

DEVELOPMENT OF THE TRANSPORT SYSTEM IN THE DOWNTOWN AREA OF MARIJAMPOLĖ

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Abstract. Transport is one of the key issues influencing the quality of life in urban territories. Therefore, it is crucial to find reasonable and sustainable infrastructural solutions to many problems which include traffic flow. Planning, construction or reconstruction of urban transport infrastructures face a dilemma: What alternative is better? Modeling such alternatives is the best way for predicting a future situation and forming strategies and development plans for Lithuanian cities. The article presents analysis of characteristics of the existing transport infrastructure and modeling of transport flows resulted in eight alternatives of the development of the downtown area of Marijampolė. The carried out modeling solves the problems related to urban transport in the down-town area and delivers data for the further economic substantiation. Analysis of modeling data suggests, that two alternatives should be chosen for the further economic substantiation.

Keywords: Urban transport system, urban transportation planning, development alternatives, modeling of transport system, economic substantiation.

1. Introduction

The European Union, the United States of America and other technologically advanced countries use traffic modeling software before implementing modernization of the transport system or of some section of that system. The vehicle/traffic participant modeling results received with the help of the software are compared with the target indicators, then an economic and financial analysis follows, and only then a sustainable solution is arrived at (Akinoyemi and Zuidgeest 2000; Chang 2006). A situation in Lithuania has hardly changed within the twenty years that the country regained its independence: no planning is mandatory in the planning and projecting stages irrespective of the object size, and no planning is usually carried out, or, if any, its scope is very limited.

Why modeling is so important? Its importance lies in the fact that bad solutions are very costly (Juškevičius and Burinskienė 2007). Let us analyze several extremities. When the demand for the infrastructure reaches the bottleneck the infrastructure is supersaturated and this results in very long idle time for vehicles and, accordingly, huge public and environmental losses. Another extremity is a situation where facilities fail to meet the needs. In this case the planned and developed streets in large part fail to carry out their function (for example

they are too wide) and the public money is used ineffectively. Leaning only on his/her experience and Lithuanian normative documents that have loopholes, a planner or a projector may make or makes mistakes (in many cases even without being aware of that) that have impact on our environment for decades. Without going too deep into the aspects of model reliability (Chang 2006; Hojer and Mattsson 2000), it could be said that no better measure has been come with and modeling is the only measure that helps avoiding big mistakes. This aspect is linked to the main modeling goals (Shepherd, *et al.* 2006; Jonsson, 2008):

- development perspectives (forecast);
- economic substantiation of construction objects;
- comparison between alternatives;
- modeling of urban development impact on the urban transport infrastructure.

The article presents the case of the town of Marijampolė which is relevant to all towns of Lithuania. The transport – urban, suburban and international – flows generated in the town of Marijampolė tend to annually increase (Grigonis and Paliulis 2007). The increasing traffic requires a well-developed and balanced urban transport system allowing sustainable development of socio-economic and environment factors that create conditions for safe traffic (Black, *et al.* 2002; Grigonis and

Paliulis 2009). The aim of this article is, therefore, to assess the possibilities for the development of the motorized transport infrastructure in the downtown area of Marijampolė employing the transport modeling software.

2. Information on the town and transport system

Marijampolė is the seventh largest town of Lithuania; since 1994 it has been the county centre. The total area of Marijampolė is 2050.7 hectares. The Šešupė River separates the town into two parts connected by six bridges. The population of the town amounts to 47 thousands. The distance between Marijampolė and Vilnius, the capital of Lithuania, is 139 km, and the distance between Marijampolė and Klaipėda, the port town, is 231 km.

Two highways of major importance intersect in Marijampolė. One of them is the *Via Baltica* highway, which after reconstruction will connect Helsinki and the Central and Southern Europe, while the other connects Königsberg (Kaliningrad) and Moscow via Minsk (Belarus).

According to the results of the 2005 and 2009 surveys (Transport and road research institute, 2006 and 2010), in 2005-2009 traffic intensity on the suburban roads of Marijampolė significantly increased, and the average intensity increase on the roads in question reached 12.5% (Table 1). It is forecasted that unless the tendency of traffic intensity changes, in 2017 traffic volumes will considerably increase in the approaches to the town and in the town.

Table 1. The average twenty-four-hour transport flows on suburban roads (vehicles/day)

Direction	Flows, 2005	Flows, 2008	Increase, %	Forecast for 2017
Marijampolė - Kaunas (A5)	12363	16265	23.99	27456
Marijampolė - Kaunas (Bypass A5)	6316	10379	39.15	24076
Marijampolė - Vilkaiviškis (A7)	4937	5104	3.27	5483
Marijampolė - Prienai (A16)	2715	6316	57.01	20539
Marijampolė - Kalvarija (201)	3544	5007	29.22	9440
Marijampolė - Lazdijai (182)	3054	2361	-29.35	1182
Marijampolė - Suvalkai (Via Baltica A5)	5124	7119	28.02	13088

Marijampolė has more than 230 streets with the length of 132.00 km, the density of the streets is 5.95 km/km². During the last 20 years the transport system of the town of Marijampolė has changed due to the industry structure of the town as well as due to large commerce objects, changes in the transport structure and a sudden rise in the motorization level. In 2000-2007 the average

annual rise in the motorization level in the town of Marijampolė amounted to 0.73% per year (537 vehicles per 1000 inhabitants in 2005, and 566 vehicles per 1000 inhabitants in 2007). The motorization level in Marijampolė is one of the highest in Lithuania (in 2007 it exceeded the average of Lithuania by 1.32 times).

When the *Via Baltica* bypass of Marijampolė was opened in 2002, the highway also absorbed the truck flow from the downtown streets. This resulted in the decrease in the total transport intensity, accident rates, noise and air pollution in the downtown area. However, the high motorization level (566 vehicles per 1000 inhabitants) and expansion of new supermarkets again resulted in higher transport flows on the main streets of the town.

In Marijampolė, the same as in other towns of Lithuania, the daily volume of transport flows sharply fluctuate. According to the survey of the traffic intensity on intersections, the evening peak hours are busier than those of the morning peak. The largest flow of vehicles during the morning peak hours (at 8:00 am) reaches 6.97% of the daily flow. Later it shrinks, and at 10:00 am the flow again reaches 6.88%, which is similar to the morning peak hours flow. The highest traffic intensity – 7.29% – is observed on 4:00 pm.

3. Zoning of the downtown area of the town

The object of the article is the downtown area of Marijampolė as this area has the highest flows of vehicles and the main streets of the town intersect there (see Fig 1). The downtown area also contains the main objects of attraction, namely: administrations, culture institutions, supermarkets and recreation centers. The downtown does not have east-west bypasses and a high-speed traffic street network, so the transit transport taking the east-west direction traverses the town. The survey gathered information on streets (permitted speed, the number of traffic lanes), intersections (traffic-light operation cycles, marking, entries) and vehicle flows.



Fig 1. The downtown area of Marijampolė

The following intersections are located in the downtown area: J. Dailidės – V. Kudirkos, V. Kudirkos – S. Dariaus and S. Girėno, V. Kudirkos – Gedimino and Geležinkelio – Stoties – Gedimino, V. Kudirkos – Laisvės, V. Kudirkos – P. Vaičiaičio, Bažnyčios – Laisvės – Vytauto and Vytauto – Sodo – P. Vaičiaičio.

The attraction objects and the elements of the transport system located in the downtown area of Marijampolė are given in Fig 2. Eight main intersections are singled out in the downtown part (4 with traffic lights and 4 with traffic signs), namely:

- intersections with traffic lights: J. Dailidės – V. Kudirkos, V. Kudirkos – S. Dariaus and S. Girėno, V. Kudirkos – Gedimino bei Geležinkelio – Stoties – Gedimino street intersections;
- intersections with traffic signs: V. Kudirkos – Laisvės, V. Kudirkos – P. Vaičiaičio, Bažnyčios – Laisvės – Vytauto and Vytauto – Sodo – P. Vaičiaičio street intersections.

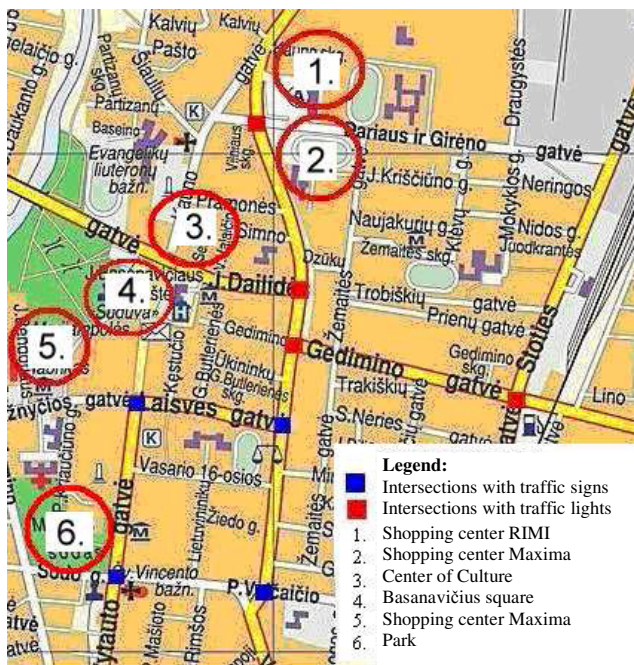


Fig 2. Transport system in the downtown area of Marijampolė

The intersections of Marijampolė have standard traffic lights. All the four regulated intersections with traffic lights (J. Dailidės g. – V. Kudirkos g.; V. Kudirkos g. – Dariaus and Girėno g.; V. Kudirkos g. – Gedimino g. and Geležinkelio g. – Stoties g. – Gedimino g.) have supplementary arrows allowing the right turn during the red traffic-light signal and supplementary sections for the left turn. The survey revealed that on the intersections of the downtown area cars account for 93.66%, micro-buses for 3.70% and trucks for 1.99% of the total flow.

Due to the density of the existing street network and technical parameters of intersections, traffic regulation measures on the main intersections fail to meet the needs during the peak hours. Pollution generated by motor-transport has negative impact on the residential environ-

ment, and heavy vehicles destroy street pavement. If the motorization level keeps growing, the trends of the population number remain the same and the development of the street network is slow, then in the near future the traffic conditions will further deteriorate.

4. The transport system model of Marijampolė

To improve traffic organization and infrastructure in the downtown area of Marijampolė, a transport system micro-model was developed. Model was developed with the help of VISIM software. The model illustrates the urban transport system and the number of vehicles on streets during morning peak hours.

The downtown was divided into 11 conditional transport zones (Fig 3). Transport zones are coincident with the street axes. These transport zones are the elements of the transport system and based on them the model generates vehicles coming in/out of the downtown area. After carrying out on-site survey, the departure/arrival matrix was calculated with regard to every transport zone. This matrix characterizes movement of vehicles on the street network in question.

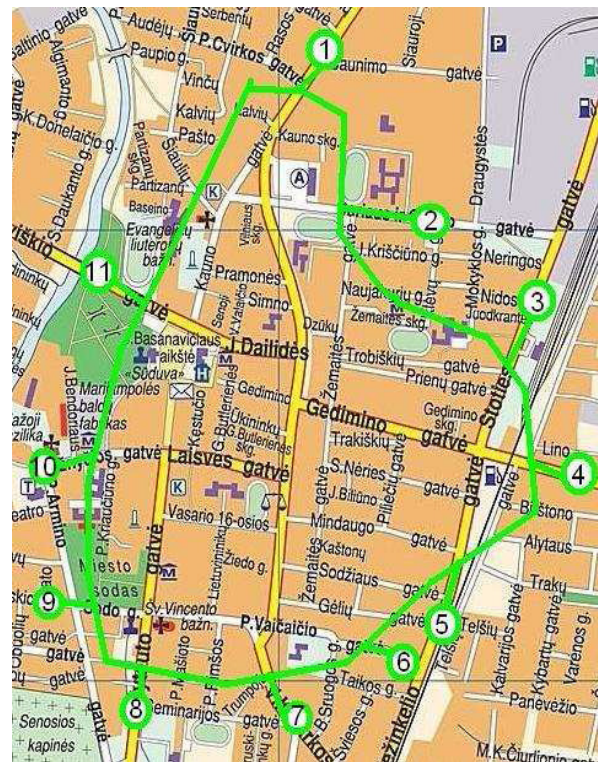


Fig 3. Transport zones in the downtown area of Marijampolė

The basic variant was calibrated against the number of vehicles arriving during the morning peak hours to eight intersections located in the downtown area. The model reliability was evaluated employing statistical methods; the main indicators were the number of observations, $N=38$, and the determination coefficient, $R^2=0.90$ (Fig 4).

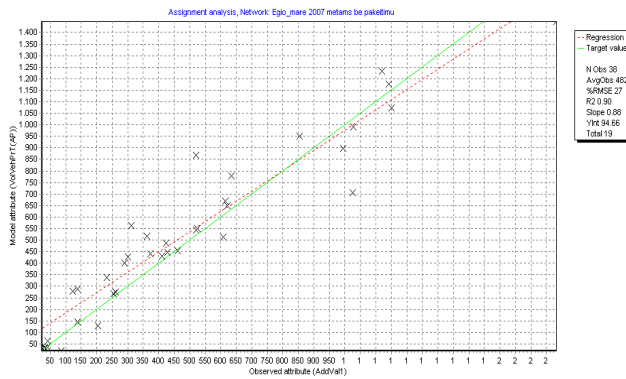


Fig 4. Model verification

The transport system model of Marijampolė may be evaluated as very good.

On-site transport survey and modeling of the basic alternative (morning peak hours) revealed that the main vehicle flow came to the town from the direction of Vil-kaviškis along the streets of Vil-kaviškio, J. Dailidės, V. Kudirkos and Laisvės (Fig 5).

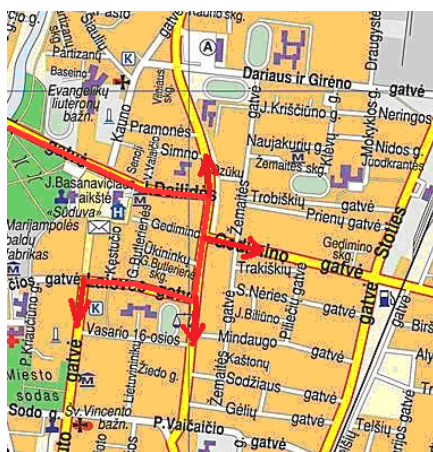


Fig 5. The main vehicle flow in the downtown area of Marijampolė during the morning peak hours

This is the flow that poses the main traffic problems. A continuous uninterrupted flow of vehicles turning to the right is present on the streets of Vil-kaviškio and J. Dailidės before the intersection of the streets of V. Kudirkos and J. Dailidės. The major part of this flow goes straight through the intersection of the streets of V. Kudirkos and Gedimino and turns to the right on the intersection of the streets of Laisvės and V. Kudirkos. Most traffic problems are posed by the intersection of the streets of Laisvės and V. Kudirkos. As the vehicles arriving along the street of Vytauto to the intersection of the streets of Vytauto, Bažnyčios and Laisvės are not allowed to make the left turn, in the modeled street network drivers who want to make the left maneuver and turn towards the street of Bažnyčios drive along the intersection of the streets of Laisvės and V. Kudirkos. However, the latter is a non-regulated intersection and vehicles that want to make the left maneuvers have to give way to an uninterrupted flow of vehicles driving along the streets of

V. Kudirkos and J. Dailidės. That poses the most acute traffic problem. In the course of modeling, a traffic jam gets formed and it persists from the intersection of the streets of V. Kudirkos and Laisvės to the intersection of P. Vaičiaičio and V. Kudirkos. On the 1700th second of modeling (basic variant) the traffic jam gets formed also on the street of P. Vaičiaičio as vehicles are not able to make the left maneuvers on the intersection of the streets of V. Kudirkos – P. Vaičiaičio due to a long row of vehicles moving in the direction of the intersection of the streets of Laisvės and V. Kudirkos. On the 3500th second of modeling the traffic jam on the street of P. Vaičiaičio ends but still quite a few vehicles are still in the traffic jam at the approaches to the intersection of the streets of Laisvės and V. Kudirkos.

Modelling of the 2017 perspective was carried out on the existing basic variant. The increase in the vehicle flows was forecasted in accordance with the average motorization level in the town of Marijampolė, and it was admitted that the average annual growth of flows was 2.24% (Grigonis and Paliulis 2007). Within the next ten years the number of vehicles in the downtown area should increase by approximately 20%. Modeling of two alternatives showed a considerable average increase in the trip time of a vehicle in the street network in question, i.e. from 140.9 to 243.5 seconds.

5. Alternatives for the development of the urban transport system

Analysis of characteristics of the existing transport infrastructure and the transport flows resulted in 8 alternatives of the development of the downtown area of Marijampolė (modeled for the traffic flows of 2017):

Alternative 1. Traffic-light regulation in the downtown area.

A local solution to the problem was offered: traffic-light regulation should be installed on the triangular intersection of the streets of V. Kudirkos and Laisvės. Besides, this alternative offers correction of traffic-light cycles on the intersection of the streets of V. Kudirkos and J. Dailidės and on the intersection of the streets of V. Kudirkos and Gedimino.

Alternative 2. A new connection near the municipality building.

It is offered to build a one-way street near the municipality building that would connect the streets of Vil-kaviškio and Bažnyčios and pass the Maxima supermarket. The purpose of this alternative is to reduce morning peak transport flows on the streets of J. Dailidės, V. Kudirkos and Laisvės.

Alternative 3. Roundabout traffic organization including the street of Žemaitės.

A one-level roundabout way was analyzed on the intersection of the streets of V. Kudirkos, Gedimino and Žemaitės, in which case traffic would be organized anti-clockwise. The vehicle flow going along the street of J. Dailidės towards the street of V. Kudirkos is diverted to the intersection of the streets of V. Kudirkos and Gedimino where two traffic lanes are available for those who

make the left turn, and two lanes are available for those who drive straight. The flow of vehicles going from the streets of V.Kudirkos and Laisvės is diverted towards the intersection of the streets of Gedimino and Žemaitės. It is offered to build two new traffic lanes on the street of Žemaitės. Turning to the left should be prohibited on the intersection of the streets of Žemaitės, J. Dailidės and V.Kudirkos. Traffic-light regulation system is re-arranged on the latter intersection.

Alternative 4. A two-level intersection on the intersection of the streets of J. Dailidės and Kauno.

It is proposed to rearrange the intersection of the streets of J. Dailidės, V.Kudirkos and Žemaitės into a two-level intersection. The street of J. Dailidės should be built under the street of V.Kudirkos without changing the altitude of the latter. The traffic along the streets of J. Dailidės and Žemaitės should be two-way (1+1 traffic lane), while the street of V.Kudirkos should be reconstructed into two traffic lanes.

Alternative 5. A direct connection between the streets of J. Dailidės and Prienu.

It is proposed to build a connection between the streets of J. Dailidės and Prienu. Traffic-light regulation should be improved on the intersection of the streets of J. Dailidės and V.Kudirkos.

Alternative 6A. One-way traffic along the streets of Laisvės ir Vasario 16-osios.

In this alternative traffic along the streets of Laisvės, Vytauto, Vasario 16-osios and V.Kudirkos is arranged anticlockwise along a roundabout. The left turn is prohibited from the street of V.Kudirkos to the street of Laisvės.

Alternative 6B. A one-way traffic along the streets of Laisvės and Vaičiaičio.

This alternative is similar to Alternative 6A but in this case the street of P.Vaičiaičio is also included into the roundabout. The following numbers of traffic lanes are available on the further listed streets: Vasario 16-osios – 2+0, Vytauto between Laisvės and Vasario 16-osios – 1+0, and from Vasario 16-osios to P.Vaičiaičio – 1+1.

Alternative 7. A one-way traffic along the streets of Laisvės and Vasario 16-osios and two levels on the intersection of the streets of J. Dailidės and Kauno.

This alternative is made up of Alternative 4 and Alternative 6B.

6. Result analysis and interpretation

The carried out modeling was aimed at the solution of the problems related to urban transport in the downtown area and posed by the basic alternative. The summary of the analysis results is given in Table 2.

Table 2. Summary of modeling results

Alternative Criterion	Basic Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5	Alternative 6 (a)	Alternative 6 (b)	Alternative 7
Modelling results:									
Non-generated	135	950	398	1605	1	1096	422	429	1
Vehicles that left the network	4334	4606	4757	2661	5569	4416	5164	5109	5671
Number of vehicles remaining within the street network	266	243	648	981	200	211	218	213	181
Travel length, h/peak hour	180.25	202.56	378.87	610.60	191.92	192.11	203.89	202.05	179.46
Average flow speed, km/h	23.94	22.10	12.33	4.1	29.8	22.39	26.32	26.33	34.46
Hourly run during the morning peak	4314.65	4476.33	4670.82	2501.33	5723.86	4301.82	5366.52	5320.33	6183
Total time spend for stopping, h	47.41	62.62	203.96	509.49	29.56	53.99	37.25	39.83	21.18
Average time spent by a vehicle for	37.10	46.49	135.85	503.61	18.44	42.01	24.19	26.44	13.03
Level of Service	D	D	E	F	C	D	C	C	B

Modeling results are compared on the basis of the Level of Service (LOS) criteria: the average driving

speed, trip length, run, time spent for stopping. Three alternatives were chosen as the best ones, namely: Alter-

native 4 A two-level intersection of the streets of Dailidės and Kauno; Alternative 6a One-way traffic along the streets of Laisvės and Vasario 16-osios; Alternative 6b One-way traffic along the streets of Laisvės and Vaičiaičio. Alternative 4 requires higher investments and extensive infrastructure reconstruction works, so it would be more suitable for further perspective. Alternatives 6a and 6b could be implemented for a near perspective as in this case only traffic organization improvement is necessary. To prove that joining two best alternatives would be more useful for the town, Alternative 7 was modeled. This alternative is a combination of Alternative 4 and Alternative 6b.

For the economic substantiation two alternatives with the best main traffic quality indicators (trip length, h/peak hour; average flow speed, km/h; hourly run during the evening peak hours, km; and total time spent for stopping, h) were chosen:

- Alternative 4 (two-level intersection on the intersection of the streets of Dailidės and Kauno)
- Alternative 6B (One-way traffic along the streets of Laisvės and Vaičiaičio).

7. Conclusions and proposals

1. The results of the work are used for the development of solutions of the general plan of Marijampolė. This is one of the examples how modeling could become a source of valuable information for further economic and environmental impact assessment.
2. Applying the program VISUM and based on the results of the survey of traffic flows during morning peak hours in 2007, a basic model of car flows was developed. Model calibration determination coefficient is $R^2 = 90\%$. Model reliability could be assessed as very good.
3. The article analyzed 8 alternatives of the development of the downtown area of Marijampolė. Modeling results were compared on the basis of the Level of Service (LOS) criteria: the average driving speed, trip length, run, time spent for stopping.
4. For the economic substantiation two alternatives should be chosen. With the economic regard the best alternative is Alternative 6B (one-way traffic on the intersection of the streets Laisvės and Vaičiaičio) and it is proposed that it is implemented immediately. The economic evaluation of Alternative 4 (two-level intersection on the intersection of the streets Dailidės-Kauno) probably will reveal that it is also useful for the public but due to high investments it is proposed that this alternative is implemented in further perspective.

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