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INTRODUCING BRT (BUS RAPID TRANSIT) AS MASS PUBLIC TRANSPORTATION SYSTEM FOR CITY OF SKOPJE

Keywords
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Abstract
Skopje, as capital city, does not differ much in terms of traffic problems from the other cities that use transport system that primarily relies on the car. Although it is a city with more than half a million inhabitants, today's public transport system includes only a bus system. The network of lines relies on the concept of direct lines, city buses do not have any kind of priority, adding travel time loss due to traffic jams (transport speed is below 14 km/h), and relatively low frequency and reliability service (transported only 50 million passengers per year).
Bus Rapid Transit (BRT) has been demonstrated to provide efficient and effective public transport that can even increase transit ridership and attractiveness within defined urban corridors in both developing and developed countries. The merit of the BRT system lies in its ability to provide a high-quality public transit service with limited infrastructure and at a relatively low capital and operating cost.
This paper summarized results of the BRT study for City of Skopje for implementation of optimal solution for Line no. 1. For

this purpose, alternative solutions have been made for placement of the alignment in the cross-section profile of the roads. The setting of the BRT alignment can be performed in several different ways, and each of these solutions has its advantages and disadvantages, and a detailed analysis has been made for each of them.

The subject is introduction of bus rapid system - BRT in the city of Skopje, i. e construction of line 1 with an alignment starting from Gjorce Petrov to Novo Lisice with an approximate length of 12.81 km in one direction and with 21 bus stops and two terminals. The objectives are reduction of traffic jam (attractive public transport and reducing the number of car travels), reduction of the travel time, reducing environmental pollution. In the process of designing line 1 as a part of the bus rapid system-BRT which is planned for the city of Skopje, to provide fast, high-capacity, reliable, environmentally friendly and attractive public transport.

1. INTRODUCTION

Bus rapid transit (BRT) is an innovative bus system with sophisticated vehicles and inflexible bus ways integrated in the cities, high capacity and high quality, high speed and frequency, distinctive image and comfort, inflexible bus ways that target improved integration with cities and lucrative promise of flexible capacity and high quality at lower costs than the railway systems. In contrast to the conventional bus systems which operate predominantly in mixed traffic, on streets or dedicated lanes, BRT achieves high capacity by canalizing passenger flows in a system of segregated busways, partially or fully separated from other traffic. The system comprises bus-only lanes which are given priority at intersections, with fares paid at stations instead of on the bus itself. BRT is much cheaper to implement than light-rail or underground metro systems, and benefits local economies, traffic and emissions. It can be implemented in phases to minimize disruption.

The capital of Macedonia, Skopje, does not differ much in terms of traffic problems from the other cities that use transport system that primarily relies on the car. Traffic jams, lost time, lack of parking place and increased environmental pollution are problems that city residents face every day. To solve these problems, the greatest results are seen in the application of solutions that already include urban mobility, which turns cities into human cities. Today, the city of Skopje has a population of 554,972 inhabitants (data for 2019 according to the estimates made by the State Statistical Office), but together with the surrounding municipalities that gravitate towards the city and are included in the system of public urban and suburban transport, this number is 633 273 inhabitants.

The public transport system in Skopje includes only a bus system. The network of lines operate on principle of direct lines and is not in line with the urban development of the city, there is an extremely high number of passengers who changing the

buses, which is contrary to the concept of direct travel, the buses don't have priority and resulting in long transport times. If we add the fact that the frequency and reliability of the service are relatively low (in peak hours only one line has a follow-up interval less than 6 min, and more than half of the lines have an interval longer than 20 min), then the low attractiveness of the public transport and residents' orientation for car use is obvious.

To overcome all these problems and improve the service of public city transport in the city of Skopje, it is necessary to introduce a fast, high-capacity, ecological and attractive type of transport, and all this is achieved by introducing a fast bus system - BRT.

2. DEFINITION AND BASIC CHARACTERISTICS OF THE BRT

BRT is a bus-based mass transit system. The system has a concrete design, services, and infrastructure oriented to improve service quality and reduce delays. Sometimes described as a surface subway, BRT aims to combine the capacity and speed of a light rail or metro system with the flexibility, cost, and simplicity of a bus system. Its main drawback compared to other urban transport systems is its demand for urban space. In many cases, when BRTs are being constructed, road space for private vehicles is reduced, as there may be no opportunity to expand the total road space. For this reason, to be most effective, BRT systems, as well as other modes, should be integrated into a comprehensive mobility and transport strategy to support and promote public transport that can include measures to discourage car use, for instance increasing vehicle and fuel taxes, land-use controls, limits, and higher fees on parking, and integrating transit systems into a broader package of mobility for all types of travelers.

Five basic features that define BRT. These features most significantly result in a faster trip for passengers and make travelling on transit more reliable and more convenient.

1. Dedicated Right of Way – Bus-only lanes make for faster travel and ensure that buses are never delayed due to mix traffic congestion.
2. Busway Alignment – Centre of roadway or bus-only corridor keeps buses away from the busy curb-side where cars are parking, standing and turning.
3. Off-board Fare Collection – Fare payment at the station, instead of on the bus, eliminates the delay caused by passengers waiting to pay on board.
4. Intersection Treatment – Prohibiting turns for traffic across the bus lane reduces delays caused to buses by turning traffic. Prohibiting such turns is the most important measure for moving buses through intersections – more important even than signal priority.
5. Platform-level Boarding – The station should be at level with the bus for quick and easy boarding. This also makes it fully accessible for wheel chairs, disabled passengers, strollers and cart with minimal delays.

3. ALIGNMENT BRT IN CITY OF SKOPJE – LINE 1

In the framework of the efforts for improvement of the public transport system in Skopje and the realization of the need for introduction of fast, high-capacity, ecological and attractive transport, the City of Skopje, based on several previous studies decided to introduce a system of rapid bus system - BAS (in the English speaking area Bus Rapid Transit - BRT). The move that is subject to processing is defined in the following boundaries: from Gjorce Petrov depot to Novo Lisice depot in Skopje with a total route length of 12,800.00 meters, as well as the scope of the approaches to the intersections (Figure 1).

Figure 1. Alignment of BRT from Gjorce Petrov to Novo Lisice in the length of 12.8 km

3.1. Analysis and selection of alternative solutions for placement of the alignment of the BRT

Several alternative solutions for placement of the alignment of the BRT have been made, so each of them has positive and negative aspects of its implementation. Those solutions are the following:

- Alternative A - placement of BRT lanes on the further right side of the roads
- Alternative B1 – with central BRT station for both driving directions and with vehicles with doors on the left side – this option will be considered as one of the possible alternative solutions.
- Alternative B2 – with vehicles with doors on the right side, separated side BRT bus stops – This alternative will be treated as one of the possible alternative solutions.
- Alternative B3 – One central BRT station, vehicles with doors on the right side, BRT lanes in the opposite direction from the rest of the traffic (contraflow) – this alternative will not be considered further.
- Alternative B4 – One central BRT station for both directions, vehicles with doors on the right side, intersecting of BRT lanes before and after the BRT station – this alternative will not be considered further.

Of the proposed variant solutions, Alternative B1 and B2 have been processed and analyzed in detail. For these alternatives, a Run Time model was made, tool for calculating the travel time that is applied in the early stages of planning or designing

fast passenger transport systems. The model is based on the calculation of time needed to pass each section or segment that is along the alignment of the rapid transit system used to transport passengers. A micro-simulation model was also created in order to perform a visual representation of the optimal solution for BRT and its impact in the spatial scope. According to the output results of the two variant solutions, alternative B2 – Separate side BRT bus stops, vehicles with doors on the right side, BRT line 1 in Skopje provides a more optimal solution and traffic solution has been made for it.

4. TRAFFIC SOLUTION

The designed traffic solution envisages a central separate alignment of BAS along Blvd. Partizanski Odredi from Gjorce Petrov depot to the intersection with Blvd. VMRO, guidance the alignment on Blvd. VMRO, st. Dimitrie Cupovski and 11th October on the same road surface with the rest of the traffic (separation of the alignment of BRT with traffic equipment), central separate alignment from Blvd. Kocho Racin to Blvd. Vidoe Smilevski Bato, guidance the alignment on st. Februarski Pohod on the same roadway surface with the rest of the traffic (separation of the BRT alignment with traffic equipment). The traffic solution is made in accordance with the world standards for designing BRT systems and the following standard widths of the cross-section profile elements have been adopted:

- BRT lane width: 3.0-3.5m
- Width of BRT traffic lane in the station area: 3.0-3.5m
- Width of BRT station: 3.5-4.5m
- Safety area between BRT and other traffic 0,5-1,0m
- Width of traffic lanes for the other traffic: min 3.0m.

Along the subject alignment are 22 BRT station, where the starting station - terminus is Gjorce Petrov and the end station - terminus is Novo Lisice. Novo Lisice Terminus is the starting/ending point for BRT, as well as other public transport lines, which should cover the surrounding area of the eastern Skopje region. The facility is located in the western corner of the planned location for a bus depot in the settlement of Novo Lisice, closest to Bul. ASNOM, which enables angular entry of BRT vehicles, their proper turning and stopping on the right side of the platform. Three 24-meter buses should stop at the terminus which sets its length and size.

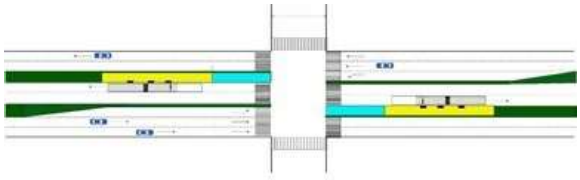

Figure 2: BRT lanes placed in the central area, vehicles with doors on the right side, BRT stations separated according to their direction, repositioning of BRT lanes before and after the BRT station

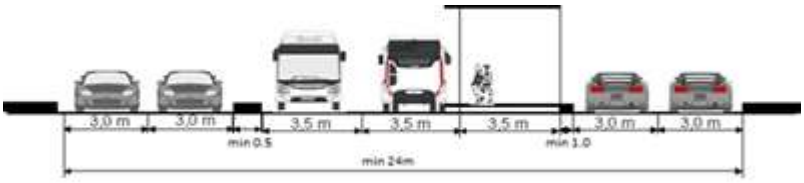

Figure 3: View of one bus stop after the intersection (the same cros section profile for the station in the opposite direction) - BRT lanes placed in the central area, vehicles with doors on the right side, separate BRT bus stops according to the direction of movement

Gjorce Petrov Terminus Station is located in the area of the existing, unregulated parking between the depot and Bul. Partizanski Odredi, under the one-level car park. It is the end point of PTC suburban buses and the starting point for BRT buses. This station will accommodate passengers coming from the suburbs in the western part of Skopje, passengers traveling by car through "Park-and-ride" and passengers traveling by bicycle, BRT buses and vice versa. From the parking lot on the first floor, access to the station is provided through 3 communication cores, while for bicycle traffic there are two parking lots provided nearby with a capacity of about 100 bicycles. At the end of the shift, the BRT and PTC bus drivers leave the passengers at the terminus station and enter the depot through the station. Appropriate horizontal, vertical and traffic light signalization has been used to mark the areas intended for the movement of BRT vehicles.

4.1. Strategy for ensuring the priority of public transport vehicles

A traffic signal control system UTOPIA has been implemented in the city of Skopje, which guidance the traffic on a network of 92 intersections and independent pedestrian crossings. UTOPIA has the ability to assign absolute, weight and selective priority to transport vehicles at signalized intersections. The priority assurance function is based on the predictions of the estimated time of arrival of the vehicle for public transport at the signalized intersections. The priority of public transport vehicles is achieved through a process of optimization of traffic control at the intersection. The optimization is performed every 3 seconds, which allows the system to react quickly, in case of changes in the scheduled time of arrival of public transport vehicles at the intersection. A system for automatic location of vehicles (ALV) for public transport has been established in the city of Skopje which enables monitoring of vehicles in real time, i.e determining the current location of vehicles (localization). The ALV system is connected to the UTOPIA traffic control system via TCP / IP connection.

5. CONCLUSION

Alternative B2 – with vehicles with doors on the right side, separated side BRT bus stops is characterized by the most optimal results from the performed analyzes and is proposed for the implementation of BAS line 1 in Skopje. The positive features

are: vehicles with doors on the right side, same as the rest of the carriers' bus fleet; keeping the advantages of a BRT alignment placed in the central area; possibility to provide a special lane used for left turns for the rest of the traffic and wider possibility for optimizing the network of public transport lines.

The implementation of this alternative is also justified according to the goals that have been set, i.e. reducing transport time one terminal to another reducing the current 70 min by more than 50%, which has been achieved and is proven by the Run Time model and "VISSIM" application for micro – simulation modeling – the result of transport time is 30 min. The goal has also been achieved to offer service in the rush hours with frequency of every 3-4 minutes, as well as the selection of environmentally friendly vehicles, articulated CNG hybrid vehicles, and minimize the necessary interventions in the cross-section profile of the existing roads.

In order to develop a tool that will establish the possibility for objective and standardized evaluation of the planned BRT systems, and considering the wide range of available project solutions for the alignment and the way the system works, an evaluation system has been developed. This system was established by the Institute for Transportation and Development Policy and is accepted worldwide. According to this system, BRT systems are ranked in one of four classes: Basic, bronze, silver and gold. The ranking method according to the total number of points is as follows: Gold standard - 85 points and more; Silver standard 70 to 84 points and Bronze standard - 55 to 69 points. Criterions of the project solution for BRT line 1 Skopje are points according to BRT standards with total 72 points = silver standard.

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