

# Guidelines for Improving the Quality of Urban Passenger Transport in the City of Sofia within the Context of Stable Urban Mobility

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**Abstract.** The problems regarding the necessity for improving the quality of urban passenger transport trips have become especially relevant in recent years due to the fact that an increasingly large portion of Europe's population now lives in major cities. They comprise about 85% of the EU's GDP. They are the engine of European economy, attracting investments and providing new jobs. At the same time, their dynamic development has led to multiple negative consequences regarding urban traffic. Despite the progress of automobile technology, the increased number of personal vehicles, the street traffic, the harmful emissions and noise pollution have become one of the biggest challenges for most cities, including Sofia. This has led to negative economic, social and ecological consequences and the destruction of the natural urban environment. Therefore, the European Commission has composed the Green Paper of Transport which outlines the primary guidelines for ensuring stable urban mobility by facilitating traffic in cities, improving the accessibility, security and safety of public transport and reducing the harmful impact of urban traffic on the environment.

## 1. Introduction

The policy for stable urban mobility is a priority for the EU's member states, but the goals outlined in it cannot be achieved without the functioning of quality urban passenger transport.

Every major city, including Sofia, needs an effective transportation system that will secure access to workplaces and services for all its citizens, guarantee safety and security during travel, minimize pollution, greenhouse effects and energy consumption [1, 2]. It has to guarantee quality transportation by public transport and it should be aimed at increasing the appeal of the urban environment. The evaluation of transport expenses and benefits has to be based primarily on social value in a wide range. The measures that need to be taken have to be aimed primarily at increasing the social effectiveness of urban passenger transport. It is crucial to carefully estimate the costs and the benefits, including the ones that are difficult to measure – for example, the ones regarding the quality of the air [3].

Increasing the social effectiveness of public transport plays a defining role in the social and economic development of major cities. Quality transport helps improve the cultural and economic relations between separate regions, smooth passenger transportation for industrial and personal needs and it becomes a basis for improving the living conditions and standards of citizens [4].

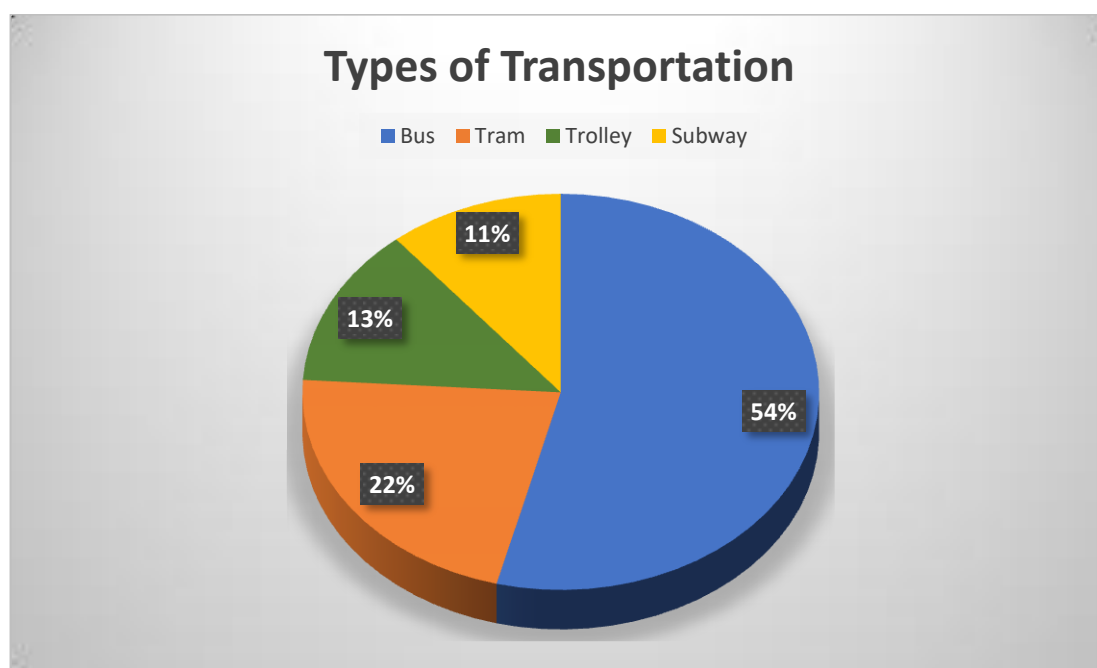
## 2. Analyzing the Mobile Situation in the City of Sofia

As the capital city of the Republic of Bulgaria, Sofia holds a key place in the country's economy. By 2016, it is inhabited by 1 304 772 people and it produces about 1/3 of the country's GDP. The city is defined by a higher employment rate and a lower unemployment rate, compared to the average factors for the country. It is the largest cultural, educational and health centers and about half of all the



institutes of higher education are concentrated in it. In recent years the city's population has drastically begun to increase due primarily to the city's appeal regarding education, professional development and employment, in addition to demographic processes, natural migration and the still untapped potential of the territories and zones around it.

In 2016 over 475 000 000 travels in the capital have been done using public transport. The types of transport used are as follows: 54% of the passengers have traveled by bus, 22% – by tram, 13% – by trolley and only 11% of Sofia's citizens use the subway (Fig. 1.).



**Figure 1.** Correlation between the types of transport and the number of travels in percentage [5]  
Source: Sofia Municipality's Program for the Development of Public Transport 2012-2015

The capital's transport services are provided by all main types of transport (bus, trolley, trams, subway, taxis and personal vehicles), which, in their entirety and interaction, form the transport system within the city's boundaries.

Buses are the primary and most preferred means of transportations for the capital's citizens. About 260 million passenger travels are done by bus every year. Urban trolleys are secondary and an alternative to buses for urban public transport users. The number of travels by trolley are about 65 million every year. The trolley route network comprises only 13% of Sofia's total urban transport route network; a large portion of it competes with bus transport. The available rolling stock of trolley transport has significantly decreased in recent years, with only 128 trolleys moving on the streets of Sofia in 2016. Tram transport in Bulgaria is less developed because of the poor condition of railways. In the past 20 years the number of trams in the capital has decreased doubly. With some tram lines, waiting intervals reach 30 minutes, which is utterly unsatisfactory when it comes to the quality of the transport service. The subway in the capital has the highest speeds, which is of the utmost significance for the conditions of the big city. It surpasses all other means of public transport with its high transportation capacity, which varies between 21 000 to 50 000 passengers per hour, in one direction. However, the construction of the subway requires the largest capital investments and therefore it is only effective in the directions with the strongest passenger flows. This is the only type of transport in the capital which has shown a significant growth in every aspect since its commission; 500 000 people use the subway in the capital on a daily basis. Taxi travels in the capital are a serious competitive alternative of public transport. They do not adhere to the regulations of stopping at bus stops; they copy public transport routes, offer higher transportation quality and attract a high-payment portion of urban public transport users. According to expert evaluations of operators, an unregulated taxi transportation leads to a 20%

loss for mass public transport [6]. Primarily, it satisfies the episodically arising needs of the urban population for higher-quality and more comfortable public transportation and it complements mass urban passenger transport during rush hour and during the night when the need for transportation decreases and mass urban transport ceases activity. It becomes an inseparable part of mass urban transport due to the increasing demands of the city's population. In recent years the number of transportations via personal automobiles in Sofia has increased rapidly. In 2016 passenger cars have the largest share of the total number of registered vehicles in the country – 82.5%, followed by trucks and towing vehicles – 11.6%. Buses comprise 0.6% and other vehicles, which include special automobiles, mopeds and motorcycles – 5.3% of the park [7]. Every day over 1 million automobiles pass through the city's streets, which causes more and more problems regarding traffic, parking and environmental pollution. The increased traffic also leads to another equally significant problem – noise pollution, which is the result of the poor quality of public transport and the lack of bicycle infrastructure. These issues are deepened by heavy-freight transit traffic in the central part of the city, which causes further noise pollution, harmful emissions in the atmosphere and risks of an increased number of severe traffic accidents within the capital.

### **3. Guidelines for Improving the Quality of Urban Passenger Transport**

In order to improve the quality of urban passenger transport in practice, it is necessary to devise a uniform plan for its future development. It has to be based on good European practices and include measures of technical, operative and organizational nature. It is the only way to fully satisfy citizens' travel needs and guarantee a higher quality of life in the city.

#### *3.1. Further Development of High-Speed Transport in the Capital*

Further development of high-speed transport in the capital, by constructing the third subway section in the city of Sofia. Global practice shows that a functioning and developed underground mass urban transport which offers comfort and convenience during travel, high velocity and freight capacity is key to the quickly and effectively servicing large passenger flows and relieving traffic in major cities. After the completion of the 1st and 2nd metro diameter in Sofia, public benefits were indicated in the city of Sofia, such as a 25% reduction of ground traffic, a 22% reduction of traffic accidents, a reduced amount of harmful gases in the atmosphere – by 90,5 thousand tons per year, a 20% reduction of noise pollution in the capital and an overall increase of the subway's share in the total number of public transport travels. Because of this, a significant number of bus lines that copy subway routes were eliminated. This is a very good tendency, considering the fact that the functioning of bus transport is linked to the largest amount of harmful emissions in the environment. In recent years the subway's development in the city of Sofia has become apparent. A quick glance at numbers and facts provides concrete evidence for it. The capital's subway fully fits in with the European vision for developing intelligent, environmentally friendly and integrated transport. The European examples and the EU's Common Transport Policy puts special emphasis on the development of fast, comfortable and environmentally friendly urban transport. Therefore, underground railways are currently being constructed or expanded with European funds in a number of cities on the Old Continent. The future of Sofia's subway involves the construction of a third metro diameter, which is expected to be finished by the end of 2018. It will have 20 subway stations and it will link the northeastern and the southwestern neighborhoods of the capital. The rail-cars will be completely automated.

#### *3.2. Incorporating Environmentally Friendly, Electrically Driven Means of Transport with Modern Equipment in the city's Transport Network, as well as Gradually Substituting Trams and Modernizing Tram Railways*

The technical condition of vehicles and the comfort they offer is crucial to increasing the quality of transportation. Modern environmentally friendly vehicles are guaranteed to reduce noise and dust pollution as well as ensure the tranquility of citizens whose place of abode is located right next to elements of public transport infrastructure. Incorporating new technology in electric transport guarantees that the kinetic energy it gives off will be converted and used repeatedly. For its part, this leads to savings and reduction in losses. Regarding the process of renewing vehicles that service public transport lines in Sofia, the implementation of European legislation, especially the parameters

and criteria foreseen in Directive 2009/33/EO of the European Parliament and the Council from April 23, 2009 for advocating clean and energy-efficient vehicles should be taken into account. Stability must be present when planning and securing the overhaul, modernization and development of the infrastructure that provides for electric transport (see Table 1).

Incorporating electric buses into the city's transport network is undoubtedly the most environmentally friendly solution for public transportation in an urban transport, with no contact network, the lowest noise reduction, no harmful impact on people's health and reduced CO<sub>2</sub> emissions.

**Table 1.** Reducing CO<sub>2</sub> emissions from the operation of electric buses with an annual run of 50 000 km.

Type of bus	CO <sub>2</sub> (tones per bus)	Reducing Chariot e-bus CO <sub>2</sub> compared to other vehicles
Chariot e-bus with an ultra-condenser	32,0	-
Electric bus with batteries	40,0	26%
Trolley	42,0	31%
Diesel bus EVRO VI	74,6	57%
Methane bus (EVV standard)	62,6	48%

Note: For the calculations, the CO<sub>2</sub>/MWh emission factor of Bulgaria for the production of electric energy in tones has been used. The emissions are lower compared to the emissions that would be given off from the direct burning of fuels by diesel and methane buses. Source: DENKSTAT

### 3.3. Intelligent Transportation Systems

Intelligent Transportation Systems (ITS) are a modern approach for observing, managing and helping the functioning of the transport system and, partially, automobile transport.

The incorporation of intelligent transportation systems covers various types of technology, whose use will become widespread in years to come. They are created by realizing interconnected telematics decisions, which include a set of instruments based on information technology, wireless communication and electronics. They allow more effective management of transport infrastructure and vehicles, which helps increase safety, reduce traffic jams, shorten travel time and reduce fuel consumption [8].

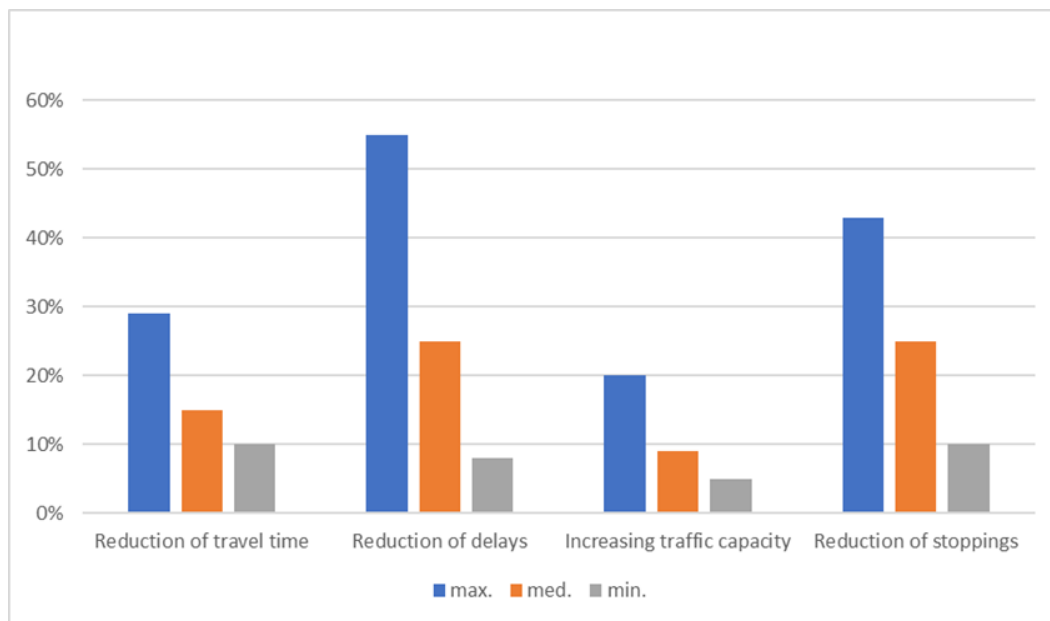
They can be used to identify problematic areas in the transportation system, but for this purpose, it is necessary to define its parameters in function of time, place and other alarming events, such as bad atmospheric conditions, emergency and repair activities. Measuring the pressure, determining the places where traffic jams and accidents are frequent and identifying the main automobile flows during rush hour will significantly help discover the reasons and solve the existing transport problems [9].

With the help of the amassed operative experience, some of the benefits from ITS are measured quantitatively with regard to the following key aspects of exploitation that concern the city of Sofia: Environment and Road Safety.

The key activity of the network management is optimizing the effective use of the available resources and capacity, shortening the travel time, delays and stoppings of vehicles.

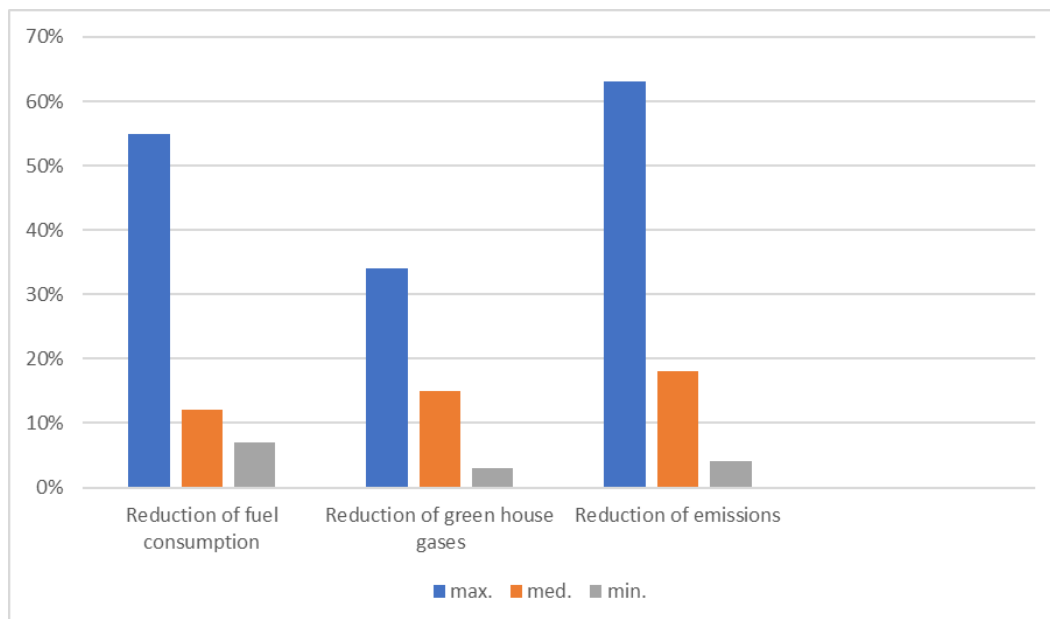
By using ITS, network management could reduce travel time by about 10% on the average and by 29% at most. Delays on the road could be reduced by about 25% on the average, traffic capacity could be increased by about 20% and compulsory stoppings could be reduced by about 40% at most (Fig.2).

There is also a direct dependency between the environment and the improved network management, which leads to the realization of positive effects such as reduced fuel consumption, greenhouse gases and emissions by about 30-60% (Fig. 3).



**Figure 2.** Benefits of incorporating ITS in network management

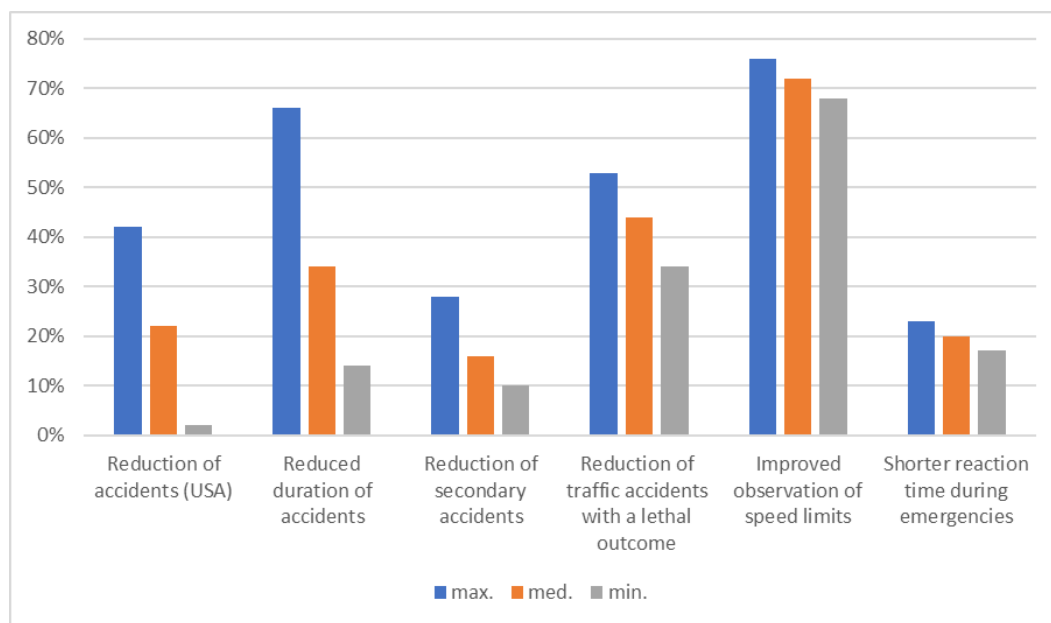
Source: Strategy for ITS Development as part of Sofia Municipality's Integrated Information System, November 2010



**Figure 3.** Reducing the harmful impact on the environment

Source: Strategy for ITS Development as part of Sofia Municipality's Integrated Information System, November, 2010.

The incorporation of ITS in the city's transport system also has undeniable benefits for the reduction of traffic accidents and crashes with a lethal outcome by about 50%, as well as for improving the situation on the road by improving the control for observing the necessary limits and better reaction on the part of drivers (Fig.4).



**Figure 4.** Benefits for road safety

Source: Strategy for ITS Development as part of Sofia Municipality's Integrated Information System, November 2010

The main goals of ITS incorporation in the capital's public transport system have to be based on the issues that impact the current transport situation, especially the significant increase of personal cars, as well as the seriously overlaid exploitation of the provided opportunities for parking in the city, the deteriorated indicators for travel time of private cars and public transport, and safety-related considerations [10].

### 3.4. Increasing the Quality of Taxi Services

**Increasing the Quality of Taxi Services.** In order to fully satisfy Sofia citizens' needs for public transportation, it is necessary to improve the service and raise the requirements regarding the technical and operating qualities of the used cars. The unorganized and random offers of taxi transport with all of their negative consequences can be avoided by using taxi services with "smart mobility". Ordering a taxi service in the future has to be done solely by smartphones and GPS, thus locating the taxi and sending the fastest car to the address. Such "smart apps" already operate in some European cities like Zurich, Berlin, Vienna, Barcelona, Warsaw, etc. The effect of it is two-fold: the order time is reduced and it creates conditions for more effective use of taxi cars by time and run. In order to reduce the harmful influence on the environment, conventional taxi cars should be gradually substituted with electric ones, which use electrically-powered engines. Compared to cars with internal combustion engines, they possess the following advantages: higher efficiency, higher acceleration, quietness, low prices per kilometre, significantly simplified car service, fewer and more durable parts and, most importantly, they do not pollute the environment.

### 3.5. Developing Bicycle Transport in Sofia

The European Commission advocates policies for reduction of motorized traffic by stimulating cycling and walking. In practice, increased bicycle traffic will improve conditions for the other traffic participants. One bicycle equals one less car on the road. Cycling in the city is often regarded as a dangerous activity. However, statistics indicate that an increased number of cyclists on the road reduces the number of dead cyclists per kilometre of travel distance. The reason is that drivers become more cautious in the presence of multiple cyclists. Thus, the stimulation of bicycle transport increases road safety in the whole city and for every traffic participant. According to the World Health Organization, cycling 30 minutes a day makes people healthier and happier. So far, a bicycle infrastructure has not been established in the city of Sofia. The development of bicycle traffic within



the city's structure is imperative and is a good reason to improve the urban environment. In turn, a high-quality urban environment will attract more investments and tourists [11]. When designing the bicycle infrastructure, road safety factors should be taken into account. The safe behaviour of all traffic participants has to be guaranteed through road tolerance and safe cycling campaigns. Successful cycling policies and the construction of a bicycle infrastructure in Sofia should be inseparable parts of the strategy for stable urban mobility.

### 3.6. Automated Traffic Control System

The integration of this system into the existing system for territorial positioning and control of mass urban transport vehicles will ensure a more equal distribution of all vehicles in the travel network, which in turn will create opportunities for unimpeded mass urban transport traffic. These two systems will allow flexible and effective development of mass urban transport by providing reliable, accurate, timely and comprehensive information for the processes related to the traffic conditions and the activities of transport operators.

### 3.7. Effective Organization and Management of the Transportation Process

The effective management should consist of building optimal links and high coordination between the different types of urban transport, guaranteeing security, speed, comfort and stability. As the biggest environmental pollutant, bus transport should service regions and provide links in zones which are not covered by tram, trolley or subway transport. The crucial gradual reorganization of tram and trolley transport as the most environmentally friendly types of ground transport is imperative to the effective management and organization of urban transport in the capital. The purpose of this restructuring is to adapt and integrate these transport types into the available and future design subway lines. Sofia's subway should become primary and structurally defining for transporting large groups of people to relatively long distances due to its indisputable technical and economic features such as environmental friendliness, high velocity, high passenger capacity and effectiveness.

## 4. Conclusion

Designing a uniform program for the future development and improvement of the quality of urban transport passenger transport within the context for stable urban mobility in the city of Sofia will guarantee the functioning of environmentally friendly, high-quality urban passenger transport, which provides opportunities for attracting more people and fully satisfying their needs for urban travels, thus reducing citizens' dependence on their cars, with subsequent environmental benefits. Accessibility to all urban zones and services will be improved, better environmental parameters such as quality of the air and noise will be reached and the population's health status will be improved. The quality of life for people with impeded mobility and people living in regions which have not been connected with the urban transport network in the past will be improved significantly. The overall image of the city of Sofia will be improved – it will have a new vision of an innovative and progressive modern European city.

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