as the occupancy of parking places in Vokiečių Street (Central street in Old Town). With the help of Police the students made the questioning of the drivers on 5 main entrance streets to the Old Town (see Fig. 1).

For the purpose of transport planning the Vilnius City is divided into a finite set of transportation regions (see Fig. 1), which during the surveys was used to determine the transit flows of the Old Town (transit flow – vehicles and their drivers passing through the Old Town with the destination related to the other transportation region of the city).

The questioning was carried out on 29 September, 6 October and 13 October between 8.00 and 13.00. In the course of a questioning n=889 questionnaires (see Table 1) were collected that were processed using the database of streets and transportation regions. Since no data was available before the survey to exactly define the extent of questioning, the survey error was determined by the following formula for defining the sample size [9]:

\[
n = \frac{N \times 1.96^2 \times p \times q}{\varepsilon^2 \times (N-1) + 1.96^2 \times p \times q}
\]

(1)

![Fig. 1. Transportation regions of the Vilnius City and the main entrances to the Old Town (questioning sites marked by ?)](image)

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From this formula the accuracy of the survey was estimated:

\[ \varepsilon = \sqrt{\frac{N \cdot 1.96^2 \cdot p \cdot q - n \cdot 1.96^2 \cdot p \cdot q}{n(N-1)}} \]  

(2)

where \( N \) - population size, the value 1.96 correspond to 95 % of probability level of the standardized normal distribution; \( p \) - anticipated probability of the event’s outcome, i.e. a probability that the considered feature will occur in the considered population (usually a probability of the worst variant is taken – the feature characteristic to half, i.e. 50 % of the population and the selected \( p = 0.5 \)); \( q \) - probability that the considered feature will not occur in the considered population (\( q = 1 - p = 0.5 \)); \( \varepsilon \) - desired accuracy, usually set as 0.05.

Table 1. Traffic flow on the main entrances to the Old Town and the number of respondents

<table>
<thead>
<tr>
<th>Name of intersection</th>
<th>Traffic flow between 8.00 and 13.00</th>
<th>Number of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pylimo–Islandijos</td>
<td>3347</td>
<td>218</td>
</tr>
<tr>
<td>Pylimo–Trakų</td>
<td>2653</td>
<td>111</td>
</tr>
<tr>
<td>Pylimo–Arklių</td>
<td>1863</td>
<td>207</td>
</tr>
<tr>
<td>Maironio–Rusų</td>
<td>4042</td>
<td>198</td>
</tr>
<tr>
<td>Sventaragio–S.Gucevičiaus</td>
<td>3063</td>
<td>155</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td>14968</td>
<td>889</td>
</tr>
</tbody>
</table>

Having estimated for a given number of questionnaires the accuracy with 95 % probability it can be stated that the features of the questioning results have \( \varepsilon = \pm 3.2 \) (%) reliability. The reliability is better than the mean reliability set at the beginning of the survey.

5. Results of the traffic surveys

Most of cars entering the Old Town were driven by men (73 %) and almost 63 % of the respondents are attributed to the group of younger people, thus, the major part of respondents is the working people. The average car occupation determined during the survey – 1,35 pers.

One of the tasks of the survey is to determine transit flows and their indicators in the Old Town of Vilnius. On the basis of transportation regions it was determined that about 19 % of respondents declared the Old Town as being their departure and arrival point. This means that the car is used by a large part of the drivers as a communication mean for a short trip to the Old Town. Such a hypothesis is confirmed by the average travel time from the departure indicated by the drivers. About 44 % of the drivers going to the Old Town have indicated that their travel duration is up to 15 minutes.

Transit traffic in the Old Town of Vilnius makes 39 % of the total number of passing vehicles (Fig. 2). Transit vehicles are those crossing the Old Town without making a stop and the drivers have no travel purposes within this area.

Most of the drivers passing through the Old Town (60 %) in a day time have job-related purposes and only few of them pass through the Old Town with daily affairs or to do shopping (6 and 1 %, respectively). A relatively large part of the drivers have indicated other travel purposes (20 %) that could be related to daily or cultural travels (to take a walk, also meetings, sports, visiting medical institutions, etc, Fig. 3).

Similar results were obtained having made the analysis of travel purposes of those who come to the Old Town. About 59 % of travels are related to their job, 10 % go to educational institutions and 18 % have other purposes. Also, only few people go with daily affairs or to do shopping (6 and 1 %, respectively).

Since job-related travels are prevailing, 68% of respondents have indicated that this is their usual travel which is repeated 4,92 times per week on average. The remaining travels are made non-periodically.

To find out the drivers’ attitude towards road pricing the following question was given: is it necessary to introduce the charge for the entrance to the Old Town in order to reduce the transit traffic? About 66 % of respondents were against charging and about 34 % expressed their approval. All the respondents without exception coming home to the Old Town (residents of the Old Town, \( N=13 \)) expressed their willingness to charge the entrance to the Old Town.

![Fig. 2. Transit traffic in the Old Town of Vilnius](image)

![Fig. 3. The travel purposes of the people crossing or entering the Old Town](image)
Traffic organization in the core of the Old Town is specific: some streets have speed and traffic restrictions or the traffic of heavy vehicles is prohibited. Pedestrian streets are only formal since they are used by traffic, parking of vehicles is allowed. Due to a rather fast development of the core of the city the traffic flows have been continuously increasing and in the last 20 years the annual increase of the traffic flows have reached 5,5 %. Table 2 gives the dynamics of traffic on the main entrances to the Old Town per an average hour in the period 1988-2005 [10].

Table 2. Dynamics of traffic in the Old Town of Vilnius per an average hour (1988-2005)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Islandinio</td>
<td>228</td>
<td>300</td>
<td>366</td>
<td>566</td>
<td>688</td>
<td>463</td>
<td>744</td>
<td>565</td>
</tr>
<tr>
<td>Trakų</td>
<td>546</td>
<td>360</td>
<td>674</td>
<td>722</td>
<td>804</td>
<td>456</td>
<td>630</td>
<td>788</td>
</tr>
<tr>
<td>Arkičiai</td>
<td>88</td>
<td>104</td>
<td>126</td>
<td>136</td>
<td>140</td>
<td>120</td>
<td>210</td>
<td>109</td>
</tr>
<tr>
<td>Subačiaus</td>
<td>1233</td>
<td>1400</td>
<td>206</td>
<td>228</td>
<td>143</td>
<td>400</td>
<td>210</td>
<td>375</td>
</tr>
<tr>
<td>Latako</td>
<td>123</td>
<td>300</td>
<td>227</td>
<td>290</td>
<td>435</td>
<td>624</td>
<td>515</td>
<td>462</td>
</tr>
<tr>
<td>S. Gacevičiaus</td>
<td>53</td>
<td>50</td>
<td>361</td>
<td>450</td>
<td>282</td>
<td>354</td>
<td>267</td>
<td></td>
</tr>
<tr>
<td>Universiteto</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>78</td>
<td>100</td>
<td>110</td>
<td>120</td>
<td>140</td>
</tr>
<tr>
<td>Total on the entrances</td>
<td>1409</td>
<td>1157</td>
<td>2118</td>
<td>2382</td>
<td>2499</td>
<td>2736</td>
<td>2604</td>
<td>2794</td>
</tr>
</tbody>
</table>

Note: In 1995 the entrance to the Old Town was charged, thus, the traffic flows have decreased at that date. Later, the charging was cancelled.

With the remaining general tendencies of 7 % annual growth of the car ownership in the Vilnius City in the year 2020 the city will have more than 600 cars per 1000 inhabitants [2-3]. The surveys and recalculations showed that the Old Town of Vilnius is entered by more than 63 thousand of cars daily by the main entrances. Transit traffic makes more than 25 thousand of vehicles per day and this has a negative impact on the tourist and recreational attractiveness of the Old Town.

6. Alternatives for reducing traffic volume

With the annual increase in the car ownership and traffic flows by 7 and 5,5 %, respectively, it is necessary to seek for acceptable solution to decrease traffic flows in the Old Town of Vilnius City.

A complete prohibition of traffic (with the help of prohibitive signs) would be unacceptable with respect to the businessmen and residents of Vilnius, therefore, the more widely analysed alternatives are the Old Town by-passes, loop or charged entrances (the charge is not applied to emergency services, special transport, disabled people, public transport). Encouragement of the use of public transport and non-motorized vehicles as well as walking on foot could be analyzed as additional measures of these alternatives.

Alternative of the Old Town by-passes

The alternative was analyzed using the VIDAS database developed on the basis of EMME/2 Traffic Flow Modelling Software. When modelling traffic flows the following elements were defined: hypothetical alternation of land use (based on the Master Plan), transport system development and the growth of the car ownership level. The scenarios were developed by logically arranging the order of probable events and based on the analysis of the existing situation and the mentioned surveys the forecast was made. When developing the scenarios the two main and separate infrastructure elements were distinguished—having the influence on the traffic flows of the Old Town, i.e. the southern by-pass of the Old Town and the southern by-pass of the city.

The modelling results showed that the southern bypass of the Old Town and the southern by-pass of the city will have the influence on the traffic flows in the territory of the Old Town. Shortly after implementation of the projects the traffic flows would be reduced by about 400 cars per hour, while in the year 2015 as much as 554 vehicles per hour would bypass the Old Town if compared to the “Do nothing” scenario. However, a general tendency of the growth of traffic flows would remain 6,1 % per year and this allows us to state that such an infrastructure development would only slightly contribute to a sustainable development of the Old Town of Vilnius City. On the other hand, the realization of the projects gives a possibility to divert a major part of traffic flows from the narrow streets of the Old Town (at present it is necessary to cross the Old Town as there are no other alternatives) and to designate them for a priority traffic of pedestrians, bicyclists and public transport.

Alternative of the loop entrance

The idea of loop-type entrance to the Vilnius Old Town was suggested ten years ago with the aim to reduce a motorized transportation attractiveness of the Old Town. One of the analyzed alternatives is given in Fig. 4.

Fig. 4. The scheme of the loop entrance to the Old Town (source: Municipal Enterprise “Vilniaus planas”)
foot). Also, unfavourable conditions are created for the transit traffic, since there is no possibility to a straight crossing of the whole territory of the Old Town. This alternative in a short-term perspective has certain advantages as no charges will be introduced for the residents of the Old Town, and the traffic loading of the core of the Old Town will be reduced. To find out a likely influence of this traffic organization scheme the modelling of traffic flows was carried out for the years 2005 and 2015.

Based on the modelling results it was determined that the traffic flows of the Old Town would increase by 5.9 % per year on average. If compared to the existing situation the traffic flows on the city streets would be reduced by 10.9 % and this relative tendency would remain until 2015.

**Alternative of the charged entrance**

The charged entrance to the Old Town undoubtedly will influence the selection of travel route and will divert the traffic flows to roundabouts streets. However, in order to evaluate this alternative it is necessary to refer to certain assumptions or to the examples of other cities.

In this case the modelling of traffic flows (VIDAS) is not beneficial or requires a wide range of additional surveys to assess the individual behaviour of the user of transport infrastructure.

Analysis of the worldwide practice had already been made and we can only mention once again the examples of Oslo (decreased by 3–4 %), London (decreased by 30 %) and Singapore (soon after charging - decreased by 73 %, in a long-term perspective – by 64 %).

The survey showed that the transit traffic in the Old Town of Vilnius makes 39 %. Part of people will have one or another reaction to the charged entrance: they will reject the travel, change to public transport, choose the “park and go” alternative by leaving the car and walking on foot, share the car with their colleagues, etc.

The academic staff of the Department of Urban Engineering carried out the expert evaluation of the influence of charged entrance on the subsystem of private transport (Table 3).

**Table 3. Evaluation of the influence of charged entrance**

<table>
<thead>
<tr>
<th>Influence on traffic flows</th>
<th>Influence on remaining traffic flows</th>
<th>%</th>
<th>Vehicles</th>
<th>%</th>
<th>Vehicles</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pessimistic scenario</td>
<td></td>
<td>20</td>
<td>4952</td>
<td>5</td>
<td>1936</td>
<td>6888</td>
</tr>
<tr>
<td>Medium scenario</td>
<td></td>
<td>27</td>
<td>6685</td>
<td>7</td>
<td>2711</td>
<td>9395</td>
</tr>
<tr>
<td>Optimistic scenario</td>
<td></td>
<td>35</td>
<td>8665</td>
<td>10</td>
<td>3872</td>
<td>12538</td>
</tr>
</tbody>
</table>

According to the medium scenario the total flow of vehicles would decrease by about 14.8 %. In a long-term perspective, when all the by-passes of the Vilnius City are constructed, the effect of charged entrance on the transport system of the Old Town will be even larger and can reach 16–20 %.

The system of video cameras is very flexible from the point of view of collecting charges (the residents could pay by the Internet, telephone, in special places) and the co-ordinately controlled system for the management of traffic flows, planned to be installed in the nearest future, would supplement it. The latter system optimizes time-delays in the crossings and gives the drivers additional (real-time) information about the alternative routes in Vilnius City.

**7. Discussion of the results**

Volumes of traffic flows in the Old Town of Vilnius are related to not only the concentrated variety of business but also to the developed structure of the city. From the long-term point of view it is necessary to reduce the number of enterprises and establishments in this territory generating large attraction of inhabitants.

Three main alternatives have been modelled and analyzed: “Old Town by-passes”, “Loop” and “Charged” entrance to the Old Town.

In case of the modelled “Do nothing” alternative a vehicle flow entering the Old Town consists of 2820 vehicles in a rush hour (see Table 4). The forecasted average annual growth is 5.8 % (for 10 years).

**Table 4. Summary of modelling and expert evaluation results**

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Reduced number of vehicles (%) in a rush hour if compared to “Do nothing” scenario</th>
<th>Forecasted annual growth of traffic flows % (for 10 years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Do nothing&quot;</td>
<td>2820 vehicles</td>
<td>5.8</td>
</tr>
<tr>
<td>&quot;Old Town by-passes&quot;</td>
<td>14</td>
<td>6.1</td>
</tr>
<tr>
<td>&quot;Loop entrance&quot;</td>
<td>10.9</td>
<td>5.9</td>
</tr>
<tr>
<td>&quot;Charged entrance&quot;</td>
<td>14.8</td>
<td>4.5</td>
</tr>
</tbody>
</table>

The “Old Town by-passes” alternative shows that after construction of the southern by-pass of the Old Town and the southern by-pass of the city the flow of vehicles entering the Old Town in a rush hour would decrease by 400 (14 %) vehicles if compared to the “Do nothing” alternative. Meanwhile, the annual growth of the traffic flows would be significantly faster – 6.1 % (10 years).

The “Loop entrance” alternative has the advantage of restricting the traffic flows by the reduced attractiveness of driving on the Old Town streets. The flows entering to the Old Town, if compared to “Do nothing” alternative, in peak hour would decrease by 308 (10.9 %) vehicles and the annual growth would reach 5.9 %.

In case of the medium alternative the “Charged entrance” would reduce the entering traffic flow by 14.8 %. A tendency for the annual growth of the traffic flows would remain within the limits of 4–5 %.

All the analyzed alternatives would undoubtedly influence the decrease of traffic flows. However, it must be taken into consideration that the alternative of by-passes is already being implemented and the woks have already started. Thinking about the more distant future it
would be important to decide which alternative has to be chosen: the “Loop entrance” or the “Charged entrance”. Modelling, expert evaluation and analysis results show that the latter alternative is more advantaged.

8. Conclusions and recommendations

1. The worldwide practice of introducing the road pricing in the cities showed that before it is introduced it is necessary to clearly define the goals to be reached: to reduce congestions and environmental pollution, to protect the Old Town and to enhance its attractiveness for tourism; also it is necessary to declare that the collected funds will be used only for the development of public transport and public infrastructure.
2. During the questioning of drivers in the Old Town of Vilnius it was determined that the transit traffic in the Old Town makes about 39%. This is more than 25 thousand vehicles per a working day causing a negative impact on the tourist and recreational attractiveness of the Old Town.
3. Traffic prohibition (with the help of prohibitive signs) is unacceptable with respect to the businessmen and residents of Vilnius, therefore, the more widely analysed alternatives are the charged entrance (the charge is not applied to emergency services, special transport, disabled people, public transport, ecologically cleaner vehicles and the residents of the Old Town) and the loop entrance to the Old Town.
4. All the analyzed alternatives have the influence on the decrease of traffic flows in the Old Town. Modelling, expert evaluation and analysis results show that the “Charged entrance” alternative is more advantaged than the “Loop entrance” alternative. The former alternative is also attractive in giving a possibility in 10 years to collect funds for the financing of public transport infrastructure.
5. One of the most simple traffic restriction mechanisms from technological and monetary point of view – recognition and registration of vehicle number plates which is used in London. There is no need to install in the vehicle additional recognition devices and the minimum number of employees is enough to maintain the system.
6. The “Charged entrance” alternative is a new mean to restrict traffic flows and to harmonize the development plans of the city. Charging should be applied in rush hours of the working days (between 07.00 and 18.00). Vehicles could be recorded on 7 main entrances to the Old Town of Vilnius City.

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References