Design and evaluation of traffic calming schemes in urban areas – the case of the city of Larissa

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Abstract

Within the framework of this paper, the design and evaluation of a comprehensive scheme concerning a variety of traffic management measures, and especially traffic calming measures, like woonerf, 30 km/h zones, bus priority measures, routes for cyclists, interventions at intersections, pedestrian facilities etc., aiming at the improvement of traffic and associated environmental conditions are presented and discussed with reference to the center of the city of Larissa in central Greece. The evaluation of these measures is based on the use of both qualitative and quantitative criteria, which were selected in accordance with the objectives and type of the proposed measures. Examples of such criteria are the geometric characteristics of traffic lanes and sidewalks, the strict use of bus lanes by authorized vehicles, the degree of use of the respective infrastructure by the pedestrians, the parking rules violations, the degree of use of the respective infrastructure by cyclists, speed, the overall perception of the environment as a safe one by the road users etc. The results presented are quite revealing about the effectiveness of traffic calming measures in central areas of medium size Greek cities, but there is a lot to be done yet concerning the research on the evaluation process of such measures.

1 Introduction

Most urban areas in the E.U. and in other countries all over the world suffer from the private car domination. The extensive use of cars results in a number of undesired effects such as environmental pollution, low safety levels, visual
intrusion, and in general degradation of quality of life. These traffic-related problems continue to increase as a consequence of both high mobility and increasing car ownership. At the same time it has been recognized that increased supply of road infrastructure cannot really offer a solution to this problem. On the contrary it promotes the use of private cars in the long run. In order to deal with this issue, transport planners have come with a variety of Transport Demand Management (TDM) measures. A rather exhaustive list of TDM measures can be found in many transport books as well in several research reports and papers [1].

Traffic calming has been always an efficient TDM measure. It discourages car users from using the car in certain areas and thus it reduces drastically traffic flows and speeds in these areas. Traffic calming are combinations of physical and/or regulatory measures that impose certain restrictions allocated in space and/or in time. In fact traffic calming measures have been mainly associated with constructions of road surface humps or thumps, street narrowing, alignment changes, use of coloured materials for surfacing, elevated (humped) pedestrian crossings, creation of lay-bys for parked vehicles and other similar constructions.

Examples of traffic calming measures can be found in many books, articles, and research reports from E.U. projects [2,3,4]. The Danish Road Directorate has issued a manual on Speed Management [5] that contains useful examples and practices for this purpose, where traffic calming is one of the most promising interventions and also a manual concerning the framework for the planning and evaluation process for speed management measures in urban areas [6].

The majority of Greek cities of large, medium and even small size experience nowadays a situation where traffic and associated environmental problems exist and seriously affect people’s life. Many attempts have been made in the past to overcome these problems but with limited success. Specialized studies about traffic calming measures concerning the urban road network are not a common situation in Greece. Therefore, most of the traffic calming measures which were proposed and implemented until now, are part of short-term traffic management schemes dealing –among others– with pedestrians, traffic flows, road infrastructure, public transport, safety, parking, environment etc.

Quite recently, the implementation of traffic calming measures has been proposed within the framework of such studies, basically aiming at the improvement of road safety level and the environmental conditions at urban areas in Greece. The availability of experience and the positive results arising from the implementation of such measures abroad was a decisive factor to implement traffic calming measures in Greek cities too. Based on the examination of the alternative traffic schemes which were proposed and partially implemented [7] in various municipalities in Thessaloniki Metropolitan Area, the following measures can be classified as traffic calming measures: pedestrianisation with no vehicle access, pedestrianisation with limited vehicle access, plateau, speed humps, changing street alignment, woonerf, street
narrowing and 30km/h zones. The above measures were implemented in different timings during the period 1991-99.

The city of Larissa in central Greece is also considered to be a good reference point because it was the first major city in Greece (together with the city of Heraklion on the island of Crete) where a master plan was designed and partially implemented at the end of '80s. An extensive pedestrian network was also designed and implemented in the city center and its greater area. The Municipality of Larissa participates in the European Network "Car Free Cities" and in other programs concerning exchange of experiences (PACTE) together with the Municipalities of Edessa, Graz and Leeds. Within the framework of this paper, the design and evaluation of a comprehensive scheme concerning a variety of traffic management measures, and especially traffic calming measures, aiming at the improvement of traffic and associated environmental conditions are presented and discussed with reference to the center of the city of Larissa.

2 Trips characteristics in the city of Larissa

Within the framework of the research project which was carried out in the city of Larissa by the Aristotle University of Thessaloniki in 1997 [8], an extensive questionnaire based survey was included. The survey consisted of a total number of 913 questionnaires (2,938 residents) and the study area was divided into 20 traffic zones. It must be mentioned at this point that the city population, according to the 1991 national census, was 110,116 residents (33,659 households). The estimation for the population for the year 2001 is 119,107 residents. The most important results of this survey are presented hereinafter in order to provide a clear image of the traffic characteristics in the study area before going to the proposed traffic calming measures. More specifically, the vehicle ownership index for various vehicle categories is presented in Table 1.

<table>
<thead>
<tr>
<th>Number of vehicles</th>
<th>Bicycles (%)</th>
<th>Two-wheels cycles (%)</th>
<th>Private cars (%)</th>
<th>Rural engines (%)</th>
<th>Other vehicles (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>65.2</td>
<td>81.1</td>
<td>28.9</td>
<td>96.4</td>
<td>18.1</td>
</tr>
<tr>
<td>1</td>
<td>24.8</td>
<td>17.7</td>
<td>65.6</td>
<td>3.2</td>
<td>41.9</td>
</tr>
<tr>
<td>2</td>
<td>6.2</td>
<td>1.1</td>
<td>5.0</td>
<td>0.3</td>
<td>22.6</td>
</tr>
<tr>
<td>3</td>
<td>3.8</td>
<td>0.1</td>
<td>0.4</td>
<td>0.1</td>
<td>10.6</td>
</tr>
<tr>
<td>4</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Proportion</td>
<td>153 per 1,000 residents</td>
<td>64 per 1,000 residents</td>
<td>241 per 1,000 residents</td>
<td>13 per 1,000 residents</td>
<td>-</td>
</tr>
</tbody>
</table>

The private car ownership and the mobility of households are presented in the following Table 2.
Table 2: Car ownership and mobility of households in the city of Larissa

<table>
<thead>
<tr>
<th>Number of private cars per household</th>
<th>Trips per household (average value)</th>
<th>Trips per member of the household</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2,26</td>
<td>1,49</td>
</tr>
<tr>
<td>1</td>
<td>3,59</td>
<td>1,61</td>
</tr>
<tr>
<td>2</td>
<td>4,17</td>
<td>1,94</td>
</tr>
<tr>
<td>Total</td>
<td>3,23</td>
<td>1,59</td>
</tr>
</tbody>
</table>

The frequency of trips to and from the city center is as follows: two or more trips per day: 52,6 %, once a day: 18,0 %, not very often: 29,4 %. The frequency of trips made to and from the city center by different modes is presented in Table 3.

Table 3: Frequency of trips made to and from the city center by different transport modes

<table>
<thead>
<tr>
<th>Frequency of trips</th>
<th>Walking trips and bicycle trips</th>
<th>Trips made by Public Transport buses</th>
<th>Trips made with private cars, taxis &amp; two-wheel cycles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very often</td>
<td>62,3 %</td>
<td>12,5</td>
<td>25,1 %</td>
</tr>
<tr>
<td>often</td>
<td>10,4 %</td>
<td>14,0</td>
<td>16,7 %</td>
</tr>
<tr>
<td>not so often</td>
<td>6,0 %</td>
<td>5,5</td>
<td>13,3 %</td>
</tr>
<tr>
<td>rarely</td>
<td>9,5 %</td>
<td>19,9</td>
<td>26,0 %</td>
</tr>
<tr>
<td>never</td>
<td>11,7 %</td>
<td>48,0</td>
<td>18,9 %</td>
</tr>
</tbody>
</table>

The trip duration to the city center (average value from all twenty traffic zones) is 13,1 minutes for walking, 15,7 minutes for bicycles, 13,1 minutes for two wheel cycles, 16 minutes for private cars, 13,5 minutes for taxis and 26,2 minutes for public transport buses. Trip distribution per mode and average trip duration are presented in Table 4:

Table 4: Trip distribution per mode and average trip duration

<table>
<thead>
<tr>
<th>Transport mode</th>
<th>%</th>
<th>Average trip duration (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walking</td>
<td>42,1</td>
<td>13,1</td>
</tr>
<tr>
<td>Bicycle</td>
<td>4,6</td>
<td>15</td>
</tr>
<tr>
<td>Two wheel cycle</td>
<td>4,9</td>
<td>12,1</td>
</tr>
<tr>
<td>Private car</td>
<td>32,3</td>
<td>19</td>
</tr>
<tr>
<td>Taxi</td>
<td>2,2</td>
<td>16,8</td>
</tr>
<tr>
<td>Public Transport bus</td>
<td>12,3</td>
<td>26</td>
</tr>
<tr>
<td>Special bus</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Truck, semi truck</td>
<td>0,5</td>
<td>-</td>
</tr>
</tbody>
</table>
Trip purposes are as follows: Return to home: 48.5%, Work: 17.5%, Education: 6.5%, Shopping: 8.3%, Recreation: 10.4%, Other: 8.8%.

Regarding the above presented data it seems that every resident makes, in general, two or more trips per day to and from the city center. The residents usually walk or use their own bicycles for their trips to and from the city center. The high number of bicycles, although no adequate infrastructure exists for them, gives a strong indication about people's will to further use environment friendly transport means when such an infrastructure will be available. The use of Public Transport is not at desirable level due to various reasons (e.g., bus stop at a long distance from point of trip origin, expensive fares, long duration of trips by bus, insufficient scheduling etc.). Finally, one out of four residents use either its own private car/ two-wheel cycle or a taxi for trips to and from the city center.

3 Proposed traffic calming measures

The proposed traffic calming measures in the city of Larissa include changes in the physiognomy of the road network and their main objective is to reduce the speed of vehicles and to improve the overall traffic and environmental conditions in the central area. They also include reduction in the width of a road, creation of dead ends, construction of mini roundabouts etc. It is known that traffic calming measures aim at the improvement of road safety, the protection of pedestrians, the upgrade of local streets, the creation of an environmental friendly urban area, the reduction of visual intrusion, the reduction in noise levels, the reduction in vehicle emissions etc. Therefore all these measures serve the overall target which is the improvement of the traffic and environmental conditions in the city center. This center according to the results of the trip characteristics survey plays an important role in the overall transportation system of the city.

More specifically the regulatory and physical measures proposed for the city center include the following (measures refer to the Public Transport system support the traffic calming measures since they affect modal split):

Upgrade and improvement of the Public Transport system
i. Incorporation of new bus lines in order to serve the city center and also the interurban bus terminals
ii. Buslanes along the main arterial network
iii. Reformation of the existing exploitation system including the transformation of through bus lines to radial ones

Construction of woonerf (priority given to pedestrians)

Implementation of 30 km/h traffic zones

Changes in the geometric characteristics of the road network
i. Widening of sidewalks
ii. Discontinuation of road alignment
iii. Elevated pedestrian crosswalks

Interventions at junctions
i. Simplification of turning movements
ii. Design of pedestrian crossings at an angle of 90° (vertically) to the road alignment

iii. Settlements for the restoration of visibility

iv. Incorporation of roundabouts

Development of transition areas (from pedestrian streets to ordinary urban streets)

Constructions on the sidewalks for the incorporation of on street parking (e.g., recess areas)

Construction of bicycle lanes or cyclists routes

Installation of proper signing (vertical and horizontal)

The master plan of these measures is presented in the following Map 1. It must be mentioned at this point that, in the framework of the efforts made by the municipality of Larissa for the improvement of the environment for the pedestrians, the city authorities decided to participate in the European Car Free Day (E.U. car free cities network) in 22-9-2000. Within the actions taken for that day the following are included:

a) distribution of relevant printed material (e.g., brochures etc) concerning the “Car Free Day”, b) meetings and other events with school authorities and city officials in order to disseminate information, c) design and production of maps with the bicycle network for that day. A number of 650 bicycles were distributed to school students. A number of 300 bicycles were available to all residents at central points. d) the bus operator has agreed to issue a rebate ticket of approximately 0.3 Euros for that day. Students made their trips by bus free of charge.

The area of 2.200 hectares in which “Car Free Day” program is implemented is presented in Map 1. The following vehicle categories were allowed to enter this area during that day: Public transport buses, school buses, emergency vehicles, vehicles belong to people with special needs, vehicles belong to administration (central/local), police vehicles, vehicles belong to press (permission holders only), vehicles to/from hotels, vehicles of parents transporting children to kindergarten and taxis for emergency purposes only.

4 Evaluation methodology and results

The evaluation of traffic calming measures is based on a number of criteria that are related to the expected effects of the measures. The most common of these criteria are the following: traffic flow, vehicle speed, traffic accidents or road safety, pollutant emissions, noise levels. Other criteria may also be used such as drivers and pedestrians’ behaviour in the area or other subjective ones such as opinions or attitudes. A questionnaire based survey was conducted in Thessaloniki in order to evaluate the effects from the implementation of speed humps on a road in front of a school area. According to the results of the survey [9] people who lived in the area before the implementation of the traffic calming
Map 1: Master plan of traffic calming measures in the city of Larissa
measures seem to be more sensitive concerning road safety. It must be mentioned at this point that such surveys are not very common in the areas of traffic calming measures in the country.

Economic criteria can be also employed such as commercial value of residences and/or shops. The success or not of the measures will depend on the values of certain indices that are used to measure the change achieved in these criteria. In the case of Larissa there were no data available for all the above mentioned criteria in order to perform a complete “before” and “after” evaluation.

Therefore, quantitative criteria apply only to the Public Transport system of the city and to the road geometrical characteristics where a rearrangement took place, while qualitative criteria apply to all the rest measures. In Table 5, the results of the evaluation of the traffic calming measures are presented, following a “before” and “after” approach. It should be mentioned at this point that driving behaviour, and also pedestrian behaviour, are not at desirable level in the country. This affects the success of the measures but it is not easy to be quantified. The Ministry of Transport and Communications has recently, started a big effort in the field of drivers’ behaviour and emphasis has been given on the design and operation of drivers’ education and examination centers in the country [10].

In order to perform the evaluation, observations, measurements, on site visits and expertise were made in the city center. Modern technology was used (or will be used in next evaluation steps) like GPS, speed-radar, digital video and photo cameras. As a result of the above mentioned process a clear image of the implementation impacts of traffic calming measures (and not only) has been obtained, with emphasis given to the impacts for pedestrians and generally the vulnerable road users (aged people, students, people with special needs, cyclists).

5 Conclusions

As a result of the above findings there is need for better enforcement in bus lanes and construction of physical separation due to illegal entrance of unauthorized vehicles. Running times of buses in bus lanes were significantly reduced in some cases but there are no available results about the effect on modal split. Woonerf were not implemented so far. Shopkeepers or residents usually react in the idea of loosing their parking places in woonerf and sometimes, due to such reactions, local authorities postponed their plans. The positive effect of elevated crosswalks in intersections is sometimes limited due to improper implementation. In any case, illegal parking seems to be eliminated in these intersections.

Problems appear to continue with illegal parking on sidewalks, unless special measures are taken. Changes in road alignment seem to have a positive effect towards the creation of a safe environment for the pedestrians. Finally it seems that only the provision of the adequate infrastructure does not necessarily means
<table>
<thead>
<tr>
<th>Table 5: Evaluation of traffic calming measures in the city of Larissa</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective</strong></td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>Change in modal split in favor of public transport</td>
</tr>
<tr>
<td>Improvement of the capacity of the Traffic System</td>
</tr>
<tr>
<td>Improvement of the pedestrian safety</td>
</tr>
<tr>
<td>Improvement of the pedestrian accessibility</td>
</tr>
<tr>
<td>Improvement of the environment</td>
</tr>
<tr>
<td>Improvement of the protection of neighborhoods</td>
</tr>
</tbody>
</table>

**Qualitative Rationale:**
- Not implemented yet.
- Proposed for consideration with new traffic management measures.
- Not implemented yet.
- Not implemented yet.
- Not implemented yet.
- Not implemented yet.
- Not implemented yet.
- Not implemented yet.

**Quantitative Rationale:**
- n.a. = Not available data.
- n.a. = Not applicable.
- n.a. = Not available data.
- n.a. = Not applicable.
- n.a. = Not available data.
- n.a. = Not applicable.
- n.a. = Not available data.
- n.a. = Not applicable.

**Rationale:**
- To improve pedestrian safety and accessibility.
- To reduce traffic volumes and improve the environment.
- To protect neighborhoods from noise and pollution.
- To address congestion and improve traffic flow.
- To enhance the integration of public transport and pedestrian access.
- To address parking issues and improve traffic flow.
- To improve traffic calming and reduce accidents.
- To address safety issues and improve traffic flow.

**Comments on the "After" Situations:**
- Limited
- Increased
- Improved
- Reduced
- Improved
- Increased
- Improved
- Increased

**After:**
- Traffic volumes
- Traffic flow
- Parking
- Pedestrian safety
- Environment

**Before:**
- Traffic volumes
- Traffic flow
- Parking
- Pedestrian safety
- Environment

<table>
<thead>
<tr>
<th>After</th>
<th>Before</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traffic volumes</td>
<td>Traffic volumes</td>
</tr>
<tr>
<td>Traffic flow</td>
<td>Traffic flow</td>
</tr>
<tr>
<td>Parking</td>
<td>Parking</td>
</tr>
<tr>
<td>Pedestrian safety</td>
<td>Pedestrian safety</td>
</tr>
<tr>
<td>Environment</td>
<td>Environment</td>
</tr>
</tbody>
</table>

**Additional Notes:**
- Limited
- Increased
- Improved
- Reduced
- Improved
- Increased
- Improved
- Increased
that a cyclist will not continue to use the traffic lanes for the vehicles. Therefore there is need for changing cyclists’ behaviour through proper educational programs. This may also apply in the case of pedestrians who continue to use, in the “after” situation, the infrastructure made for the cyclists. Finally it became obvious that a standard evaluation framework is needed in order to enable objective and subjective evaluation of traffic calming measures in the country.

References


[10] Aristotle University of Thessaloniki, Faculty of Rural and Surveying Engineering, Department of Transportation and Hydraulic Engineering, Determination of the structural and operational elements of traffic educational parks and examination centers for candidate drivers, Project Co-ordinator Mintsis G., Final report, Thessaloniki, 1998.