# SUBSTANTIATION OF COMMUNICATION INFRASTRUCTURE SELECTION IN NEWLY DEVELOPED TERRITORIES

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**Abstract.** The mobility need, especially of motorized, has significantly increased in recent decade, the public became more and more dependent on the means of communication. Transport became an inseparable part of the way of life of modern human being which helps to satisfy needs but creates new needs. With undoubted benefit these changes caused the new problems, such as traffic congestions, time losses or increased noise and pollution. These arguments made it necessary to look for new ways and means to get under control the existing communication system processes in the newly planned urban territories and to develop new innovative tasks for the EU urban communication systems in order to ensure effective and uninterrupted functioning of communication system and implementation of the main communication objectives. This scientific work analyzes the need for communication system in the newly developed territories, describes the world-wide software packages used for modelling of junctions, gives an illustrated example on how to select the type of intersection for the territory planned to be built-up in Molėtai city, describes advantages of the selected type of junction.

**Keywords:** traffic volume, territorial planning, modelling software, comprehensive plan, intersection, junction.

## 1. Introduction

To make good decisions on territorial planning is a task that has become increasingly difficult. In Soviet times all the decisions planned in the general plan of the city used to become obligatory, without any alternatives. Therefore, the city plan used to be implemented as exactly as possible. And in a period of only 5–10 years adjustments to the city plan used to mature. The planning process involved only specialists and representatives of municipal government, whereas the city plan was a secret document (Juškevičius 1995). Such planning is not suitable for nowadays market system. The goal of sustainable development is to combine economic growth, social progress and sparing use of natural resources, maintaining ecological balance and ensuring favourable living conditions for current and future generations. Development is fostered in a certain territory, in its natural environment, thus it is important to find out reasonable extent and form of development, so that life quality is maintained and negative impact on environment is reduced (Burinskienė, Rudzkienė 2004, 2007, 2009; Kavaliauskas 2008). On the market the most important role falls on a private initiative, based on the information about market supply, demand, prices, profit probability or other investment benefits. However, the market alone cannot determine the economic efficiency of cities, environ-

mental quality and social harmony. Thus, a city must be administered – its development must be regulated, controlled and planned (Steponavičienė, Juškevičius 2000).

After restoration of independence the situation has changed. In recent years most investments are allocated to the largest Lithuanian cities which, from the socio-economic point of view, are the most developing. This causes the increasing differences in urban development and human welfare. One can notice the more clear tendencies for uneven development of residential areas, formation of socially and economically negative locations distinguished by especially low quality of life, arising threat for the formation of cities of economic and social stagnation and ecological instability. The practice of comprehensive plans, started in 2006–2007 in more than 50 municipalities and single cities with the financial assistance of European Union, shows that the development of the existing planning system has taken the road of complicated and formal procedural requirements having nothing to do with problem identification and the search of objective systemic problems. Several reasons for the decrease in planning efficiency are as follows (Burinskienė, Venckauskaitė 2008):

– the lack of qualified specialists;

– a system of planning works is not logical and simple;

−insufficient investments into urban development, into measures of vital importance for the urban functioning;

−the lack of complexity in solving urban development tasks;

−insufficiently humanized urban environment, consequences of urban development measures are not taken into consideration;

−there are no good-quality territorial planning standards.

Formation of urban structures and systematic evaluation remain one of the most important problems causing reduction of planning efficiency. The main negative factors result from an undeveloped and non-systematic planning system (Juškevičius, Jauneikaitė 2008).

To sum up the above-mentioned problems it could be stated that for ensuring a sustainable urban development the largest attention should be paid to an even development of urbanized territories involving economic, social and environmental aspects (to humanize existing territories), also to city administration, creation of city image, representation of public demands and social interest.

Transport is an inseparable part of residential territories. Therefore, one of the most important objectives of urban development is to ensure that the quality of urban mobility corresponds to the main objectives of citizens. Then, in the urban development the quality factors of urban structure, physical communication and other communication means become the most important ones. The size of urban communication network is essentially determined by the following main factors (Juškevičius 2003):

−transport mobility of the residents;

−type of activity of urban enterprises (traditional industrial enterprises using plenty of raw materials or the activity is related to, for example, information technologies);

−position of the city in respect of national or regional communication networks (air, road, maritime, river);

−significance of the city in a local system of settlements;

−density of urban built-up;

−extent of the use of underground and over ground space;

−car ownership level.

Planning a city street network should be based on the principles of sustainable transport system. In Lithuania these principles have not been applied so far, though, in Europe they are not new (Venckauskaitė, Skrodenis 2007). Though the comprehensive plans of cities and municipalities have been intensively prepared, at present there are no uniform methodology or construction regulations to regulate the territorial planning documents. When planning communication systems, in the territorial planning documents each organizer uses his methodology.

## 2. Modelling software recommended for planning communication infrastructure

Modern computer technologies allow for a more accelerated and precise estimation of the processes, performance of different simulation, technical and economical grounding of solutions (Grigonis, Paliulis 2007). When solving any traffic organization tasks in junctions, it is necessary to have data about traffic characteristics: traffic volume and its changes, possible manoeuvres, driving speeds, junction saturation degree, driving directions, service level etc. Geometrical parameters are also necessary. Transport investigations could be divided into several types: operational, traffic management, traffic organization, determination of various regularities and processes. The overall objective of modelling – to collect information, based on which to model a traffic process, i.e. with the highest possible accuracy of mathematical formulas and descriptions to outline parameters and characteristics of traffic flows. Having developed accurate models, they ensure a more efficient control of traffic in junctions, managing the work of passenger transport and making future forecasts.

A number of intersection modelling software has been developed. Some of them are used to model all types of junctions, the other are applied to a concrete intersection type. The most worldwide used junction modelling software is: *Arcady*, *Picady*, *Oscady*, *SIDRA INTERSECTION*, *LISA+*, *Crossing* etc.

*Arcady* software is designed for modelling only roundabouts, analysing traffic flows and traffic congestions at roundabouts and predicting delays at them. This software could be used to predict accident risk, to design new and reconstructed roundabouts and to select their parameters. It could be used for modelling small as well as large roundabouts with up to 7 arms.

*Oscady* software is designed for modelling and predicting saturation degree, queue lengths and time losses at isolated signal controlled intersections. With the help of this software signal timings can be optimized in a way to obtain max capacity of the junction or min delays at traffic lights. It can be also used as a tool when designing new signalized junctions and reconstructing existing designs.

*Picady* is a computer program for modelling and analyzing uncontrolled intersections. It is suitable for designing new junctions and assessing the effects of modifying the existing designs. It can be used to analyze traffic flows, to calculate delays, to analyze accidents at junctions controlled by various types of road signs. It is also used to model pedestrian traffic.

*LISA+* is a comprehensive software package developed by the company Schlothauer and Wauer and used for designing, analyzing and modelling signal controlled intersections. This software is used by more than 180 companies and scientific establishments not only in Germany but all over the world. Each action made with this software is checked by logical control and the obtained coordination results are checked according to the latest methodology for calculating signal cycles. There is an additional possibility to create individual signal timing plans using the *VS-PLUS*

subprogram. This gives a possibility to synchronize the obtained data with other systems, for example, with traffic control computers through the previously intended guides meeting OCIT standards. The software helps to identify and to analyze conflict points at a junction. *LISA+* can coordinate the selected single intersections, thus giving a possibility to create "green waves". Also, it can be used for modelling uncontrolled intersections, modelling and analyzing uncontrolled roundabouts.

*Crossing* software is designed for modelling and analyzing only signal controlled intersections. It can help to perform analysis of conflict points at a junction and to design the coordinated traffic control systems. The software is provided with many functions for designing traffic signals, such as calculation of inter-timings in a graphical form, making inter-timing matrices, creation of phases' sequences for compatible signal groups, correction of optimization and/or manual fixed-time signals, coordination of single signal controlled intersections etc.

Software package *SIDRA INTERSECTION* has been developed at Akcelik and Associates Pty Ltd, Australia. *SIDRA INTERSECTION* is one of worldwide used junction modelling software, which is for use as an aid for design and evaluation of signal controlled intersections, signal controlled pedestrian crossings, single point interchanges (signal controlled), roundabouts, 2-way stops control, all-way sign control, and yield sign control. The flexibility of *SIDRA INTERSECTION* allows its application to many other situations, including uninterrupted traffic flow conditions. *SIDRA INTERSECTIONS* is an advanced micro–analytical traffic evaluation tool that employs lane-by-lane and vehicle drive-cycle models coupled with an iterative approximation method to provide estimates of capacity and performance statistics (delay, queue length, stop rate etc). Although *SIDRA INTERSECTION* is a single intersection analysis package, you can perform traffic signal analysis as an isolated intersection (default) or as a coordinated intersection by specifying platooned arrival data.

*Arcady*, *Oscady* and *Picady* software are easy-to-use tools having many advantages, however, each of them is applied to a concrete type of junction. *SIDRA INTERSECTION*, *Crossing* and *LISA+* software are complicated and having many possibilities though *Crossing* software is intended only for signal controlled intersections. *SIDRA INTERSECTION* and *LISA+* can be used for modelling at grade junctions of various types. Having assessed advantages and disadvantages of all software packages intended for junction modelling for further investigation and modelling of the most suitable type of junction, the software *SIDRA INTERSECTION* was selected, since it provides an opportunity to identify not only the main characteristics of junctions but also the level of service (LOS), fuel consumption, operating costs and transport pollution.

Each city is unique, therefore, concrete decisions are inevitably different. Sustainable development in this case becomes only a principle, interpretation of which is very subjective. The task of this scientific work – by using computer programs and traffic volume data to select the most suitable type of junction for the planned territory. The objective is to provide tools to better integrate the consideration of auto and transit LOS in urban street design and analysis.

## 3. Service of communication system in the territories to be developed. LOS concept

Physical urban development is interpreted as urbanization of new territories, creation of new underground and over ground spaces, reconstruction and restoration. The evelopment has to maintain the former and to give a new living quality for the citizens. Control of traffic flows is a complex task of urban planning and traffic organization, the main objectives of which are (Burinskienė *et al.* 2003):
– to reduce time losses for public, cargo and individual traffic at intersections;
– to increase traffic lane capacity at junctions by "compacting" traffic flows, i.e. leaving in-between vehicles a min distance necessary for traffic safety conditions;
– to reduce passenger time losses at intersections;
– to reduce the number of fatal and injury accidents at intersections;
– to cut down additional fuel costs at intersections when engines are idling;
– to decrease the number of stops in street segments and intersections;
– to ensure a more even movement of all vehicles in street segments and to reduce speed variations there;
– to reduce traffic noise level generated by additional stops at intersections and their approaches;
– to reduce environmental pollution with exhausted gases due to additional acceleration and deceleration of traffic flows and idling of engines when crossing intersections.

With passive attitude towards urban development, using no modern traffic organization measures, no order for planning and development of urban communication system, unacceptable total disbalance of communication system would be reached. Therefore, it is necessary to take innovative measures of urban communication management, to create favourable conditions for public and environment, to harmonize their inter-relations and to construct conceptions of sustainable communication system development suitable to the unique environment of the city. In order to achieve all this various traffic control and organization measures could be used.

For the evaluation of service level in street segment or intersection the foreign countries use a concept of level of service (LOS) which suggests that the LOS is a qualitative measure that describes the operating conditions within an intersection or roadway section, and the perception of those conditions by the facility's users. The factors used to measure the LOS provided by any given facility, might include any or all of the following:
– user's comfort;
– convenience;
– travel time;

– manoeuvrability;
– interruptions in traffic;
– speed;
– cost;
– number of stops;
– fuel consumption.

LOS is used to determine the LOS of roads, street segments as well as signal controlled and uncontrolled intersections. Every type of transport infrastructure facility (junction, freeway segment, arterial, or pedestrian) has different operating parameters that are used to determine its LOS. For junctions, the main operating parameter is average control delay per vehicle defined in units of seconds per vehicle. There are 6 levels of service defined for each transport infrastructure facility type. Each level has a letter identification from A to F with LOS A representing the best operating conditions and LOS F the worst. Summary of average control delay per vehicle in seconds for signal controlled and uncontrolled intersections is given Table 1.

**Table 1.** Average control delay per vehicle in seconds

| LOS | Uncontrolled intersections | Signal controlled intersections |
|---|---|---|
| A | ≤ 10 | ≤ 10 |
| B | > 10 and ≤ 15 | > 10 and ≤ 20 |
| C | > 15 and ≤ 25 | > 20 and ≤ 35 |
| D | > 25 and ≤ 35 | > 35 and ≤ 55 |
| E | > 35 and ≤ 50 | > 55 and ≤ 80 |
| F | > 50 | > 80 |

When a low LOS is defined, it is necessary to take actions to improve it. Before starting implementing new communication infrastructure projects, decisions must be made that would meet the highest LOS levels for the longest possible service time. In order to choose proper decisions, it is necessary to make predictions and modelling the predicted situation.

In Lithuania LOS has not been defined so far, though, taking into consideration the changing transport system and increasing adjustment to the transport system of Western countries, the LOS must be started to be defined. Requirements for the LOS of signal controlled and uncontrolled intersections are given in *Highway Capacity Manual 2000* and they are used in this paper**.** For more effective using of LOS in Lithuania it is necessary to specify all transportation values according Lithuanian conditions.

## 4. Investigative part

For the investigative part the city of Molėtai was chosen. At present the Comprehensive Plan of Molėtai City is under preparation, the decisions of which are planned to be implemented until 2018. The city of north-eastern Lithuania is located in Utena County and is the administrative centre of Molėtai district. Though the city's development was highly influenced by social, economic and political factors, the largest influence on the city's formation was made by main international roads and natural environment. Based on 2008 data, the number of population was 6930. The analyzed territory is situated in the historical centre of the city, where a larger part of social infrastructure objects, periodic and episodic service objects and many workplaces is concentrated (Fig. 1).

Based on the Master Plan of Molėtai City conception,



**Fig. 1.** Analizing territory of Molėtai town

the sustainable development alternative is suggested to be accepted – it is planned to develop the city by expanding the urbanized territory towards northern direction and to move the "centre of weight" of the citizens more close to the historical city centre and to the concentration zone of social infrastructure objects. The predicted level of car ownership in Molėtai City in 2018 is 470 cars/1000 population. Such a level of car ownership will make a significant impact on transport infrastructure (Fig. 2).
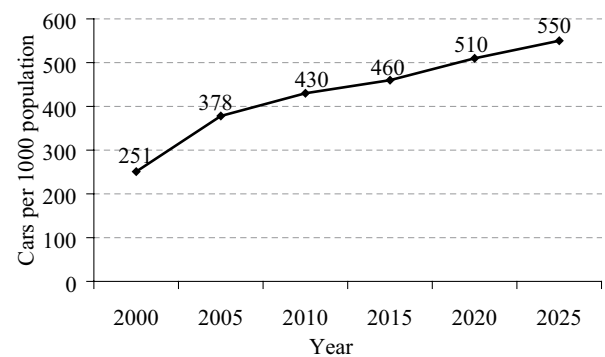


**Fig. 2.** The level of car ownership in Molėtai City and its forecast (cars/1000 population) according Comprehensive Plan of Molėtai City Conception

As mentioned above, the *SIDRA INTERSECTION* was selected. The junction suite *SIDRA INTERSECTION* was applied for modelling the link from a multi-storey residential territory to the urban street network planned in the Comprehensive Plan of Molėtai City. Traffic volume needed for modelling the current situation was counted at morning and evening rush hours in 2009. At the morning rush hours traffic volume was about 30% higher than in the evening. For this reason modelling of the junction was based merely on the data of morning rush hours. Model-

ling focused on finding out the best type of intersection for the analyzed situation, which would meet the parameters of capacity, LOS, economic and other. With the help of the *SIDRA INTERSECTION* the current situation was modelled. Modelled alternatives were compared with regard to fuel costs, LOS, operating costs and pollution.

## 5. Current situation

In the analyzed territory (Fig. 1) a territorial expansion of the city is planned. Within the expanded territory residential areas are planned with three possible service centres at the existing main and planned service (C2 category) street junctions. The centres are planned to be provided with everyday shopping centres or other small commercial objects of similar character. Development of residential territories is planned in stages – starting with the current city perimeter at the main streets (round the planned service centres), with a gradual expansion in the northern direction. Building-up type is varied from single 3–4 storey multi-flat houses and blocked houses to one-flat houses. A larger density of population and building-up is planned at the future service centres; towards the edges of the territory the building-up becomes more thin, population density decreases. Residential territory would cover the total area of about 96 ha with a planned population of 2500. The planned density of population is 25 inhabitants/ha allowing to form and service a sufficiently sustainable environment and to organize a good communication within the analyzed territory. The link of the planned residential territory in the northern part of the city with the current communication system of Molėtai City is planned through the junction of Dariaus ir Girėno and Molėtūno streets in the eastern part of the city and through the junction of Vilniaus and Turgaus streets in the northern part of the city. For a further analysis the junction of Dariaus ir Girėno and Molėtūno streets was selected.

The analyzed junction of Dariaus ir Girėno and Molėtūno streets is situated on the eastern outskirts of the city. The junction is also joined by a gravel street which is planned as a link with the newly created residential quarter. The existing configuration and the main parameters of the street are in Fig. 3.

In May 2009, at the morning rush hours between 7 and 8 a.m. traffic counts were carried out at the analyzed junction. The total traffic volume at the junction – 195 vph (vehicles per hour) of which 8% of heavy traffic. Data on

traffic volume is given in Fig. 4. Traffic counts showed that at present traffic volume of the existing streets is 195 vph. The forecasted annual growth of traffic volume in Molėtai City until the year 2025 is 2% on average per year. Taking into consideration the existing traffic volume, the future building-up density and the future number of population in the planned territory, it is expected that in 2025 traffic volume at the morning rush hours can reach 356 vph.
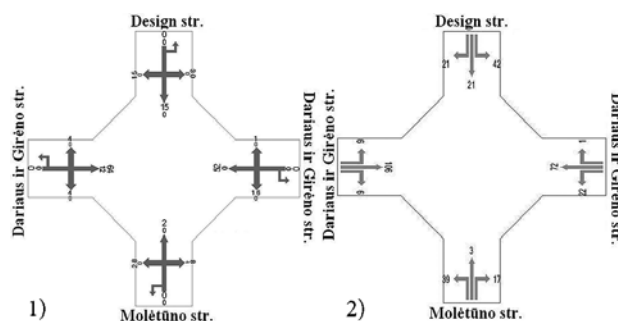


**Fig. 4.** Traffic volume: 1 – existing; 2 – forecasted

## 6. Types of intersections

For the analysis of the planned territory of Molėtai City the following at-grade intersections could be selected of the following main types: uncontrolled, signal controlled and roundabouts. Principal configurations of the intersections are given in Fig. 5.

Uncontrolled intersections are junctions, where no engineering measures are used for traffic organization and the road users follow the "right-hand" rule. Intersections of this type could be constructed only under the following conditions:
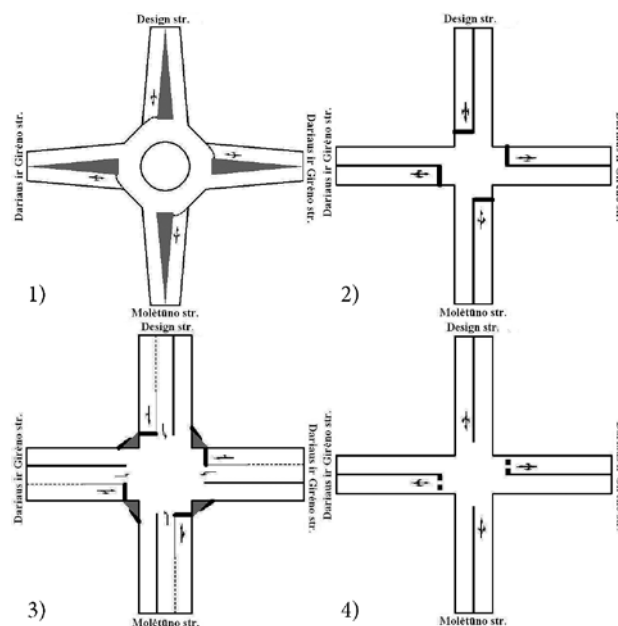


**Fig. 5.** Principal schemes of the intersections: 1 – roundabout; 2 – signal controlled (2 phase); 3 – signal controlled (4 phase); 4 – yield-controlled and stop-controlled



**Fig. 3.** The existing street configuration and the main geometrical parameters

– crossing streets are of the lowest category;

– width of neither of the streets exceeds 9 m;

– traffic volume does not exceed 380 vph;

– pedestrian traffic volume does not exceed 150 pedestrians/h;

– suitable geometrical conditions for street intersection and visibility.

Usually, junctions, where there are no traffic organization measures, could be characterized by the largest number of accidents, numerous conflict situations, low capacity.

Intersections controlled by traffic signs are constructed at the crossing of lower-category streets. Traffic control with the help of traffic signs is effective where:

– traffic volume of light vehicles does not exceed 380 vph;

– pedestrian traffic volume to the largest direction does not exceed 150 pedestrians/h.

The main requirements for the construction of intersections controlled by traffic signs are the same as for uncontrolled intersections; however, at intersections, controlled by traffic signs, a higher level of traffic safety is ensured. Intersections, controlled by traffic signs, are of 2 types, when traffic is controlled by:

– one or more "stop" signs;

– specific "Yield" (known as "Give way") signs.

Signal-controlled intersections are considered to be one of the most effective traffic organization measures. Installation of traffic lights at intersections reduces fuel consumption and travel time losses, increases traffic safety for all road users and, if compared to uncontrolled intersections, increases junction capacity and reduces environmental pollution. Signal-controlled intersections are effectively to install if the total traffic volume of the junction exceeds 560 vph. To significantly reduce travel time losses and increase junction capacity in the central part of the city, it is purposeful to join single traffic lights into the coordinated traffic control system. To rationally solve all the traffic organization tasks and to evaluate the scattering of traffic flows due to unequal dynamics of vehicles, the complicated simulation models are used – movement of traffic flows within the street network is optimized, single traffic lights are joined into the coordinated traffic control systems.

Roundabouts are intersections with a circular shape and with a specific design and traffic control features. These features include yield control of all entering traffic, channelized approaches and appropriate geometric curvature to ensure that travel speeds on the circulatory roadway average are about 20–30 km/h. Thus, roundabouts are a subset of a wide range of circular intersection forms. Roundabouts can be divided into mini, urban compact, urban single-lane, urban double-lane, rural single-lane, rural double-lane, turbo roundabouts. Diameter of roundabouts can be from 13 to 60 m. It depends on the type of roundabout.

## 7. Selection of intersection type with the help of *SIDRA INTERSECTION* software package

*SIDRA INTERSECTION* uses advanced gap acceptance techniques for junction capacity and performance analysis based on empirical models to calibrate gap-acceptance parameters. Gap-acceptance capacity models apply to the analysis of minor movements at 2-way stop and "Yield" sign junction, entry streams at roundabouts and opposed turns at signal controlled intersections. *SIDRA INTERSECTION* uses M3D model (Akçelik 2007):

$$Q_g = \left(\frac{3600}{t_f}\right) \times \left(1 - \Delta_m q_m + 0.5\varphi_m q_m t_f\right) \times e^{-\lambda(t_c - \Delta_m)}, \quad (1)$$

where $Q_g$ – capacity value, vph; $t_f$ – follow-up headway; $t_c$ – critical gap; $\Delta_m$ – average intrabunch headway, s; $q_m$ – opposing flow rate, vps; $\varphi_m$ – proportion of free vehicles; $\lambda$ – a model parameter calculated as:

$$\lambda = \varphi \times \frac{q}{1 - \Delta \times q}, \quad (2)$$

where $q$ – the arrival flow rate, vps.

As mentioned above, it is forecasted that the planned residential area will add to the morning rush hours about 70 vph. To select the most suitable intersection type four above-mentioned alternative types of at-grade intersection have been modelled and analyzed.

According to the current Lithuanian normative documents *R 36-01 "Automobilių kelių sankryžos"* (Automobile Road Junctions) and *STR 2.06.01:1999 "Miestų, miestelių ir kaimų susisiekimo sistemos"* (Communication Systems of Cities, Towns and Villages), the exact geometrical parameters of the modelled junction alternatives were selected (Table 2).

Also, with the help of *SIDRA INTERSECTION* phases of the signal controlled intersections were modelled for the analyzed territory (Fig. 6).

The results for *SIDRA INTERSECTION* outputs were analyzed and are presented in Table 3 to be easy option to make a comparison.

Analysis of data, obtained during modelling, obviously shows that the effective intersection capacity after construction of roundabout would be ensured up to 2528 vph. Similar capacity would be ensured also by a yield controlled intersection. However, the capacity of signal controlled junctions is 1.3 and 2.6 times (depending of the number of phases) lower.

If yield controlled intersection or roundabout are constructed, the highest LOS would be ensured. However, the LOS of signal controlled intersections is lower. For the given and forecasted traffic loading, roundabout offers a better capacity and hence degree of saturation is less than of 2-way and signalised junctions. The average delay is the lowest at 2-way yield junction. The lowest operating costs, fuel consumption, average junction travel time and pollution are for 2-way yield junction.

**Table 2.** Parameters of the modelled junction

| Parameters | Roundabout | Signalised junction | | Priority junction |
| --- | --- | --- | --- | --- |
| | | 2 phases | 4 phases | |
| Approach/exit lane width, m | 4/4.5 | 3.5/3.5 | 3.5/3.5 | 3.5/3.5 |
| Width of separating island, m | 3 | – | – | – |
| Number of traffic lanes at the junction | 1 | 1 | 2 | 1 |
| Island diameter, m | 16 | – | – | – |
| Circulating width, m | 6.5 | – | – | – |
| Pump price of fuel, Lt | 3.6 | 3.6 | 3.6 | 3.6 |
| Design life, number of years | 16 | 16 | 16 | 16 |
| Growth rate, % | 2 | 2 | 2 | 2 |
| Traffic volume 2009/2025, vph (rush hours) | 195/356 | 195/356 | 195/356 | 195/356 |

**Table 3.** *SIDRA INTERSECTION* outputs of the modelled junctions

| | Roundabout | Signalised junction | | Give way junction |
| --- | --- | --- | --- | --- |
| | | 2 phases | 4 phases | |
| Effective intersection capacity, vph | 2528 | 1809 | 933 | 2449 |
| 95% back of queue, m | 4 | 11 | 28 | 5 |
| LOS/LOS (worst movement) Implementing/2025 | A/A; A/B | B/B; B/B | C/C; C/C | –/A; –/A |
| Degree of saturation implementing/2025 | 0.076/0.104 | 0.148/0.198 | 0.287/0.383 | 0.080/0.113 |
| Control delay (average), spv | 8.5 | 14.9 | 28.3 | 7.0 |
| Operating cost (total) at implementing junction/2025, Lt/h | 197/262 | 210/279 | 244/325 | 188/252 |
| Fuel consumption (total), L/h | 18.5 | 19.2 | 20.8 | 17.9 |
| Travel time (average), s | 51.3 | 55.9 | 69.6 | 48.2 |
| $CO_2$/CO/NOX, kg/h | 46.4/3.34/0.1 | 48.2/3.52/0.104 | 52.2/3.64/0.108 | 45/3.28/0.098 |
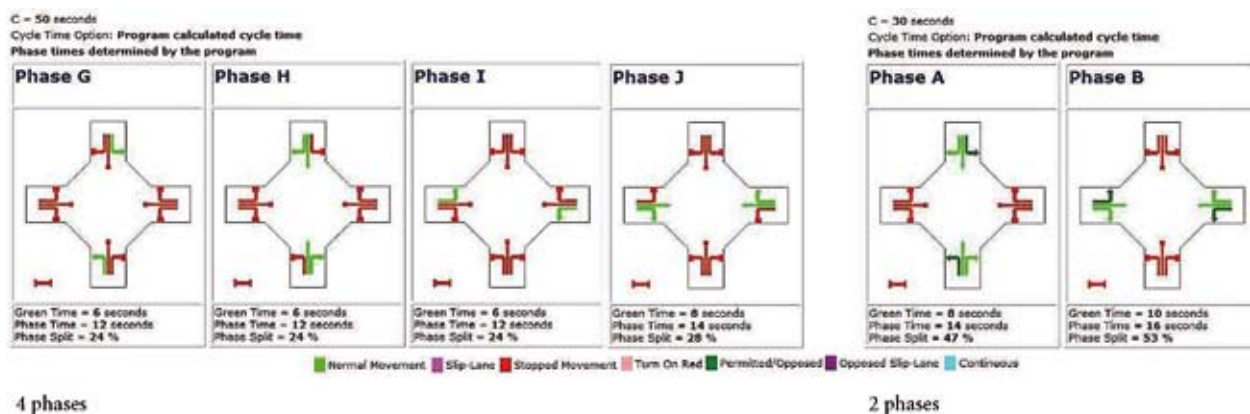


**Fig. 6.** Phases of signal controlled intersections

It was determined that the traffic volume being not large, the most effective type for Dariaus ir Girėno and Molėtūno streets junction is 2-way yield junction. However, modelling did not take into consideration demand of land and traffic safety. It was calculated that 2-way yield junction would require 40 m², roundabout – 80 m². It is known that 2-way yield 4-arm junctions have 32 conflict points, whereas, a roundabout has only 8 conflict points. Based on the Order V-410 (of 19 November 2008) of the

Director General of Lithuanian Road Administration under the Ministry of Transport and Communications of the Republic of Lithuania, the accident losses are valuated as follows:

    – cost of a person killed 2 010 615 Lt;

    – cost of a person injured 182 569 Lt;

    – cost of damage – only accident 5797 Lt.

Taking into consideration that 2-way yield 4-arm junction has more conflict points and, thus, a larger acci-

dent risk and higher accident losses, it is suggested to construct roundabout as the most effective type of the junction. Besides, the junction is located at the administrative border of Molėtai City, serving for the city as "city gates" and defining a rural-urban driving regime. When a roundabout is constructed, the further questions of city image formation when entering Molėtai City, could be analyzed and solved.

## 8. Conclusions and proposals

In what cities the future generations will live in Lithuania, it will depend on common efforts of planners, scientists and city developers, the public, administrative abilities of all-level politicians and on implementation of decisions made. Quality of communication territories and spaces determine the functioning quality of the city and the impact size. On this the city's prestige and attractiveness to investments depend. Communication structures, especially the main ones, are large attraction objects, operation of which makes the influence on the use and attractiveness of adjacent territories (land) and on market prices of land and buildings.

In Lithuania LOS has not been defined so far, though, taking into consideration the changing transport system and increasing adjustment to the transport system of Western countries, the LOS must be started to be defined.

Modelling and substantiation of urban communication systems can be performed by using modern modelling measures. Modern modelling tools are very useful for assessing different types of junctions in urban transport systems, comprehensive planning, analysis and forecast between transport infrastructure facilities and urban development considering different types of junction.

The objective of this study was to compare the operational performance of roundabout, signalized and 2-way yield junctions under similar traffic conditions. This means that traffic volumes were the same during the study. The operational performance of the different kinds of junctions was modelled and analysed using the measures of junction effectiveness given by *SIDRA INTERSECTION* outputs.

This study was developed by a method of comparison. In the existing situation there is an irregular 4-way yield controlled intersection. Having collected data on traffic volume and geometrical parameters, having made forecasts for the future traffic volume, 4 different type junctions were modelled and the obtained results compared. Comparison of alternatives based on the results of effective junctions capacity, back of queue, LOS, control delay, operating costs, fuel consumption, travel time, traffic safety

and pollution showed that the roundabout will be the best solution and the best type for the analysed junction in the upcoming 16 years.

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