

7th INTERNATIONAL CONFERENCE
"TOWARDS A HUMANE CITY"
Environmentally Friendly Mobility
Novi Sad 6th and 7th December 2019

Vuk Bogdanović, PhD¹

E-mail: vuk@uns.ac.rs

Vladimir Depolo, PhD²

E-mail: vlada.depolo@gmail.com

Valentina Mirović, PhD¹

E-mail: plast@uns.ac.rs

Dragan Jovanović, PhD¹

E-mail: draganj@uns.ac.rs

Zoran Papić, PhD¹

E-mail: njele@uns.ac.rs

Jelena Mitrović Simić, PhD¹

E-mail: mjelena@uns.ac.rs

Boško Matović, PhD¹

E-mail: boskom@uns.ac.rs

Nenad Ruškić, PhD¹

E-mail: nruskic@uns.ac.rs

Nenad Saulić, MSc¹

E-mail: n.saulic@uns.ac.rs

Nemanja Garunović, MSc¹

E-mail: garunovic@uns.ac.rs

Ana Vujičić, MSc¹

E-mail: ana.vujcic@uns.ac.rs

Miodrag Počuć, MSc²

E-mail: miodrag.pocuc@adomne.rs

Igor Vukobratović, BSc²

E-mail: igor.vukobratovic@adomne.rs

¹ University of Novi Sad, Faculty of Technical Sciences

Trg Dositeja Obradovića 6, Novi Sad, The Republic of Serbia

² "ADOMNE" d.o.o.

Šumadijska 1, Novi Sad, The Republic of Serbia

SMART PLAN NOVI SAD

- Invited lecture -

Key Words

Smart city;
Smart mobility;

Abstract

During the year of 2017 Novi Sad started the processes related to the realization of the project Smart City. The activities of the project SMART PLAN were primarily directed

Sustainable mobility

to smart mobility, which represents one of six basic characteristics of the smart city. Within the first phase of the project, many research studies were conducted resulting in data on mobility, public transport system, traffic conditions, parking and traffic safety. After the research results processing, data bases were formed which were the starting point for further steps in the project realization. By means of the comparative analysis of different data from the formed bases, different indicators were determined to be the basis for the assessment of the current state and travel matrices were formed. Based on the results of the first phase of the project, taking into consideration spatial, social, economic and demographic characteristics, the travel model on the territory of the town of Novi Sad was formed. The basis of the new traffic model was the previously formed transport model within the project NOSTRAM, which was done by the town of Novi Sad in the previous decade. The formed transport model served for testing all planned infrastructure interventions and activities in the street network, defined within the existing planning documentations, as well as other proposed measures of traffic policy in short-termed, mid-termed and long-termed period, after the year of 2017. After the conducted analyses, the action plan was proposed for conducting the proposed activities on the realization of plans and measures in all areas, which would contribute to Novi Sad traffic system advancing in the spirit of sustainable mobility and smart city.

1. INTRODUCTION

Sustainable and smart mobility is according to all relevant sources one of six fields which characterizes a smart city [1,2]. Smart mobility is always the result of smart traffic system which apart from the use of information technologies also means new models which enable a unique policy, correlation and integration with smart management, economy, environment, people and way of life. All stated fields represent basic characteristics of smart relationship, that is (SMART) city.

Novi Sad has a long and rich tradition in traffic system development planning, which, among others, influenced on becoming one of the most successful and beautiful cities in the region. Deviation from the heritage and planning policy of traffic development in accordance with the principles of sustainable development, would affect generation of the problems which can degrade traditional values and recognizability of Novi Sad as a spatial and comfortable, cosmopolitan, central European city. In order to preserve the identity of Novi Sad, attractiveness and quality of life, it is necessary to plan the development of traffic system in the following period, but also to correct as many as possible mistakes occurred as a

consequence of a turbulent period, that is, the process and changes happened in our region at the end of the twentieth century.

Novi Sad was among the first cities in the region which developed the traffic model NOSTRAM [3] in 2009 (**NO**vi **Sad** **Traffic** **TRAN**sport **MO**del). This model enables a great precision outcomes analyses of variant solutions, that is, positive and negative consequences of their application, in the spirit of sustainable mobility and principles of a smart city. In order to have a functional model, it is necessary to update data bases periodically which refers to mobility characteristics, traffic flow, parking, public transport, traffic security, etc.

Activities related to the data collecting and their analysis in the form adapted to the model has been conducted within project SMART PLAN - THE FIRST PHASE [4]. Within the second phase of the project, SMART PLAN - THE SECOND PHASE [5], on the basis of the formed data bases, movement matrices have been defined, necessary for the functioning of NOSTRAM in accordance with the real state on the network and hypothesis of city development (population, construction development, etc.), based on the analyses the solution proposals related to all means of transport have been tested. In accordance with contemporary planning principles, the outcome of planner's procedure are the proposals of action plans with whose application sustainable development goals would be achieved.

The basic goals of the smart city project in the field of traffic and mobility are based on general goals of city sustainable development and smart city. The policy goals of sustainable and smart mobility are based on giving priority to non-motorized transport means, as well as to public transport, in relation to passenger cars. All policies of sustainable mobility and smart city are directed to the application of stimulative measures for non-motorized movement and public transport and restriction of the use of passenger cars by applying different non-stimulative measures of traffic policy (access restriction on certain parts of street network, increase of parking price, charging taxes for entering certain city zones, tax increase, etc.).

2. DATABASE FORMING

Databases formed in the previous project phase SMART PLAN - THE FIRST PHASE on the basis of different research studies represented the base for the creation of the second phase of the project SMART PLAN. Within the first phase of the project, databases were formed as well as the reports on:

- Mobility,
- Traffic conditions characteristics,
- Public transport of passengers,
- Parking,
- Traffic safety.

Within the mobility characteristics determination, the following research studies have been conducted:

- Surveys in households,
- Survey and outer passengers counting,
- Survey and counting on the outer cordon.

Research results processing was used for forming travel matrices which have been added with the report on mobility.

Within the traffic conditions characteristics determining, the following research studies have been conducted:

- Traffic counting on the street network and traffic flow characteristics determining regarding all vehicles categories and pedestrians,
- Velocity characteristics determining on the street network,
- Level of service determining at key intersections and sections in the city.

The research on public transport characteristics included:

- Technical-exploitation characteristics of all public transport lines in the city,
- All day passenger counting on all public transport lines,
- Survey of public transport passengers.

The research in the field of parking conducted at all locations, that is, all parking spaces with parking charging, that is:

- Available surfaces for parking and parking regimes,
- Parking characteristics (duration, accumulation, turnover),
- Parking samples.

In the field of traffic safety , the following have been researched:

- Absolute indicators of traffic safety,
- Attitudes of traffic participants about the risks,
- Behaviour indicators.

This study methodology has been shown in the figure 1 and it generally consists of two phases. In the first phase, the research was conducted and necessary data for the study creation were collected. After the first phase, forecasts were made and the model in the program package VISUM was formed. The formed model enabled all proposed measures testing, regardless of the predicted time period of their realization, that is, regardless of the fact whether it is about short-termed, mid-termed or long-termed measures.

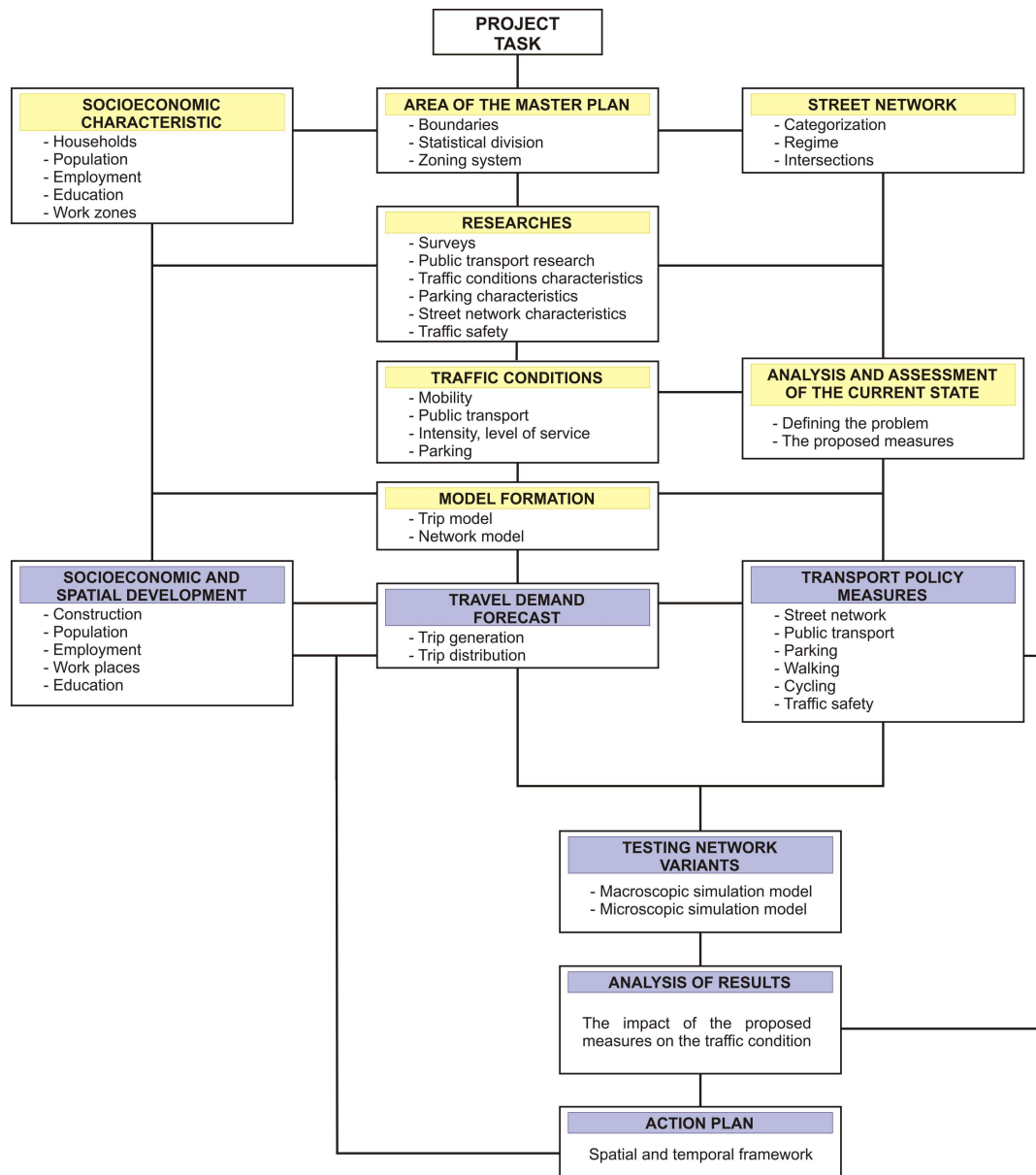


Figure 1. Methodology and the flow of the study creation

3. MODEL FORMING

In order to define development plans which refer to the City, updating and calibration of the Transport model of Novi Sad NOSTRAM were conducted. The forecast of the traffic demand, that is, the number of journeys, and then the number of vehicles on the basic road and street network of Novi Sad, was made for the year 2027, for the planned period longer than General Plan. The basic data on which the forecast of the expected traffic is based are the rates of travel generating determined in the survey in households, the outer traffic increase rate and indicators from earlier demographic and economic research studies in Novi Sad, which are related to planned development indicators in Novi Sad.

3.1. The model of flow distribution on the existing road and street network

Transport model of Novi Sad NOSTRAM has been developed within the software package "VISUM" and it consists of two key elements: computerized display of traffic network and traffic demand matrices.

On the basis of the data from the conducted research studies from the first phase of the plan creation (survey in households, survey of outer passengers and the survey on the outer cordon) and socioeconomic data by traffic zones and districts (number of residents, number of flats, surface of residential area, surface of the business property area) matrices on public transport journeys and journeys by passenger cars were formed.

The model calibration was done in two steps. The first step was related to passenger cars calibration, and the second to the calibration of the passenger transported in public transport.

The model calibration of passenger cars was conducted on the level of vehicles counting at the most significant intersection and sections. The model was calibrated on the base year of 2017 on totally 152 links. With the calibration, the mean relative mistake of 9% was achieved and the correlation coefficient R^2 of 0.95. It has been determined that the assessed (modeled) flows correspond to the observed flows (determined by counting). This implies that the model corresponds to real traffic demand and it can be reliably used in the development of traffic forecasts in Novi Sad. The result of passenger cars flows distribution on the existing road and street network of Novi Sad, that is, the results of model simulation have been shown in the following figure.

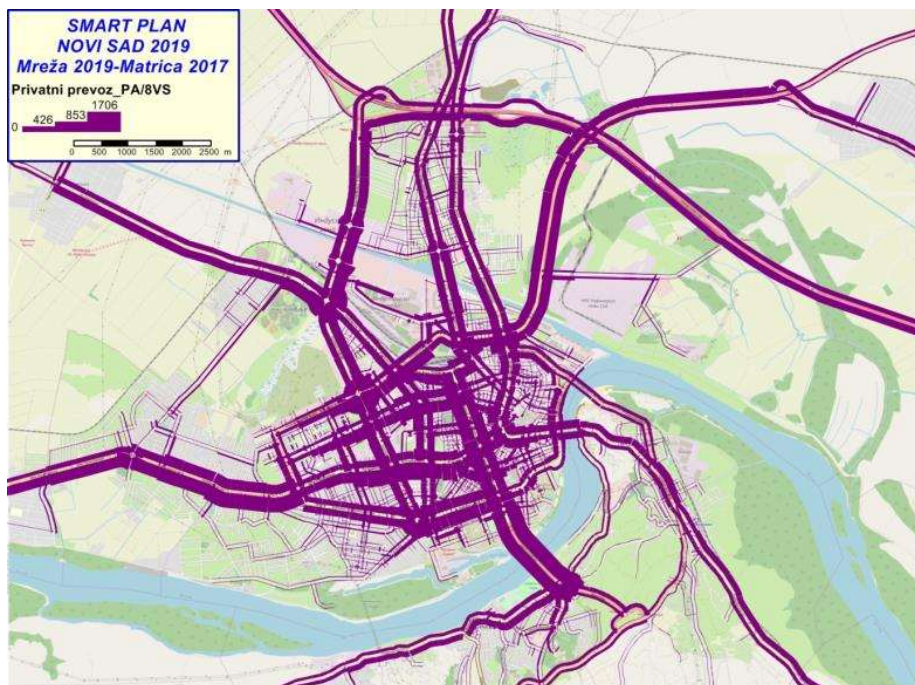


Figure 2. The current traffic load with passenger cars in the morning peak hour

The model calibration on the level of passengers public transport has been done in the way that the network of state was “burdened” by calibrated public transport travel matrix in 3 steps:

1st step: public transport system level;

2nd step - level of suburban corridors;

3rd step -level of input-output corridors into the city centre

The model was calibrated on the base year of 2017 on totally 16 links. With the calibration the mean relative mistake of 2% was achieved and the correlation coefficient R^2 of 0.99. The obtained calibration results completely confirm the correctness of the methodological procedure, since the differences are negligibly small, which means that the model represents the state of the public transport system from 2017, when system passengers counting was conducted. The passenger number calibration results have been shown in the following figure.

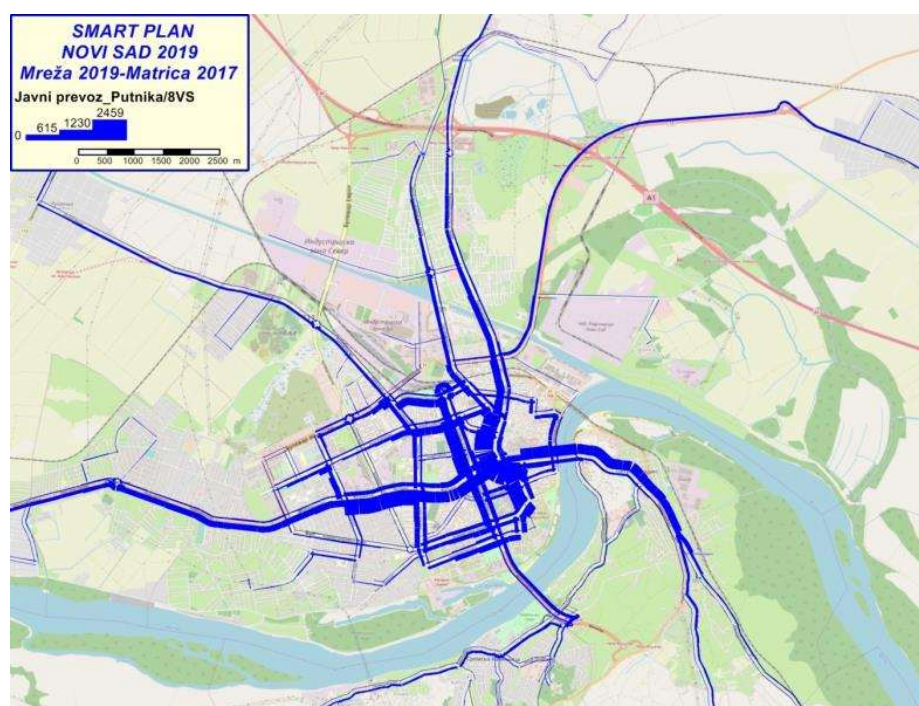


Figure 3. The existing number of passengers in public transport in the morning peak hour

3.2. Traffic demand trends and forecast

In order to test different development variants, the obligations inherited through basic plan documents (General Plan of Novi Sad by 2021, Spatial Plan of the City of Novi Sad and measures proposed in 2009 through the traffic study NOSTRAM) were analyzed.

For the needs of this study the total number of origin and destination journeys (production and attraction) of every zone was calculated on the basis of the travel generating rate achieved in traffic research (for each traffic zone and district) and

expected changes in the number of passengers and work positions of every traffic zone of the research area. The distribution of journeys ends obtained in the previous model group (travel generating models) was conducted by combining the application of two models of spatial distribution for the period of morning peak hour: synthetic method (Gravity model) and the method of increase factor (Fratar model). The results have been shown by origin-destination matrix O-D or demand matrix in which each of the elements represents the number of journeys from the origin zone “o” into the destination zone “d” ($o, d = 1, 2, \dots, n$; n - number of traffic zones of the city for which the analysis is done).

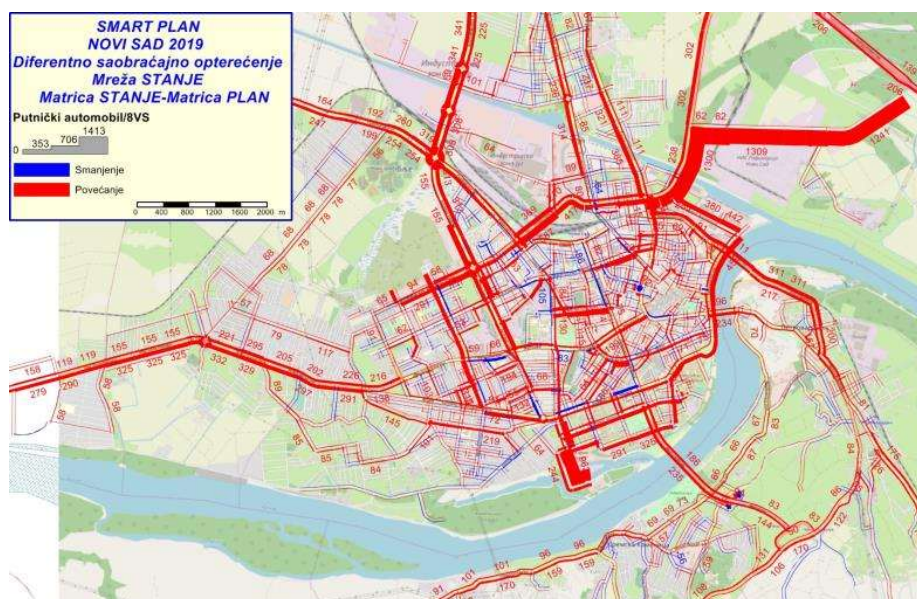


Figure 4. Different traffic load of the planned matrix in relation to the matrix of state in the existing traffic

The basic indicator which served for mutual variant evaluation is the percentage of capacity utilization on the planned links in the planned traffic.

Analysis of the percentage of capacity utilization of the existing traffic network burdened by the existing traffic showed that the existing traffic network of Novi Sad is satisfactory. Also, in case when the existing network of capacity utilization with the planned load on a large number of sections exceeds 90%. In accordance, modelling of the future traffic network has been made, which was proposed in the plan documentation which has been made so far. The obtained results of traffic load and the percentage of capacity utilization of the planned traffic network have been shown in the following figures.

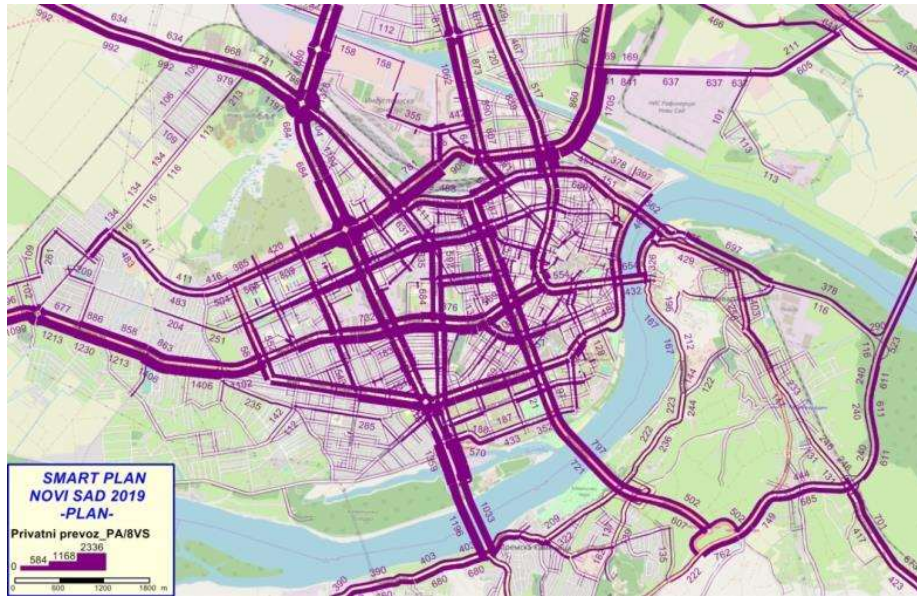


Figure 5. Expected traffic load of the planned traffic network burdened by planned traffic in the morning peak hour

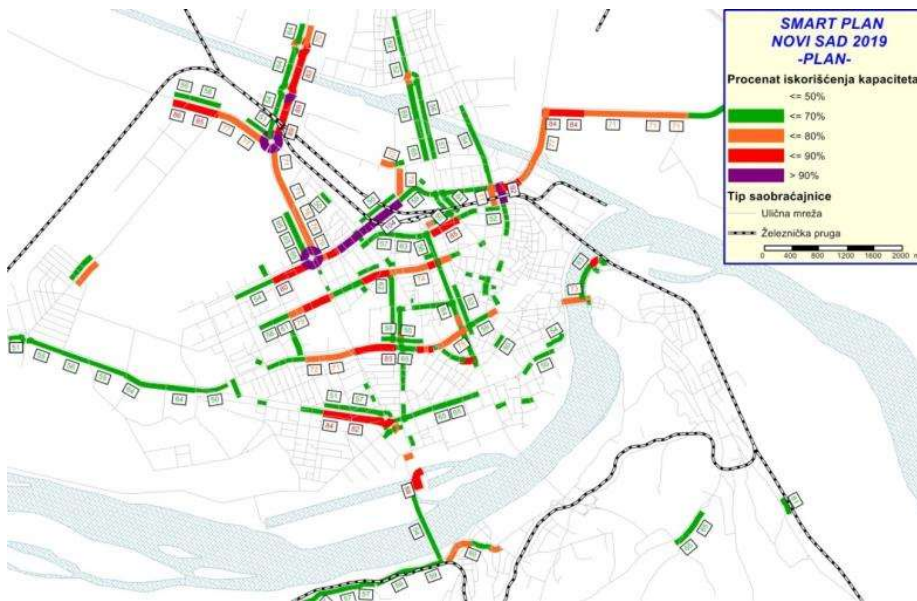


Figure 6. Percentage of capacity utilization of the planned traffic network burdened by planned traffic in the morning peak hour

On the basis of these analyses the priorities for the advancement of road and street network in Novi Sad have been defined, and at the same time the priorities and construction order. Interventions and building on the traffic network of the city are to comply with the priorities defined in the study, so as to achieve an acceptable level of service in the street network.

4. STATE ASSESSMENT

On the basis of the collected and analyzed data, the state has been assessed in the form of tables with the indicators describing advantages and disadvantages of the traffic system in the field of public transport, parking and cycling and pedestrian traffic. In the following table the method of the state assessment has been shown on the example of the public transport.

Table 1. List of indicators describing advantages and disadvantages of public transport system

Advantages (+)		Disadvantages (-)	
INDICATOR	VALUE	INDICATOR	VALUE
Coverage of the area of Traffic Master Plan	Participation of the area of Plan within 300 m around the bus stop	Passenger loss in a longer time interval	% of the decrease in passenger number in the period 2012 - 2018
	Participation of the area of Plan within 500m around the bus stop	Low average vehicle velocity	Average vehicle velocity in a day /peak hour
Availability of passenger public transport system	Participation of work positions within 500m around the bus stop in relation to the total number of work positions	Zone system characteristics	Number of fare zones
	Participation of work positions within 500m around the bus stop in relation to the total number of work positions	Number of fare items	Total number of fare items
Acceptability of transport fare for the users	A monthly expenditure for public transport for a three-member family does not exceed 8% of monthly incomes	Relationship City- Carrier	type of relationship
		Existence of the bus stops of low utilization	Total participation of the bus with the volume of entrances and exists lower than 200 passengers a day
		Quality of the bus fleet in the context of the environment protection	Participation of drive units (vehicles): Diesel of EU4 norm and higher; natural gas or hybrid or electric drive. totally - less than 50%
		Easiness of entering /leaving vehicles	Participation of low-floor buses in the total number by types: not lower than 60% by each type
		Easiness of entering / leaving vehicles for the disabled	Participation of buses equipped with ramps in the total number: - solo- min. 50% - articulated - min. 50% - midi-bus - min. 50%

5. ACTION PLANS

Strategic and special goals defining for all fields of traffic system of Novi Sad, defined in accordance with general goals of sustainable and smart city.

5.1. Strategic goals in the field of public transport

On the basis of the system current state analysis the following strategic goals have been defined:

A. Short-term (by 2021)

- Carry out the rationalization of the zone system by enlarging, that is, reducing the number of zones. Introduce a zone system on the territory of city and in the suburban area.
- Regulate the relationship of the City and Public Carrier by Public Service Contract.
- Introduce a contemporary public transport management system and form the Control Management Centre,
- Introduce a contemporary system of charging based on e-tickets. This goal is connected with the previous.
- On parts of the street network where general traffic influences the velocity of public transport vehicles. Introduce special lanes with a video monitoring. Gradually introduce the priority to public transport vehicles at critical intersections,
- Renew the bus fleet,
- Increase inspection activities for the suppression of illegal transport.

B. Mid-term (by 2027)

Continually increase the participation of vehicles with environmentally friendly aggregates (Euro 6, CNG; electric drive),

- Prepare Public Carrier for switching to electric vehicles (install the system for vehicle maintenance, choose the line network segments where these vehicles will run and equip them with necessary infrastructure).
- Continue the reorganization of line network (new lines, alternative directions for the existing lines - connected with the construction of street network, reduction of number of bus stops with a very low number of inputs/outputs, reduction of the number of departures with the most burdened terminus by dislocating to less burdened terminus).

C. Long-term (after 2027)

- Return the volume of transportation service from 2012. This goal demands a longer period since its realization is connected with all the goals above mentioned.

- Continue the preparation for the introduction of the system with high/mid capacity based on rail vehicles. This goal is connected with the overall development of Novi Sad (city territory expanding, increase residential density at the existing locations, etc.).
- When it is necessary, open public transport market for other carriers as well.

5.2. Strategic goals in the field of parking

The following strategic goals have been formulated on the basis of system state analysis:

A. Short-term (by 2021)

- Corrections of the existing parking regime. Proposal of the parking for “an extra zone”, as well as pre-defining of certain parking spaces with the currently valid into another parking zone. Parking space within the campus to become a “white” parking zone.
- Corrections in the field of fare policy. Parking price correction in accordance with the trend of increase of the number of registered passenger vehicles in Novi Sad, average gross income and the price of an individual ticket in JGSP (Public transport carrier) Novi Sad in the first zone. A higher amount for the privileged ticket for the second car in the family.
- The change of the city Decision on determining fees for land development by which investors for the unbuilt parking places pay a symbolic amount to the city budget.
- Forming a special city earmarked fund from which money could be used for investing into the construction of parking garages and other off-street car park capacities.
- Removal of unregistered and damaged vehicles from the existing car parks
- Horizontal marking of parking lots would increase available space for parking, that is, the available parking surface would be most rationally used.
- A more active participation of communal police in detection and sanctioning of parking in green surfaces and other areas where it is not allowed.
- Zero tolerance to usurpation of parking places designated to the disabled.
- Possibility of reporting irregular and haughty parking by citizens via MMS messages or other multimedia services.

B. Mid-term (by 2027)

- Parking garages building at more locations in the inner and wider central zone.

- Construction of close (safe) bicycle parking garages.
- Application of information technology and “smart” solutions in the field of parking.
- Regulation of delivery vehicles parking and stopping in the street network.

C. Long-term (after 2027)

- Construction of collective parking terminals (“P+R” terminals) with organized transport of parking users towards the city and backwards.

5.3. Strategic goals in the field of pedestrian and cycling traffic

Based on the analysis of the system state regarding cycling and pedestrian traffic on the territory of the city of Novi Sad, the following strategic goals have been defined:

A. Short-term (by 2021)

- Increase of the safety level of pedestrians and cyclists on the street network of the city of Novi Sad.
- Remediation, reconstruction and modernization of the existing pedestrian and cycling infrastructure.
- Application of the basic parameters of design and cycling infrastructure which are in accordance with the contemporary manuals for cycling traffic design and planning.
- Application of contemporary solutions in the field of cycling and pedestrian traffic regulation.
- Development of the system for offering services in cycling traffic.
- Expanding services intended for cyclists.
- Promotions, education and campaigns conducting related to pedestrian and cycling traffic.

B. Mid-term (by 2027)

- Construction of new cycling lanes in accordance with the proposed network for a better coherence of the cycling network.
- Traffic calming in order to improve the conditions of pedestrian and cycling traffic.
- Improving the accessibility of the street network for pedestrian and cycling traffic
- Integration of cycling transport and the system of passenger public transport
- Advancement and expending of “bike sharing” system.
- Construction of open and closed (safe) parking places for bicycles

- Traffic policy integration.
- Creation of strategic plans in the field of pedestrian traffic planning.
- Creation of strategic plans in the field of cycling traffic planning.
- Institutionalization of cycling planning and promotion in the local self-government bodies.

C. Long-term (after 2027)

- To close Beogradska Street in the suburbs of Petrovaradin fortress
- Expanding of the pedestrian zone in the city
- Construction of new cycling corridors on the territory of Novi Sad.
- Construction of pedestrian-cycling connection between Novi Sad and Sremska Kamenica.
- Connecting of the city cycling paths with the suburban network of cycling paths and international network of cycling routes.

Plan of activities is essentially the output result of every strategy. In accordance with the above mentioned goals, within the study SMART PLAN - THE SECOND PHASE, a plan of activities was stated in the field of public transport, parking and cycling and pedestrian traffic. For each activity in the stated fields a short description has been given and the purpose, that is, the expected result of the initiative. In the plan the existence / non-existence of the necessary plan and technical documentation has been analyzed, as well as the existence /non-existence of the study or the analyses of justification. The activities were shown in detail by phases and implementation deadlines, as well as the estimated means for the initiative realization.

For each activity, action plan and the assessment of the means necessary for the realization have been defined. Plan of activities includes the description, purpose and expected results. For a number of the proposed activities the need for justification analysis was estimated (or its existence has been stated), documentation necessary for the implementation of the activities, dynamics and the estimated implementation time, activities operators and the assessment of the means necessary for the realization of the proposed measure.

In the following table there is an example of the action plan for the correction of fare policy in the field of parking.

Activity:	Correction in the field of fare policy
Short description:	Low prices of parking compared to the prices in the nearby cities, price of services of JGSP (Public city transport carrier), etc. It is necessary to increase the basic parking charging and abolish privileged tickets for more cars in one household.
Purpose/ Expected result:	With the increase of parking price, non-stimulation of a number of users from everyday use of passenger cars can be expected, with simultaneous increase of the number of journeys by public city transport, by bicycle or on foot. Tightening criteria for privileged resident tickets issuing could affect relinquishing possessing the second or the third car.
Necessary documentation:	-
There is a study/ justification analysis:	Smart plan – the second phase
Phases and estimated implementation time:	Phase 1 – proposal of new parking prices Phase 2 – administrative procedure (Decision creation) Phase 3 – Decision adopting, placing new additional boards with new prices of parking service Duration: Phase 1: around 1 month Phase 2: around 2 months Phase 3: around 3 months
Operator:	City Administration Public utility company “Parking Service Novi Sad”
Estimated realization fund	Replacement of the existing additional boards (there are about 195 parking areas within “extra”, red, blue and white colour) - minimal expenses in the amount of around 3,700,000 dinars

6. CONCLUSION

The basic goals of the study SMART PLAN have been decided on the basis of strategic goals of sustainable development of traffic system and smart city. In accordance with the general goals, within the study SMART PLAN, research has been conducted as well as the analyses of complete traffic system of Novi Sad, which included:

- Proposals and conclusions about the existing plan and project documentation,
- Characteristics of traffic, road and street network,

- Characteristics of residential mobility and land purpose,
- Characteristics of passenger public transport system,
- Parking characteristics,
- Characteristics of pedestrian and cycling traffic.

The conducted research studies were the basis for updating the Transport model NOSTRAM. After the calibration, the transport model was completely accorded with the state of transport demand of Novi Sad from 2017. As a platform for the model development, the program package "VISUM" was used.

On the basis of the conducted analyses in further procedure, by methods of comparative analyses and synthesis, with the use of application software packages for the processing of the data collected in the research, the assessment of the traffic system state was done. The advantages and disadvantages were analyzed in the field of mobility, public transport, parking and cycling and pedestrian traffic.

The general conclusion is that there are negative trends which primarily appear in ever higher use of passenger car for meeting the needs of mobility and lower use of public transport, which is one of the key factors for the fulfillment of strategic goals of sustainable and smart city.

In order to assess the influence of the proposed measures on the behaviour of traffic system, demand forecasts were made, based on the known City development plans and plan horizon of the study, by 2027. The demand was interpreted by appropriate journey matrices used for network burdening (of general and public traffic).

In order to stop negative trends, short-term measures have been proposed by 2021, mid-term by 2027 and long-term after 2027, for the improvement of the state of traffic system of Novi Sad. For the field of public transport, parking, pedestrian and cycling traffic, action plans have been proposed, which included system changes, necessary decisions and activities which should be done the city administration, traffic-regulative and infrastructure measures.

REFERENCES

- [1] *Mapping Smart Cities in the EU*, Directorate General for Internal Policies, Policy Department A: Economic and Scientific Policy, 2014.
- [2] <http://www.smart-cities.eu/?cid=2&ver=4>
- [3] Urbanism Public Enterprise, *Saobraćajna Studija Grada Novog Sada Sa Dinamikom Uređenja Saobraćaja – NOSTRAM (Traffic Study of Novi Sad with the Traffic Management Dynamics Novi Sad with the Traffic Management Dynamics)*, 2009.
- [4] Faculty of technical sciences, ADOMNE d.o.o., *Smart Plan - The first phase*, 2018.
- [5] Faculty of technical sciences, ADOMNE d.o.o., *Smart Plan - The second phase*, 2019.