CITY OF BELGRADE

SECRETARIAT FOR PUBLIC TRANSPORT

UNIVERSITY OF BELGRADE
FACULTY OF TRANSPORT AND TRAFFIC ENGINEERING

Summary

PLANNING AND DESIGNING OF THE TAXI SYSTEM IN BELGRADE FOR PERIOD FROM 2020 TO 2024

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The main activity in planning and designing a public transport system includes an optimal modal split and journey distribution among those modes that provide a balanced optimum concerning inhabitants' mobility. Successful and liveable cities rely on an efficient mass passenger transport system which, in synergy with flexible transport systems (paratransit systems), provide users with combined transportation services, i.e. combined mobility services.
The main objectives of this research and development project are aimed at creating a scientific and professional basis for changes in the structure, operation, organization and management of the taxi system following a defined transport policy at the level of the City of Belgrade and actual transport needs and demands of the system's users, and creating conditions for the system to become an efficient subsystem of the City of Belgrade's public transport.
The research and development project was made and presented in four mutually linked books, each of which represents a separate whole, i.e.:
Book 1 – Methodology of making the research and development project (methodology is based on the postulates of the system engineering and takes a bottom-up approach, as well as on modelling based on methods, techniques and tools from the field of transport engineering. Total pages:30).

Book 2 – Due-diligence analysis of the existing taxi system in Belgrade (Within this part of the project, a whole range of activities was carried out to conduct a thorough and systemic analysis of the existing taxi system from several different aspects which are grouped into several sections that represent inherently complex activities that are part of the planning and designing of the taxi system in Belgrade. Total pages:171).

Book 3 – The elements of the taxi system's infrastructure – taxi stands (Within this part of the project, the characteristics of 154 taxi stands were investigated and analyzed. The following characteristics are given for the most important taxi stends identified - 31 stands (volume, circulation, average time spent by a taxi vehicle at the stand in the period from 6 a.m. to 10 p.m.). Accumulation of taxi vehicles at equal time sections was provided for other stands which were spatially identified. Traffic and technical drawings of taxi stands were given for the stands under the authority of the Secretariat for Public Transport which were spatially identified based on the existing traffic signalization. Total pages:356).

Book 4 – Reengineering of the existing taxi system in Belgrade (This part of the project represents a set of activities directed at the reengineering the existing state and designing the future state of the taxi system in Belgrade. It also includes the activities related to providing conditions for the continuous process of future development and positioning of the complete taxi system in terms of its sustainability, having in mind the real needs of users and possibilities of the City of Belgrade, i.e. creating a sustainable taxi system tailored for Belgrade and its users. There are several complex processes included in this part of the project and these are divided into four chapters: Structure and basic elements of the taxi system operation in Belgrade; Organization and management model of the taxi system in Belgrade; System for monitoring and control of the taxi system operation in Belgrade; Proposed amendments to the regulatory acts for the implementation of the new system. Total pages:165).</td></tr>
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SUMMARY

Reason, objectives and tasks of the research and development project

Flexibility, dynamism and adaptability represent the basic characteristics of the modern urban space which constantly changes in time and space and adjusts itself to the intensive needs and demands of modern society. Public transport system with its performances, technology, quality, costs and environmental effects represents one of the major factors of how a city and its transport system operate.

The main activity in planning and designing a public transport system includes an optimal modal split and journey distribution among those modes that provide a balanced optimum concerning inhabitants' mobility. Successful and liveable cities rely on an efficient mass passenger transport system which, in synergy with flexible transport systems (paratransit systems), provide users with combined transportation services, i.e. combined mobility services.

Within combined mobility, different subsystems are coordinated in such a way that enables users to travel easily by combining multiple travel modes where each subsystem performs a most suitable physical and operational role providing each user of the system with a free choice concerning mobility realisation. The application and development of the combined mobility concept provide the users with the utmost convenience, while technical and economic efficiency of the transport system is raised to an optimal level.

The taxi transport is part of a flexible passenger transport subsystem that provides users with a whole day (24/7) public service using vehicles of appropriate capacity at short distances, concerning users' demands and based on predefined and known terms. An operator provides a transport service based on a predefined transport request (trip start time, route selection and transport length) for which the user pays a predefined price of a transport service that is defined based on a model which is usually part of the city's internal acts. It is usually the competent local authorities that define the tariff policy (a basic price and a model for pricing taxi services) and its implementation concerning specific taxi service characteristics in the transport market.

The taxi transport subsystem (hereafter taxi system), as part of the urban transport system in the City of Belgrade, represents an important factor in the development of the combined mobility concept with extremely significant benefits and influence on an efficient and quality life of its inhabitants. Using this subsystem, in synergy with the other existing subsystems of public passenger transport (bus, trolleybus, tram, and urban-suburban rail transport) has multiple advantages over private passenger transport subsystems (primarily passenger cars). The most important of these advantages are:

- It saves public space because it decreases the use of private cars;
- It affects modal split of motorized travels because it increases the number of the public passenger transport system users;
- It improves the passenger transport system's dynamism;
- It has an effect on the transport service to be provided more flexibly and comprehensively;

- It decreases the travel time as one of the main elements of all aspects of quality as viewed by the users of the system;
- It reduces travel costs compared to private car use (it does not require users' direct investment costs concerning the infrastructure and vehicle ownership as well as users' direct costs for driving (fuel consumption costs, parking cost, vehicle maintenance cost, etc.);
- It provides a high level of accessibility in space and time (a possibility of an individually tailored journey from door to door at the desired time - 24/7);
- It increases the ecological suitability of the urban transport system, etc.

However, even though the taxi system in Belgrade plays an important role in meeting the inhabitants' needs, it exhibits many systemic and functional issues. The most important of these issues are:

- Insufficiently defined and accurate regulatory frameworks and responsibilities on all management levels (inconsistencies on how the industry is viewed, i.e. whether the taxi system represents a business industry in the free market or public service. Frequent changes of regulatory acts with no systemic risk analysis, etc.)
- Inadequate structure of the system (offered capacities, primarily the number of operational vehicles in the market of transport services, are not aligned with actual transport needs and demands for this type of service);
- A relatively low level of service quality – satisfactory operating level in terms of accessibility in space and time, but with low quality of service level in terms of basic aspects of comfort;
- The extremely heterogeneous structure of the vehicle fleet (the system includes mainly vehicles with outdated technology in terms of safety, comfort, aesthetics, environmental protection, etc.)
- Regulation at the local level does not entirely meet modern demands for managing this system;
- Inadequately defined authorities concerning the system organization and management;
- The lack of monitoring and control at the strategic and tactical level of management;
- The lack of uniform technology of trip requests using modern applications;
- Existence of irregular taxi vehicles and drivers, etc.

Bearing in mind the foregoing issues, the Secretariat of Public Transport of the City of Belgrade, as the owner of the taxi services market, has decided to perform a comprehensive analysis of the existing taxi system to ensure long-term and quality solutions concerning the improvement of the system and service quality, efficacy and efficiency as well as organization and management that need to be delegated to the experts of local authorities.

The main objectives of this research and development project are aimed at creating a scientific and professional basis for changes in the structure, operation, organization and management of the taxi system following a defined transport policy at the level of the City of Belgrade and actual transport needs and demands of the system's users, and creating conditions for the system to become an efficient subsystem of the City of Belgrade's public transport.

The tasks of this research and development project are a result of the above-mentioned objective. The most important of these tasks are:

- Due-diligence analysis of the existing taxi system regarding all elements of the structure, operation, organization and management;
- Determining the current strengths and weaknesses, opportunities for and threats to the system (SWOT analysis of the existing system)
- Defining a reliable information basis from the existing taxi system through systemic research of the characteristics of the system's users as well as the characteristics of the demands and trips in the system, as the main input for all activities in the process of reengineering and designing;
- Designing a new structure and main elements of the taxi system operation in Belgrade based on real data from the system and actual needs of the City of Belgrade's inhabitants;
- Reengineering of the existing network of taxi stands in the urban part of Belgrade;
- Defining a proposal of the new organization and management model for the taxi system in Belgrade;
- Defining the technological process of monitoring and control of the system operation;
- Defining the proposal of the amendments to regulatory acts for the implementation of a new system.

While designing the taxi system in Belgrade, typical experiences of the taxi system operation in selected cities in the world were taken into consideration, by analyzing typical case studies.

The research and development project was made and presented in four mutually linked books, each of which represents a separate whole, i.e.:

Book 1 – Methodology of making the research and development project

Book 2 – Due-diligence analysis of the existing taxi system in Belgrade

Book 3 – The elements of the taxi system's infrastructure – taxi stands

Book 4 – Reengineering of the existing taxi system in Belgrade.

Book 1 - Methodology of making the research and development project

As the project's main goal is to plan and design a taxi system in Belgrade for the period from 2020 to 2024 by creating new conditions for long-term and quality solutions for improving the quality of the system and service, a specific and original methodology was defined which applies the postulates of the system engineering and takes a bottom-up approach (system demands origin directly from the stakeholders' needs) as well as modelling based on methods, techniques and tools from the field of transport engineering.[1]

The methodology of planning and designing a taxi system is made of three mutually related phases and is based on implementing modern and available solutions in accordance with available resources of the system and demands of the key actors in the system, i.e., on the solutions that are developing to create conditions for gradual changes in the system without sudden and abrupt changes within the system.

The methodology includes three phases:

[1] With the aim of creating a quality and efficient project, the methodological approach includes a wide range of methods such as the methods

Phase 1: **Project preparation phase**

Phase 2: **Due-diligence analysis of the existing taxi system in Belgrade**

Phase 3: **Reengineering and designing the taxi system in Belgrade**

A detailed methodological procedure of planning and designing the taxi system in Belgrade is shown in Figure 1 below.

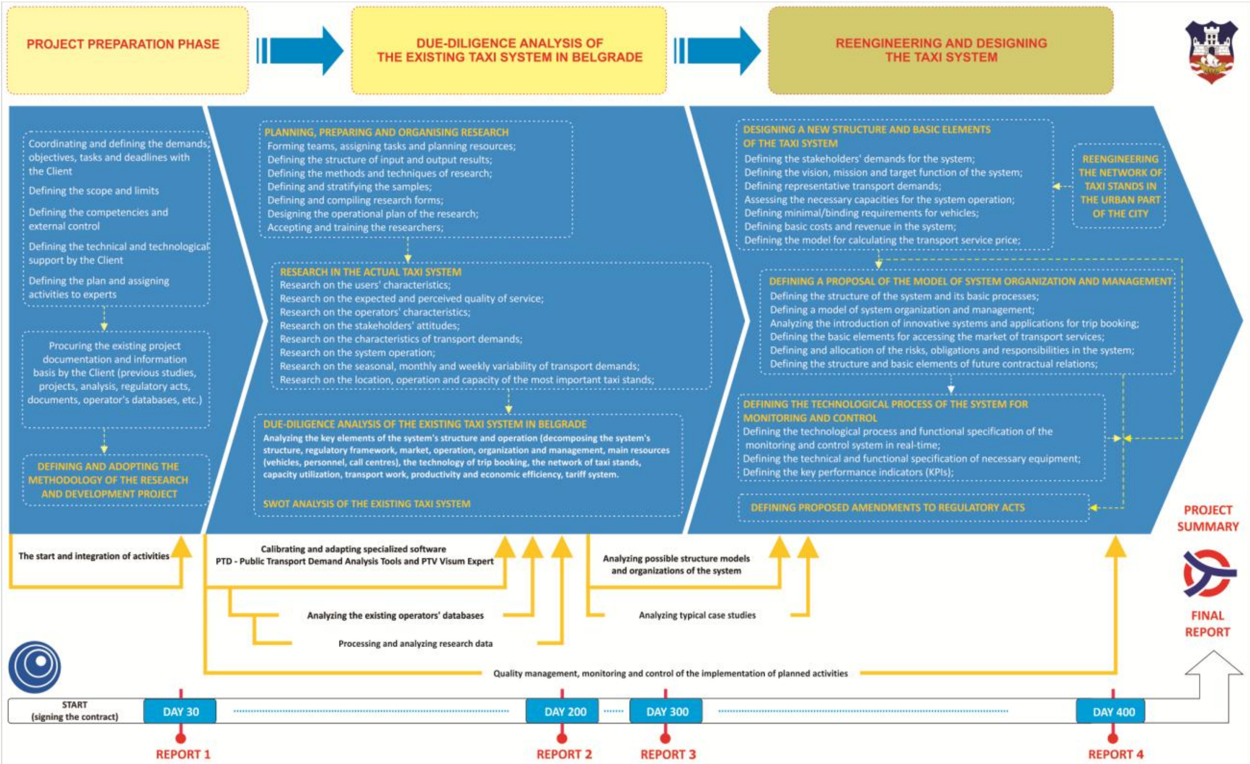

***Figure 1**. The methodological procedure of planning and designing the taxi system in Belgrade*

Book 2 – Due-diligence of the existing taxi system in Belgrade

According to the project terms of reference (ToR) defined by the Client, the subject of analysis and research in this part of the project is the taxi system in the urban area of the City of Belgrade (the area of the General plan), which is also the area covered by this project[2].

The main objective of this part of the project is to conduct an in-depth technical and technological analysis of the existing taxi system in Belgrade by also applying SWOT analysis.

Within this part of the project, a whole range of activities was carried out to conduct a thorough and systemic analysis of the existing taxi system from several different aspects which are grouped into several sections that represent inherently complex activities that are part of the planning and designing of the taxi system in Belgrade.

[2]The market of the taxi system transport services includes the territory of 10 municipalities of the City of Belgrade, covering the area of 1,030 km^2 (31.85% of the city's administrative area) and the population of 1,299,995 inhabitants (78.34% of the entire population of the City of Belgrade).

In the first phase, several independent types of research were conducted in the actual taxi system in Belgrade aimed to collect comprehensive information about the structure and functioning of the existing taxi system.

Planning, preparing and organizing research is a very important part of a systemic approach to planning which requires activities that include forming competent teams, assigning tasks, planning resources, defining the structure of input and output results, the choice of methods and research technology, defining and stratifying samples, designing research forms, making operational plans of research, training the researchers, as well as other activities necessary for quality preparation of research in the actual taxi system in Belgrade.

The key aspect of the research refers to the quantification and analysis of transport needs and demands, and analysis of user characteristics and trips in the taxi system in Belgrade, which meant conducting the following types of research:

- Research and analysis of user characteristics in the taxi system. This type of research was conducted through a users' survey on a representative sample (Survey form AK-1). A total sample of 2,068 users was collected.
- Research and analysis of the expected and perceived quality of service in the taxi system. A total sample of 2,068 users was collected.
- Research and analysis of the operators' characteristics in the taxi system. This type of research was done using the interview method – by surveying the drivers on a representative sample of 415 taxi drivers in the system (Survey form AK-2).
- Research on attitudes and opinions of experts (representatives of local authorities and existing operators) on certain aspects concerning the system's improvement in the future. This type of research was done through a survey of experts on a representative sample of 15 experts (Survey form AK-3).
- Research and analysis of locations, operation and capacity of the most important taxi stands in the urban area of the City of Belgrade. This type of research was done using the method of recording geographical locations of the existing stands, research on their operation during specific periods of the day (Survey forms SO-3 and SO-4). A total of 154 stands were recorded.

Figure 2 shows numbers, data and facts related to the research process in the existing taxi system in Belgrade.

While conducting the above-mentioned research 37 researchers and 10 members of the operational team were hired. They invested a total of 2,500 working hours. Apart from the above number of researchers, the planning process of the research included seven experts from the field of passenger transport, as well as five members of the team in the research preparation phase. A total of about 4,000 working hours was invested in these activities.

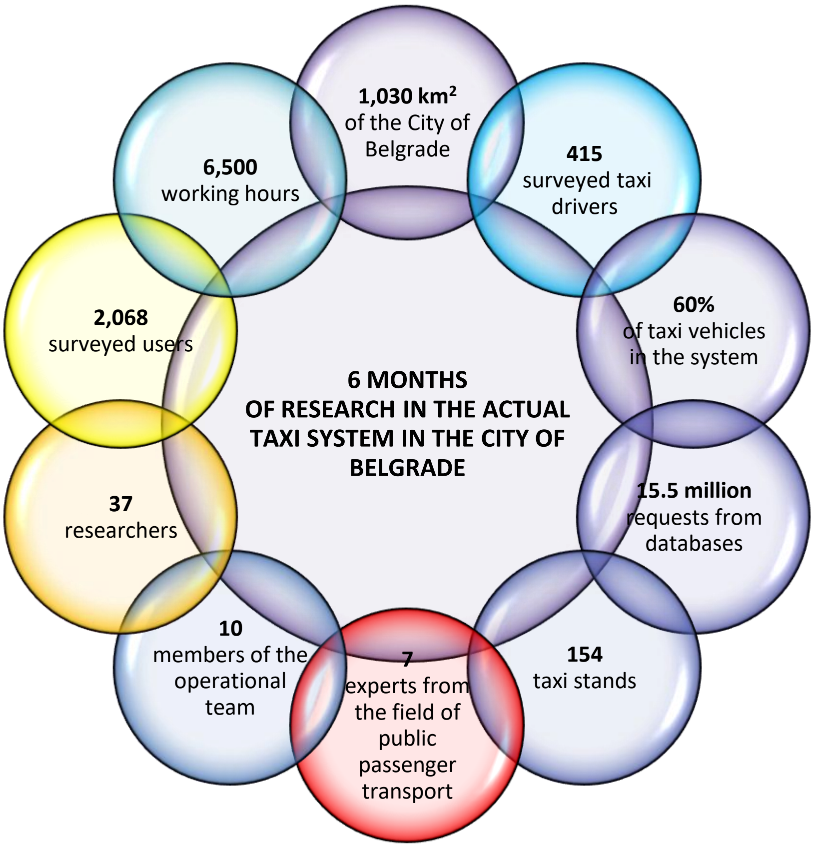

Figure 2. *Research in the actual taxi system – numbers, data and facts*

Apart from the above-mentioned research in the actual taxi system in Belgrade, research that included the analysis of the available databases of the existing operators in the taxi transport market in Belgrade was also conducted (it included a representative sample of the operators that account for over 60% of active taxi vehicles in the system):

- Research and analysis of the characteristics of transport demands. This type of research was carried out using the methods of transport engineering and in-depth analysis of the transport demand characteristics and the taxi system operation based on the databases of the existing operators.
- Research and analysis of the taxi system operation (during 24 hours)
- Research of seasonal, monthly and weekly variations of transport demands. This type of research was carried out by using the methods of statistical analysis of times of registered trip requests from the databases of existing operators.

The results of the above-mentioned research represent the highest priority in the process of the systemic and target-oriented procedure of planning and designing the taxi system in Belgrade. These results are directly incorporated in the process of the system design.

Legal and regulatory framework of the taxi system operation

This chapter gives an overview of all laws and bylaws that define the conditions for market access and a way in which the taxi system in Belgrade operates.

The environment in which the taxi system in Belgrade operates

The chapter entitled The environment in which the taxi system in Belgrade operates provides an analysis of the traffic and transport system of the City of Belgrade and an analysis of the transport services market.

The taxi system organization and management in Belgrade

Having in mind the great complexity of the structure of the existing system of public passenger transport in Belgrade, in this phase of the project, an analysis of organization and management at the macro level of the public passenger transport system as a whole, and the micro level of the organizational and management structure of the Secretariat for public transport departments that are directly in charge of the taxi system were carried out.

An analysis of existing operators according to the type of organization (entrepreneurs, companies, associations) and an analysis of the access to the taxi system market in Belgrade were carried out, bearing in mind that at the operational level, that is, the level at which the production technology of transport service is defined and targeted function ensured, all work is mainly done by taxi operators under their own internal organizational and management model.

The taxi system operation in Belgrade

The taxi system in Belgrade is analyzed from the aspect of time and a manner in which it operates. The taxi system in Belgrade operates non-stop, i.e. 24 hours seven days a week (24/7). Taxi drivers have flexible shifts (the start and end time of the shift is not defined).

It has been shown that taxi vehicles with or without passengers follow certain rules, which are defined by the technology of the public passenger transport, on the one hand, and on the other hand, the technology of the taxi system (the technology of service booking, the technology of driving and fare collection according to the transport work done, etc.).

Resources in the taxi system in Belgrade

Resources in the taxi system in Belgrade are analyzed from two perspectives: the characteristics of the vehicle fleet and human resources in the system (drivers).

Concerning the vehicle fleet characteristics, the age and model of vehicles were analyzed, the type of propulsion energy, maintenance technology, unavailability of vehicles due to repairs and regular servicing of vehicles, and the share of repair costs and maintenance in the total of costs of vehicle operation.

The following features of the taxi drivers in the system were analyzed: age, the type of activity, number of years spent working in the taxi system, average daily working hours, work done per shift during the day and the number of days of absence.

A degree of digitalization of the system of booking and requesting trips

There are several ways for taxi drivers to accept requests in the taxi system in Belgrade: being hailed by a user in the street, accepting a request at a taxi stand or accepting a request and booked trips made through call centres and/or applications. This chapter analyzes the level of technical and technological development of the existing systems for requesting and booking trips.

Operational management of the majority of taxi associations/companies in Belgrade is based on the principle of the joint use of a modern application which enables quality and fast communication between the dispatch centre and the driver in the process of assigning a trip.

The integrated system for booking and requesting a trip at the level of association/company, apart from the basic function of receiving transport demands, enables vehicle monitoring and management to increase the system's efficiency and effectiveness, reliability and stability, informing the passengers better, efficiently measuring the system's performances, the operators' benchmarking, etc. However, the potentials of the second function in the existing systems are largely poorly used or not used at all.

Following the existing hierarchical model of the system for booking trips, monitoring and control, an overview of the software part of the system is given through applications for the operators' dispatch centres, applications for taxi drivers, applications for users, and monitoring and management of providing taxi services at locations of special interest.

The analysis of taxi stands in the taxi system in Belgrade

This chapter gives the main characteristics of the operation of taxi stands in space as well as specifics spotted while researching the actual taxi system. Book 3 of this research and development project (Elements of the taxi system's infrastructure – taxi stands) reveals in-depth characteristics of the stands in addition to the results of the research on the characteristics of operation and gives an overview of the traffic and technological design of taxi stands.

Performance and efficiency of the taxi system

The analysis of the system performance results and exploitation of taxi vehicles in the taxi system in Belgrade was based on the data from the official databases of the existing operators (including over 60% of active taxi vehicles in the system). The databases contained the total number of 15,443,914 demands accepted in the period from January 1st, 2019 to December 31st, 2019. The detailed analysis used 9,279,372 demands with complete characteristics and thorough data, which represents an exceptionally representative and stratified sample of the taxi system operation in Belgrade.

These were the outputs of the data procession and analysis: decomposition of the total time spent for fulfilling transport demands, distribution of the number of trips according to the trip duration, distribution of the number of trips according to the time spent for realizing trips (from making the request to trip end), distribution of the daily trip number per vehicle, distribution of trip length, distribution of the methods of requesting a ride, distribution of demands per hours in a day, distribution of the “unrealized“ demands, distribution of working hours and variation of the distribution of transport demands per days in a week and months in a year.

Tariff system and service price in the taxi system in Belgrade

This chapter includes the analysis of the applied tariff system in the taxi system in Belgrade. The current pricelist envisages several tariffs which differ depending on the time of service provision (day, night, holiday, etc.) but also depending on the distances of passenger trip (outside the marked points of the urban area). Besides, the chapter analyzes the price of the taxi service for the location of particular interest – Airport "Nikola Tesla".

Estimated costs of the taxi system operation in Belgrade

This chapter describes the basic cost structure of the taxi system in Belgrade. Apart from the detailed description of costs, the chapter provides its estimated values at this point. The description of cost structure and their estimation was conducted at the level of one taxi entrepreneur, i.e. one vehicle and one driver, for one year.

SWOT analysis of the current state of the taxi system in Belgrade

SWOT analysis is based on determining Strengths and Weaknesses, Opportunities and Threats in the existing taxi system in Belgrade taking into account the sensitivity and risks that the application of this system might have regarding the environment. The primary aim of SWOT analysis is to obtain a clear and objective image of the taxi system's state and create a reliable input for conducting activities directed at reengineering of the existing and designing the future state of the taxi system in Belgrade.

Analysis of characteristic experiences related to the taxi system operation in the selected cities

This analysis represents an analytic method for studying specific real situations in similar systems of taxi passenger transport. This activity aims to analyze the challenges, events and solutions to threats and problems the cities, competent institutions and operators were facing in the phase of planning and designing the taxi system in their local environments.

BOOK 3 – The elements of the taxi system's infrastructure – taxi stands

The third book of this research and development project presents detailed characteristics of 31 taxi stands, out of the total of 154 stands in the Belgrade taxi system included in the research of the actual system. The following characteristics are given: volume, circulation, average time spent by a taxi vehicle at the stand in the period from 6 a.m. to 10 p.m. Accumulation of taxi vehicles at equal time sections was provided for other stands which were spatially identified.

Traffic and technical drawings of taxi stands were given for the stands under the authority of the Secretariat for Public Transport which were spatially identified based on the existing traffic signalization.

The results provided in this part of the research project represent a reliable information basis regarding the key elements of the system's infrastructure and the foundation for the creation of future planning documents. The data on taxi stands were inserted into the VISUM software.

BOOK 4 - Reengineering of the existing taxi system in Belgrade

This part of the project represents a set of activities directed at the reengineering the existing state and designing the future state of the taxi system in Belgrade. It also includes the activities related to providing conditions for the continuous process of future development and positioning of the complete taxi system in terms of its sustainability, having in mind the real needs of users and possibilities of the

City of Belgrade, i.e. creating a sustainable taxi system tailored for Belgrade and its users. There are several complex processes included in this part of the project and these are divided into four chapters:

- Structure and basic elements of the taxi system operation in Belgrade
- Organization and management model of the taxi system in Belgrade
- System for monitoring and control of the taxi system operation in Belgrade
- Proposed amendments to the regulatory acts for the implementation of the new system.

Structure and basic elements of the taxi system operation in Belgrade

The basic aims for designing the new structure and main elements of the future operation of the taxi system were defined in accordance with the established objectives of the reengineering of the existing state of the taxi system, expert and scientific findings of the authors' team based on previous years-long experience gained in numerous similar projects, experience in organizing and managing large and complex transport systems, as well as the available information on the taxi system in Belgrade, the project ToR defined by the Client and demands of the key stakeholders in the system.

Creation of a sustainable taxi system tailored for the City of Belgrade represents one of the basic imperatives of the system's development. The initial phase of designing the system structure asks for the meticulous definition of the vision, mission, targets and target function of the taxi system.

The future vision of the taxi system is related to the vision of the complete passenger transport system in Belgrade and should contain strategic choices and values defining the purpose and existence of the taxi system. The taxi system mission should determine the reasons or purpose of the system's existence. In other words, the mission should express the present and future activity and business operation of the taxi system.

The target function of the taxi system in Belgrade should quantify and specify the postulates and attitudes defined by the system's vision and mission. Defining the target function represents a complex procedure of designing frequently conflicting demands of the stakeholder groups within the system and out of it which should be realized in the future to preserve the system's existence and permanent development. On the one hand, the target function of the taxi system is defined by the size and characteristics of the transport service market and demands of key stakeholders in the system, and on the other hand, by the characteristics of the complete system's structure, technology and organization (the input data obtained in the conducted complex and comprehensive research in the actual system).

The basic pre-requisite for reaching the target function of the taxi system in the city of Belgrade is a systematic change of elements relating to the structure, organization and management of the complete system. In the future, the target function could be fulfilled by conducting systematic activities primarily directed at the precisely defined method of market access, market allocation and consequently optimal use of the capacities. To calculate transport capacities, it is necessary to define representative transport demands in the taxi system. These demands represent the basic input value for calculating the required capacities, particularly the number of vehicles which can be reached from the null-project year (2020) throughout the following five-year planned period (2024) without abrupt changes and unpredictable circumstances in the system.

Apart from the representative transport demands, the sub-chapter Defining transport demands for the taxi system also defines the methodology for determining the optimal number of operating vehicles based on the queuing theory. The methodological procedure for calculating the required number of vehicles in the taxi system is represented in the picture below.

The representative transport demands are base values used for defining the input elements for determining the required number of operating vehicles in the transport system. In addition to the representative value of the intensity of the transport demand arrival rate for the taxi service per specific periods in a day, the representative values of service time were adopted, as well as the values of the intensity of the serviced user rate.

The following parameters were selected to be the basic parameters of the system quality related to the optimization of vehicle number in the taxi system in Belgrade:

- Probability of service (probability of access to the taxi system) expressed as the possibility for a user to have at least one vacant taxi vehicle at any time of the day (24/7 concept);
- Maximum user waiting time for a vacant vehicle, i.e. the user patience interval;
- Degree of vehicle usage in the system which must enable the taxi system sustainability, i.e. sustainable business operation while producing the demanded level and quality of transport service.

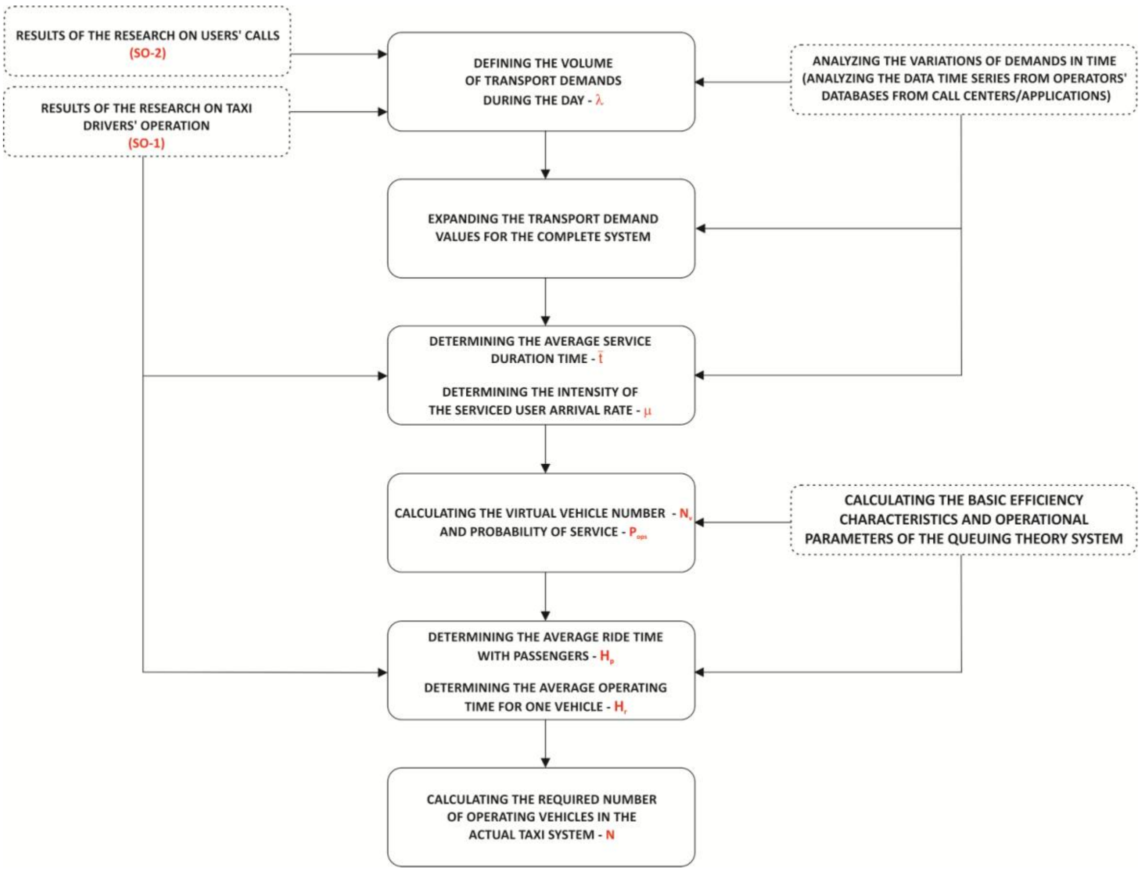

Figure 3. *Methodology for calculating the required number of vehicles in the taxi system* [3]

[3] Methodology represents the original scientific work and regulated by the Law on Copyright and Related Rights and shall be used only for the needs of the city of Belgrade

Based on previous findings on the taxi system operation and in-depth analysis of the characteristics of the taxi system in Belgrade, we applied the **mass service system with queuing, infinite number of places in a queue, limited user time spent in a queue and unlimited user time spent in service channels.**

Based on the actual data on the existing system's operation, the initial phases of the methodology for determining the required operating vehicle number include the calculation of basic input parameters for the selected queuing system, i.e. the mean service duration time - $\bar{t}$ [minutes] and the intensity of user (demand) arrival rate - λ [demands/minute]. All values are expanded for the complete system. The next step determines all other characteristics of the system's efficiency and parameters of the operation of the taxi system in Belgrade necessary for calculating the required number of vehicle:

- Absolute (A) and relative (Q) capacity of the system, i.e. the average number of demands serviced in a unit of time and the mean number of the serviced passengers out of the total number of passengers who demanded the service;
- The intensity of the arrival rate of serviced customers (μ);
- User patience interval (t_s);
- The intensity of the arrival rate of "impatient" customers (ϒ);
- Probability of the access to the system – probability of service (P_{ops});
- Cancellation probability – the user was not serviced (P_{otk});
- The average number of occupied taxi vehicles – usage probability (n_{zk});
- Probability for an arbitrary vehicle to be occupied (P_{zk});
- Probability for the complete system to be occupied (P_{pz});
- Reduced intensity of demands or the average number of demands entering the system for the mean duration time of service (ρ);
- The average value of time which starts with the passenger entering the taxi vehicle and ending with the user leaving the vehicle, or leaving the vehicle vacant (t_{zk});
- The average number of queuing customers (k_r);
- The average time a customer spends in a queue (t_r);
- The average time between serviced customers (t_{ops}).

Based on the stated input parameters, we calculated the so-called number of "virtual" vehicles for the given arrival rate intensity and average time of service duration in the actual system (N_v) which equals the average number of demands entering the system for the average time of service duration. The probability of service P_{ops} and the probability of taxi vehicle usage P_{zk} are calculated for the obtained "virtual" number of vehicles. Thus determined probability of taxi vehicle usage P_{zk} is as a rule larger than actually possible values because of the characteristics of the taxi system operation technology.

Having in mind the above mentioned, the last step determines the specific values of the operational parameters – the average operating time for one vehicle (H_r) and the average time of driving with passengers (H_p) as the characteristics of the observed system in Belgrade. Thus, the efficiency of the actual system's operation is quantitatively determined under the same conditions regarding the intensity of the demand arrival rate and mean service time. The difference between the efficiency of the actual and virtual systems is expressed through a larger number of required operating vehicles.

Finally, the last step of the methodological procedure for calculating the required vehicle number in the taxi system determines the required number of operating vehicles for the duration of one shift (N), as a function of: the virtual vehicle number – N_v, the probability of service – P_{ops}, the average operating time for one vehicle - H_r, the average time of driving with passengers in the actual system - H_p, the coefficient of utilization of the vehicle fleet - α.

The complete procedure is repeated for each of the characteristic periods in a day. It should be underlined that when calculating the required number of vehicles, the transport demands in the observed periods of the system's operation which make up a working day should fulfil the conditions of stationarity. In other words, each of the observed periods of stationarity (k) has the unique (representative) value of the intensity of the demand arrival rate λ_κ, which is separately defined.

The output of the methodological procedure of the required number of operating vehicles in the taxi system is the total number of vehicles in the taxi system (N) which equals the sum of the required number of operating vehicles for each of the characteristic stationary periods in a day.

Also, the model sensitivity was analyzed. In other words, the project presented several scenarios depending on the desired probability of service, and consequently the required number of operating vehicles in the taxi system in Belgrade (the following table and figure).

Table 1. *Change of the required vehicle number in the taxi system depending on the probability of service*

No.	Probability of service - P_{ops} (-)	Vehicle number –N (vehicles)
1	P=0.85	6,617
2	P=0.87	6,773
3	P=0.90	7,006
4	P=0.93	7,240
5	P=0.95	7,396
6	P=0.98	7,640

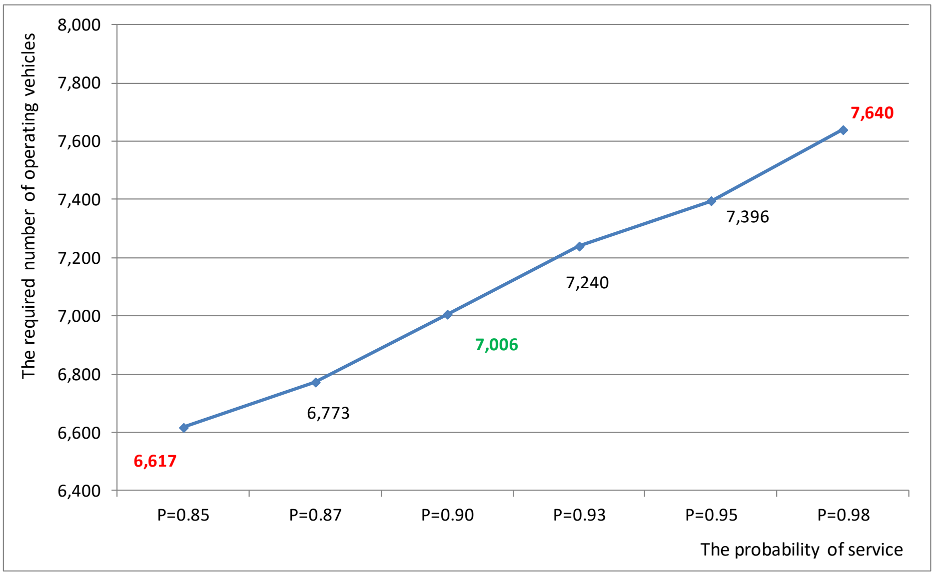

Figure 4. *Change of the required number of operating vehicle depending on the probability of service*

Based on the elasticity analysis of the change of the required number of operating vehicles, and depending on the change of the level of the probability of service, the selection of the optimal probability of service and the appropriate total number of operating vehicles in Belgrade's taxi system was recommended: Pops=0.90 and N=7,006 vehicles. It should be mentioned that the suggested number of operating vehicles involves the number of vehicles operating 8 hours in a day, i.e. the vehicles operated by one driver (according to the principle – one vehicle, one driver).

The chapter named Calculation of the basic costs and revenues involves the definition of the minimum standards for the basic elements of the system's structure (primarily taxi vehicles) and standardization of the basic costs in the system (costs of the vehicle and driver operation, other costs, unit costs and system's revenue, etc.).

To conduct a high-quality standardization of basic costs and income, this part of the project first presents the estimated operational costs divided into fixed and variable costs. Then, the chapter presents the adopted indicators which reflect the intensity of vehicle exploitation. Based on the unit costs and indicators of exploitation, the calculation of the total costs and income in the taxi system in Belgrade was done.

Fixed costs are not dependent on vehicle exploitation and have a constant value in the observed period. The fixed costs include the vehicle depreciation lifespan, MOT test tax, communal and administrative taxes, road tax, mandatory insurance, Casco insurance, meal allowances, revenue and contributions (self-employment flat-rate tax, health care, retirement and disability insurance, etc.), charge for using radio broadcasting services, applications, association membership, etc.

Variable costs depend on the intensity of vehicle exploitation. The analysis includes the costs which are parts of total costs, such as the costs of driving energy, maintenance, tyres and other variable costs (washing of vehicles and alike).[4]

The calculation of unit and total costs included the consideration of the average daily number of trips of one vehicle in the taxi system in Belgrade (6, 8, 10, 11, 12, 14, 16, 18 and 20), different purchase values of vehicles (EUR 4,000, EUR 8,000, EUR 12,000, EUR 16,000 and EUR 20,000) and the structure of utilization of different types of propulsion energy under the existing state of the taxi vehicle fleet in the city of Belgrade (data obtained by analyzing the databases of the Client of the project).

The identification and quantification of the indicators of the system's operation in the observed period were conducted for cost calculation. The methodological procedure envisages the selection of the following indicators as the indicators of the system's operation:

- Total number of days – inventory days;
- Total number of holiday or sick leave days;
- Total number of days when the vehicles have technical failures;
- Available number of days;
- The average number of Saturdays;
- The average number of Sundays;
- Number of non-business Saturdays and Sundays;

[4] The mentioned costs are estimated to account for 90% of the total operational costs.

- Non-business days in the period Monday-Friday;
- Total number of business days;
- Duration of a shift expressed in hours;
- The average duration of trips with passengers;
- The average waiting time during trips with passengers (minutes).

On the other hand, the selected indicators of the exploitation intensity used for calculating costs and income (values of the trip number and parameters of the travelled distance) are: number of trips per day - Nv_d, the annual number of trips - Nv_{god}, the total number of realized kilometres with passengers - Kp_d, the total number of realized kilometres during a day - K_{md}, total annual number of realized kilometres with passengers - Kp_{god} and the annual mileage (the number of realized kilometres - Km_{god}).

The following table provides the results of calculating the estimated costs and income for an average vehicle for different usage intensities and vehicle purchase prices for the existing tariff system.

Table 2. *Estimated costs and income in the taxi system in Belgrade for the existing service cost (RSD)*

Number of trips per day Nv_d	Total annual travelled distance Km_{god}	Total annual income per vehicle (RSD)	Total annual costs (RSD) – Vehicle EUR 4,000	Total annual costs (RSD) – Vehicle EUR 8,000	Total annual costs (RSD) – Vehicle EUR 12,000	Total annual costs (RSD) – Vehicle EUR 16,000	Total annual costs (RSD) – Vehicle EUR 20,000
6	21,400	**1,149,002.10**	1,762,831.33	1,865,254.85	1,948,798.36	2,013,461.88	2,059,245.40
8	28,533	**1,532,002.80**	1,877,241.77	1,996,499.79	2,096,877.82	2,178,375.84	2,240,993.87
10	35,666	**1,915,003.50**	1,991,652.21	2,127,744.74	2,244,957.27	2,343,289.80	2,422,742.33
11	39,233	**2,106,503.85**	2,048,857.43	2,193,367.22	2,318,997.00	2,425,746.78	2,513,616.57
12	42,800	**2,298,004.20**	2,106,062.65	2,258,989.69	2,393,036.73	2,508,203.76	2,604,490.80
14	49,933	**2,681,004.90**	2,195,221.34	2,339,731.12	2,465,360.90	2,572,110.69	2,659,980.47
16	57,066	**3,064,005.60**	2,292,797.27	2,437,307.06	2,562,936.84	2,669,686.62	2,757,556.41
18	64,199	**3,447,006.30**	2,390,373.21	2,534,882.99	2,660,512.78	2,767,262.56	2,855,132.34
20	71,333	**3,830,007.00**	2,487,949.14	2,651,338.93	2,814,728.71	2,978,118.50	3,141,508.28

The presented data indicate that according to the current taxi fares, the vehicle with the purchase value of EUR 4,000, with the usage intensity of 11 trips a day, which represents one trip above the average, and the annual travelled kilometres of 39,233 km (which corresponds to the average value in the system), makes the profit of 57,646.42 RSD/year.

If the eight-hour workday was adopted and applied, operating vehicles would realize the average number of 12 trips in a day, which is sufficient for making the profit for the first two vehicle categories according to the presented calculation of total costs and income. The above-described analysis leads to the conclusion that a significant number of taxi vehicles in the system are not active for eight hours but that their working hours are mostly shorter.

All vehicles included in the calculation (with the purchase value from EUR 4,000 to EUR 20,000) would make a specific profit if they managed to realize 14 or more trips in a day at an annual level (currently this is done by 23.14% of vehicles).

After the definition of indicators, the calculation of the minimum and maximum price of the transport service was conducted. The calculation of the transport service price was carried out using the model which correlates the ratio of the system's costs and income and the average number of realized trips in the system.

The analysis showed that there are three characteristics values of the average number of trips per day for calculating the estimated annual income and costs:

- 10 trips/day – the average number of trips in the system which does not ensure the cost efficiency at the current point of time and, which is mainly caused by a considerable number of drivers whose average working hours are shorter than 8 hours per day (approximately 30%);
- 12 trips/day – the average number of trips in the system which ensures the cost efficiency for the first two categories of vehicles (according to the purchase price) at the current point of time. This number of trips was obtained by an additional analysis of the average number of trips realized by operating vehicles in one hour (1.5) and the adopted eight-hour workday.
- 14 trips/day – the average number of trips in the system which ensures the complete cost efficiency for all vehicle categories (according to the purchase price) at the current point of time.

The following table shows the values of the unit fares per kilometre for different tariff categories (the starting price was kept as fixed and was not included in the calculation).

Table 3. *Maximum and minimum fares according to the average number of trips per vehicle*

Average daily number of trips per vehicle	Minimum price		Maximum price	
	Tariff 1	Tariff 2	Tariff 1	Tariff 2
10	70	90	95	115
12	56	76	80	100
14	46	66	65	85

In the chapter Reengineering of the existing network of taxi stands, the possibility of expanding the capacity at the existing stands is assessed on a detailed analysis and conducted research. Moreover, this chapter provides the analysis of the need for introducing new taxi stands and calculation of the required capacities of new taxi stands in the urban area of Belgrade.

The analysis of operational characteristics of the existing 154 taxi stands determined that it was possible to expand the existing capacities at 5 taxi stands. The potential number of additional places was provided. Besides, preliminary designs for the stated locations are done. The total costs of expanding the capacities at the existing stands amounted to RSD 88,850.00.

A detailed list of characteristics of the suggested locations was provided along with the description of the existing location state for 16 potential taxi stand locations. For all suggested locations, the data needed for suitability assessment were recorded, the number of places for taxi vehicles was calculated, and the possibility of using the suggested location for a taxi stand was evaluated.

Fifteen suggested locations which were determined to fulfil the conditions for designing new taxi stands. For these locations, we provide a preliminary calculation of construction and investment costs for the implementation, containing the description of works and necessary equipment. The estimated price of constructing and marking the 15 stand locations (with a total of 69 places) amounts to RSD 1,342,458.00 excluding VAT. Finally, the distribution of investment costs for constructing new stands and their future maintenance was proposed. This part of the project includes the preliminary designs for new taxi stands.

Organization and management model of the taxi system in Belgrade

Organization and management model of the taxi system in Belgrade depends on the target function of the system (which directly affects the selection of the system organization model) on the one hand, and on the other hand on specific conditions in the system itself and the environment, such as transport policy of the city, level of technical and technological development, existing structure and organization of the system, desired level of changes, demands of key actors, etc.

The process of designing the organization and management structure was based on the systemic analysis and reengineering of the existing structure and organization of the taxi system, general systems theory and postulates of transport engineering. The design process is characterized by stochasticity, dynamism, structural changes, adaptivity and multidisciplinarity.

The first phase included the structural decomposition and analysis of the existing taxi system, the definition of specific groups of tasks and activities to be realized in the system, definition of appropriate organizational segments at all management levels (S-T-O) with the aim of the optimal realization of the system's target function, analysis of the applied and verified models which were elaborated and implemented based on the conducted empirical research on the configuration and structure of several systems (the case studies of positive practice examples), etc.

Special attention was paid to the fact that the future model of organization and management structure has to include elements representing objectives and the target function of the taxi system in Belgrade, consistent and complete action plan for realization of the system's objectives, responsibilities for each activity, distribution of authorities, rights, obligations and risks, method of connecting and coordinating the activities and actors, minimum changes in the existing system, etc.

The main output of this step is adequate organization and management structure of the taxi system, defined competencies and relationship between the key actors in the system (the owner of the transport service market, operators and other actors in the system), defined competencies per management level (S-T-O), and definition and allocation of risks, obligations and responsibilities. All this was performed following the stated principles and bearing in mind the possibility of the real implementation in Belgrade's system without abrupt and unpredictable circumstances.

Bearing in mind the great complexity of the existing taxi system structure in Belgrade and ToR defined by the Client, for the needs of this research and development project we conducted a detailed design of the organization and management structure of the part of the Secretariat for Public Transport which has the direct authority over the taxi system, i.e. the organization and management structure and competencies of the Sector for Taxi Transport, focusing on the new organizational unit – the Monitoring and Control

Department. The following figure shows the proposal of the future organizational model of the Sector for Taxi Transport with the allocation of activities and competencies.

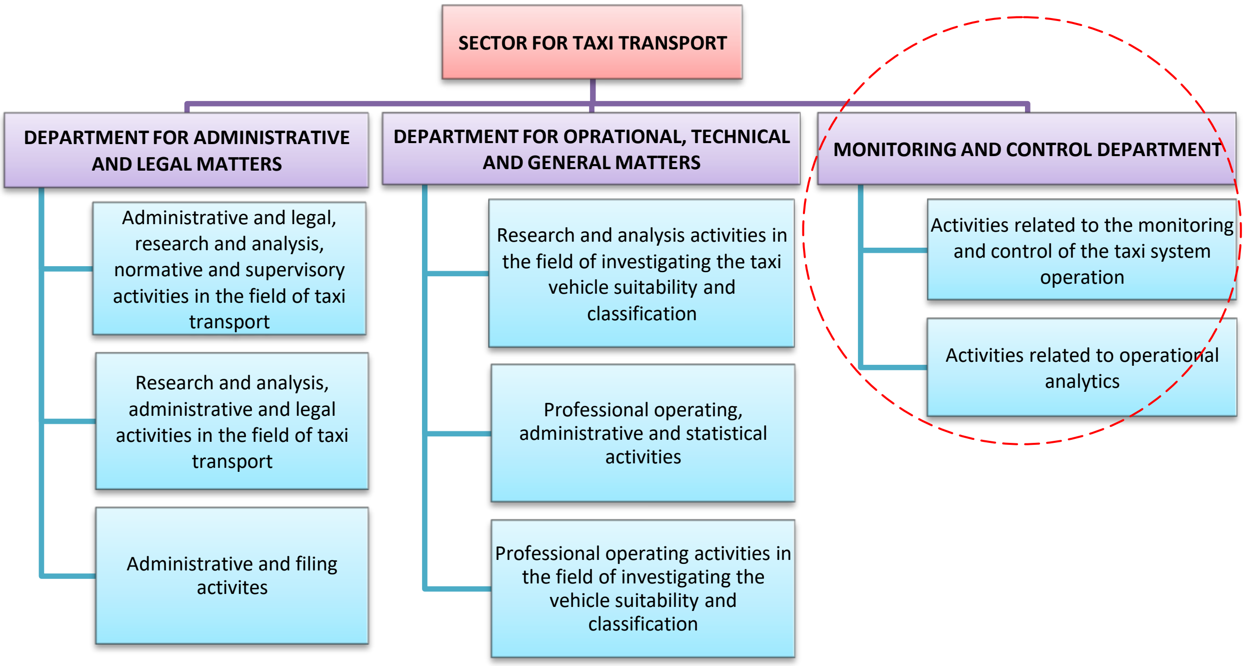

***Figure 5**. Proposal for the new organizational model of the Sector for Taxi Transport*

The proposed organizational requires the reengineering of activities and competencies per all management level. The following figure provides a schematic presentation of the structure and key activities per management levels in the taxi system in Belgrade.

The consistent application of the proposed organizational and management process would eliminate the main shortcomings of the existing model and provide conditions for fulfilling the basic postulates in organizationally complex technological systems stating that the basic sub-processes were owned by experts. This would ensure a higher level of specialization, a high degree of adaptation to technological changes, greater flexibility and adaptability to technical and technological changes, etc.

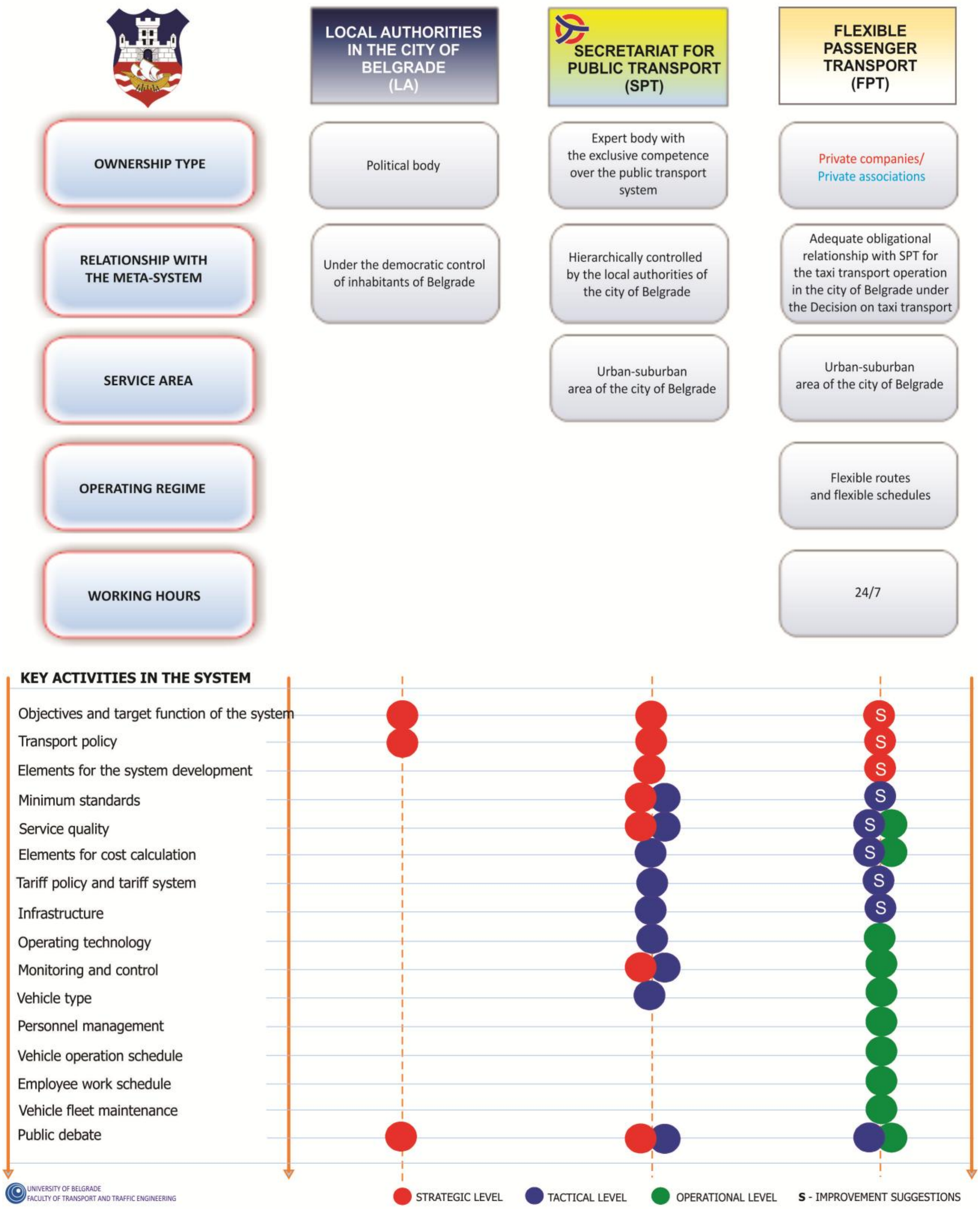

Figure 6. Structure and management levels in the taxi system in Belgrade (BIRD MODEL: AN-BG.tx)

Since the city of Belgrade is the owner of the complete transport service market, including taxi services, the requirements for performing taxi activities on Belgrade's market are established by the city authority competent for the public passenger transport operation (the Secretariat for Public Transport) for all interested operators whose main activity is the taxi passenger transport and who are registered for performing this activity under the Law governing the registration of economic subjects and industry of taxi passenger transport.

Therefore, the chapter named Basic elements for accessing the taxi service market in Belgrade defines the main principles defining access to the transport service market, based on:

- Clear and simple procedure;
- Equity for all interested parties;
- Providing conditions for the selection of the best operators for the taxi transport operation;
- Creating conditions for the development of a balanced system;
- Improving the cost-effectiveness and economic efficiency of the system, i.e. creating conditions for the system's sustainability;
- Introducing the competition for the service market access while eliminating unloyal competition in the system, to provide equal conditions for all operators;
- Minimizing negative impacts on the environment by encouraging the use of environmentally-friendly vehicles.

This section of the project defines the requirements to be fulfilled by an entrepreneur or a company (in terms of drivers, vehicles, seats and business reputation) and the method of proving the stated requirements. It also offers the Methodology for updating the active status of the granted permissions for the taxi transport operation following the changes in transport demands. This activity is significant because of its direct impact on the sustainability and efficiency of the taxi system. The continuous monitoring and stability in terms of using key resources (vehicle number, drivers, etc.) would finally result in the improvement of the total quality level of the taxi system in Belgrade.

The methodology envisages periodical checking whether the requirements are fulfilled in terms of meeting the prescribed conditions for performing the activity and minimum required operation, based on which the permission for performing taxi transport remains active or is denied.

The realization of minimum requirements is expressed using the following defined coefficients:

Coefficient of realization of the minimum working hours at an annual level (K_{Hr}) is defined for each vehicle-driver as the ratio of the realized working hours and the minimum number of working hours at an annual level, or:

$$K_{Hr} = \frac{Hr_g}{Hr_{ming}} \quad (1)$$

Coefficient of realization of the minimum number of realized trips at an annual level (K_{TZo}) is defined for each vehicle-driver as the ratio of the number of realized trips and the minimum number of realized trips at an annual level, or:

$$K_{TZo} = \frac{TZo_g}{TZo_{ming}} \quad (2)$$

The taxi system in the City of Belgrade has specific working conditions, primarily due to the traffic situation in the transport network and stochastic transport demands. Therefore, it is suggested to introduce the coefficient of the fulfilment of the requirements for maintaining the active permission which will include both mentioned coefficients.

Coefficient of the fulfilment of the minimum requirements for maintaining the active permission for the taxi transport operation (K_{IU}) is calculated as the arithmetic mean of the two previously defined coefficients:

$$K_{IU} = \frac{K_{Hr}+K_{TZo}}{2} \qquad (3)$$

The calculation of the coefficient is conducted once a year. To keep the permission active, the following requirements must be met:

- $K_{IU} \geq 1$;
- $K_{Hr} \geq 0,5$;
- $K_{TZo} \geq 0,5$.

The pre-requisite for monitoring and correction of the number of granted permissions is the existence of an integrated monitoring and control system at the level of the taxi system in Belgrade.

An important segment of every system, formalized in contractual relationships or in any other way, is the prediction and accurate definition of situations which might occur due to various risks, and measures for overcoming or mitigating their effects.

Having in mind the specific conditions in the taxi system in Belgrade, the chapter Risk allocation in the taxi system in Belgrade shows the risks in the taxi system and their allocation on the actors, risk impact assessment, risk occurrence probability, factors affecting the risk and measures for preventing or minimizing the risk:

1. Inadequately regulated obligational relationships
2. Inadequate monitoring and control of the system
3. Planning risk
4. Inadequate procedure for granting permissions
5. Management risk
6. Revenue risk
7. Risk of operational costs
8. Unloyal and illegal competition risk
9. Risk of service cancellation – Temporary disruption of performing the taxi transport activity at the request of the operator
10. Risk of service cancellation – Disruption of service provision by the operator without the request for the temporary disruption of performing the transport activity
11. Environmental risk
12. Political and regulatory risk
13. State of emergency or force majeure risk.

The final activity in this project section refers to defining the elements of future obligational relationships between the key actors in the system. One of the basic aims for defining clear and comprehensive contracts/agreements in the taxi system is the distribution of competencies and responsibilities between the parties (local authorities and operators). The contract type in the system between the market owner and operators primarily depends on the system's structure, laws and bylaws, allocation of defined risks among the contractual parties, as well as on the method of regulating the activities related to additional initiatives which might help realize the target function of the system.

Having in mind the specific characteristics of the transport service market in the taxi system in Belgrade, the process of defining the elements of future obligational relationships between the key actors in the taxi system in Belgrade should include previously defined conditions for market access, specific rights/obligations of the right grantor and beneficiary, primarily in terms of the system organization and management, tariff policy, costs and revenue, monitoring and control of the fulfilment of contractual obligations, contract duration, penal policy, etc.

The process of defining the elements of future contractual relationships between the key actors in the taxi system in Belgrade explicitly includes the results of the conducted research on the attitudes of local authorities and existing operators in the system.

System for monitoring and control of the taxi system operation in Belgrade

Monitoring and control represent the mandatory final phase of every management process, with the basic aim of ensuring the efficient application of all designed processes in the system. This process practically supervises, analyzes and evaluates whether the process of the complete taxi system operation is conducted according to the planned and designed elements, i.e. whether the outputs of the process comply with the established target function of the system.

One of the pre-conditions for the high-quality and efficient operation of the taxi system in Belgrade is the implementation of a modern system for monitoring and control of the operation. The integrated monitoring and control system should enable the unification of monitoring and managing the vehicles in the complete system to improve the efficiency and effectiveness of the system's operation, reliability and stability, better passenger information system, efficient measurement of the system's performance, the operators' benchmarking, etc.

This is a mandatory and extremely significant step in the management of the taxi system in Belgrade since continuous changes happen both within and outside the system and require permanent supervision, deviation measurement, adaptation and correction.

Since the taxi system represents a complex system, its monitoring and control is a very important process. Therefore, it was proposed for the monitoring and control process of the operation of the taxi system in Belgrade to be based on two principles:

A. **Monitoring of the system's operation in real-time.** The aim of applying this technology is the improvement of reliability and stability of the system's operation in space and time using modern IT technologies, increase of efficiency and effectiveness, informing the passengers better, efficient measurement of the system's performance, the operators' benchmarking, etc.

The future monitoring and control system for the taxi system operation in real-time should be designed, developed and implemented along with the accompanying software. The databases and reports should enable the experts of the Secretariat for Public Transport to design and manage the most important sub-processes in the taxi transport in Belgrade. Operators should use this system as a tool for efficient management of the transport process in their micro-environment, to produce and provide high-quality taxi service.

Б. Diagnostic testing of the system's outputs. This process is related to carrying out the activities directed at comparing and measuring the deviations from the planned (expected) KPI_{tx} values, as well as taking up the activities for checking the need for introducing changes into the system to bring the system into the designed state.

When conducting the diagnostic testing process, two analysis vectors are considered: on the one hand, evaluation of the service quality by users and, on the other hand, evaluation of the system and service quality by the Secretariat for Public Transport and taxi operators. Thus defined monitoring and control method helps the decision-makers to timely notice and recognize possible deviations, take up activities and select possible alternatives to change undesired circumstances. The following figure shows the methodology of the diagnostic testing of the need for introducing changes into the taxi system in Belgrade.

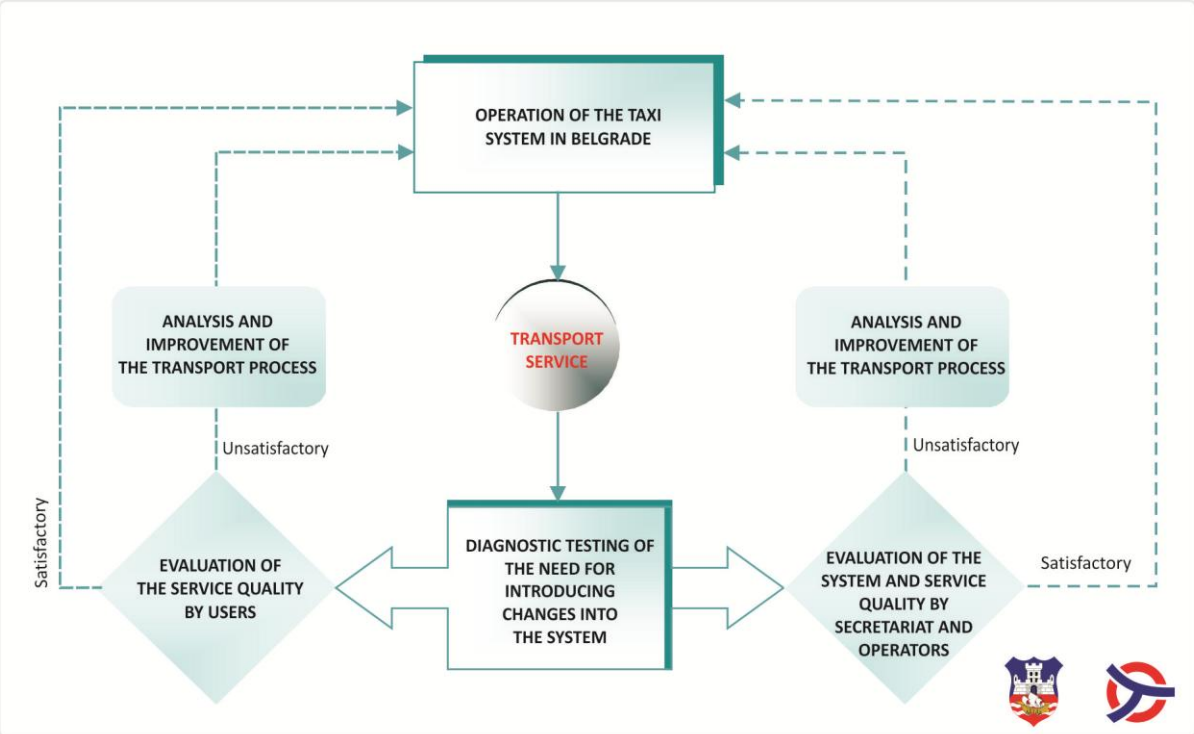

Figure 7. *Monitoring and control methodology based on the diagnostic testing principle*

This chapter also contains a detailed description of the monitoring and control system in real-time. The basic shortcoming of the existing hierarchical model is lack of adequate management at the highest hierarchical level (tactical and strategic level) which should unify the data for the complete taxi system and thus enable high-quality and efficient management of transport demands, as well as the monitoring and control of the complete transport process.

To eliminate the shortcomings of the existing model, the activities at the highest management level should be integrated into the Secretariat for Public Transport – Sector for Taxi Transport. The following figure shows the proposal of the hierarchical management levels in the new Monitoring and control system of the taxi system operation in Belgrade

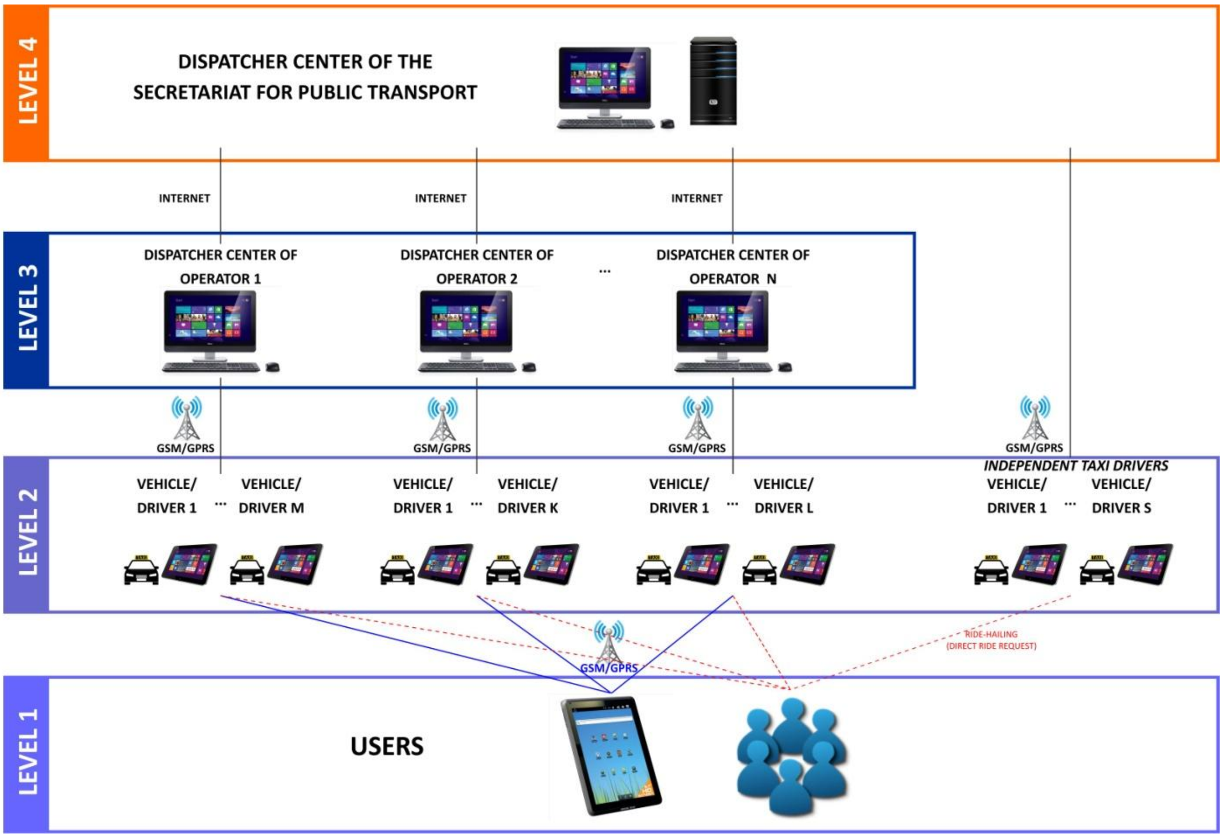

Figure 8. *The hierarchical model of the new Monitoring and control system of the taxi system operation*

Also, we defined a proposal of the basic functional and technical specification of the real-time monitoring and control of the system operation, with the recommendations regarding the necessary hardware and software for key actors in the system – local authorities and operators (the following figure).

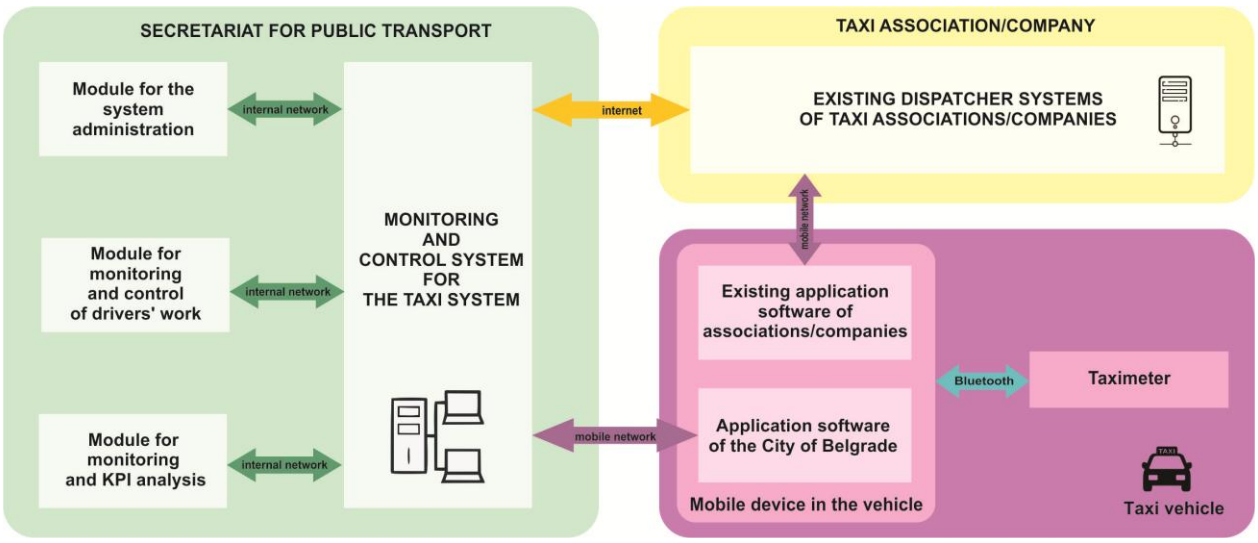

Figure 9. *Architecture of the monitoring and control system of the operation of the taxi system in Belgrade*

The following activity is defining the key performance indicators (KPIs) of the system's operation required for monitoring the taxi system operation. The KPI indicators represent specific parameters used in the process of monitoring and analyzing the taxi system operation to define the degree of fulfilment of the system's target function.

The basic aim of this activity is the development of the methodological framework for calculating the key performance indicators of the taxi system (KPI_{TX}) which explicitly express the efficiency and effectiveness of the taxi system, as well as the development of the model relationships between the defined KPI_{TX} indicators and elements of the taxi system structure and operation, criteria for their optimization, method and dynamism of monitoring, etc.

The total number of 28 KPI_{TX} indicators were proposed along with their definition, model, defined levels of monitoring and criteria (each indicator can be expressed in four, time cross-sections: hour, day, month, and year):

1. Total number of granted permissions
2. Total number of active permissions
3. Total number of inventory vehicles
4. Total number of operating vehicles
5. Utilization coefficient of the inventory vehicle fleet
6. Total number of trip requests (demands)
7. Total number of fulfilled requests (demands)
8. Total number of unfulfilled requests (demands)
9. Probability of service (system's) reliability
10. Productivity of the inventory vehicle fleet 1
11. Productivity of the inventory vehicle fleet 2
12. Productivity of the inventory vehicle fleet 3
13. Productivity of the operating vehicle fleet 1
14. Productivity of the operating vehicle fleet 2
15. Productivity of the operating vehicle fleet 3
16. Total working hours
17. Total working hours with passengers
18. Gross transport work
19. Net transport work
20. Operating speed
21. Environmental suitability of the system
22. Dynamic fatality risk
23. Damage risk
24. Percentage share of complaints and reclamations
25. Average assessment of the integrated service quality
26. Coefficient of realization of the minimum working hours at an annual level
27. Coefficient of realization of the minimum number of realized trips at an annual level
28. Coefficient of the fulfilment of the minimum requirements

The defined KPI_{TX} indicators could enable the comparison of the observed indicator in different time sections, which represents one of the pre-requisites for high-quality management of the taxi system at S-T-O management levels.

Proposed amendments to the regulatory acts for the implementation of the new system

Considering the aims of this research and development project and the conceptual solutions resulting from the consistent application of the methodological procedure which will lead to the changes in the structure, operation, organization and management of the taxi system following the transport policy at the level of the city of Belgrade and the key actors' demands, the final activity refers to defining the proposed amendments to regulatory acts for the implementation of the new system which are under the competence of the market owner – the City of Belgrade.

The project included the Draft Proposal of the Decision on taxi transport which, apart from detailed conditions for performing the taxi transport, includes specific conditions for a company and an entrepreneur, characteristics and features of taxi vehicles and manner of performing the taxi passenger transport at the territory of the city of Belgrade. The proposal of the Decision also provides a precise definition of the manner of determining the minimum volume and quality of transport service in the taxi system in the area of the city of Belgrade (minimum required level of performance indicators for taxi vehicle/driver based on which the active status of the granted permissions for performing taxi transport is updated).

CONCLUSION – EXPECTED EFFECTS

This research and development project systematically encompassed the most significant aspects related to the improvement of the structure, organization, management and operation of the taxi system and represents an analytic and reliable basis for the systematic improvement of the complete taxi system in Belgrade.

The designed solutions are based on the data and results of the conducted complex studies in the actual system and years-long experience of the authors in designing complex transport systems, bearing in mind the limitations related to the current taxi system and the current transport policy in the city of Belgrade. A specifically designed methodological procedure resulted in the reengineering of the taxi system structure and realistic and high-quality solutions enabling the continuous process of future positioning of the system in terms of its sustainability and independence.

The designed activities help transform the taxi system in Belgrade into the future desired state without abrupt changes and unexpected circumstances, i.e. create a completely well-ordered state of the system whose basic feature would be directed at reaching the system's sustainability and improvement of the transport service quality.

The thorough application of this research and development project, whose individual parts contain all elements of a scientific research project, and particularly the consistent application of the activities regarding the new concept of the improvement of the structure, organization, management and operation of the taxi system at the strategic level would provide conditions for the gradual transformation of this complex and destabilized system from the unfavourable to the desired state following global trends and national possibilities.

The systematic and consistent application of the conceptual solutions from this research and development project would provide the following effects, which are differentiated according to the key stakeholders in the system:

THE CITY OF BELGRADE

- Development of the high-quality public mobility service and improvement of the transport service quality of the complete public passenger transport;
- Defined mission, vision and target function of the taxi system under the actual needs and demands of all system stakeholders (local authorities, operators and passengers);
- Competences and management level at the strategic level based on the expert principle and use of modern software and applications;
- Transformation of the existing system from "a system on its own" into a very important "subsystem of the city";
- Creating conditions for raising the system's level of quality based on the actual demand of the system's users;
- A modern system of flexible passenger transport whose all elements are adjusted to the specific demands of users;
- Creating conditions for the sustainable development of the system based on producing and selling the transport service;
- Appropriately regulated transport service market and transparent process of access to the taxi service market in Belgrade;
- The rational investment level for improving the system's operation;
- Beginning of the system's digitalization to improve the system's efficiency;
- Providing conditions and objective circumstances for the long-term improvement of the taxi system in all aspects of its structure, with the gradual system development without abrupt changes and unpredictable situations based on the actual available resources;

TAXI SYSTEM AND TAXI OPERATORS

- Defined elements for the complete arrangement and regulation of the taxi service market;
- Creating conditions for the sustainable development of the taxi system based on producing and selling the transport service;
- Taxi system operation based on the actual transport needs and user demands;
- Compatibility of used transport capacities with transport demands;
- Changes in the system's structure (primarily in the system's organization and management) with clearly defined and allocation of competences, obligations, rights and risks per management level;
- More effective and more efficient management and operation of the system at the tactical and strategic level;
- Decrease of all risk types and misunderstandings between key actors;
- Transparent process of accessing the transport service market;
- Creating conditions for the development of an integrated and balanced system;
- Increase in the economic and productive efficiency of the system;
- The increased dynamism of the system;
- Monitoring and control of the system according to modern technology development;

- A more efficient control system of the system's operation – increased level of stability and reliability of the system's operation by introducing a modern monitoring and control system;
- Production and delivery of the transport service tailored to users' demands;
- The gradual development of the system without abrupt changes and unpredictable situations based on actually available resources;
- Creating conditions for the continuous process of the constant system's adaptation to the changeable environment, where the environment has a permanent impact on the system on the one hand, and on the other hand, where the system affects the environment in which it exists and adapts to;
- Creating a sustainable and acceptable taxi system for different interest groups;

TAXI SYSTEM USERS

- Fulfilment of specific demands of different user categories in the taxi system, through specifying the demanded elements of the transport service quality;
- Impact on the general and specific aims of the taxi system;
- Purchasing the transport service tailored to users' demands;
- Increased level of the system's stability and continuous operation;
- Increased level of the system's reliability (particularly in the segment of spatial and temporal availability);
- A higher level of service quality with the same or similar existing resources;
- Creating conditions for the continuous adaptation of the system to the actual users' demands and changeable environment, etc.