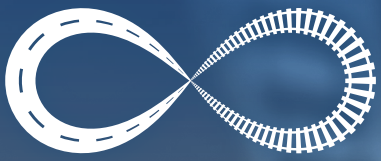

CETRA 2018

5th International Conference on Road and Rail Infrastructure
17–19 May 2018, Zadar, Croatia

Road and Rail Infrastructure V

Stjepan Lakušić – EDITOR

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IMPACT OF EXCLUSIVE BUS LANE ON URBAN ARTERIAL PERFORMANCE MEASURES

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Abstract

The introduction of an exclusive bus lane can be one of the operational measures that will improve the quality of public transport, especially on urban arterials with intense traffic flows. By using an exclusive traffic lane, buses can reduce their travel time and increase speed, resulting in a more efficient public transport, better level of service and satisfied passengers. However, the change of an existing traffic lane into a bus lane may have an impact on the quality of traffic on the adjacent lanes and the arterial as a whole. So, it is necessary to analyse and evaluate this impact before implementing a new mode of traffic regulation. This paper presents a traffic analysis of the possibilities of changing the curb traffic lane into a bus-only lane on an arterial street in Split. Using the calibrated simulation model, the average speeds, travel times and average intersection delays were compared for variants with and without a bus lane. Field data were used for performing simulations, and additionally, variants with increased traffic volume were also tested. Based on the obtained results, i.e. the performance measures of arterial and intersections level of service, comments and a conclusion were provided regarding the possibility and purpose of introducing the bus lane in terms of the impact on the traffic flow quality.

Keywords: bus lane, urban arterial, analysis, performance measures, simulation

1 Introduction

Everyday activities of people who live in the urban area are often performed by using some type of transportation. In addition to personal vehicles, the public transport has an important role in urban mobility. When people opt for a specific mode of transportation, they rely on the time of travel as the basic criterion, and in that sense the public transport should be reliable, organised and efficient in order to be appealing to its users.
The introduction of an exclusive bus lane can be one of the operational measures that will improve the quality of public transport, especially on urban arterials with intense traffic flows. By using an exclusive traffic lane, buses can reduce their travel time and increase speed, resulting in a more efficient public transport, better level of service (LOS) and satisfied passengers. This measure is most commonly executed by converting one of the existing traffic lanes into a bus lane. However, the change of an existing lane into a bus lane may have an impact on the quality of traffic on the adjacent lanes, increase of delay and lower LOS on intersection approaches. Hence, it is necessary to perform a traffic analysis and evaluate the functionality and efficiency of this conversion.
This paper presents possible ways of locating and using lanes for public transport and presents a traffic analysis of the changing the curb traffic lane into an exclusive bus lane on an arterial street in Split. By using the calibrated simulation model, the simulation of traffic flows and the analysis of the functioning of 5 signalized intersections within the analysed

area were performed. The average travel speeds of vehicles and the average bus travel times were compared for the variants with and without a bus lane in the conditions of the existing traffic volume and the traffic volume increased by 20 %. The paper also compared average intersection delays and LOS on specific intersection approaches.

2 Exclusive bus lanes

Bus speeds and travel times along arterial streets are influenced by (1) the frequency and duration of stops, (2) interferences from other vehicles (including standing vehicles), and (3) traffic signals [1]. In order to make buses more efficient and appealing to passengers, bus preferential measures such as an exclusive bus lane can be introduced. Exclusive bus lanes are a portion of the street designated by signs and markings for the preferential or exclusive use of bus vehicles, sometimes permitting limited use by other vehicles. They are implemented by repurposing general traffic lanes or parking lanes, and can be exclusive at all times, or only during peak times or daylight hours. Full-time lanes better serve transit performance and visibility, but peak-period lanes may be appropriate in specific contexts [2]. Figure 1 illustrates three basic ways of introducing an exclusive bus lane into an existing road profile, where the public transport vehicles move in the same direction as the other vehicles in the traffic flow.

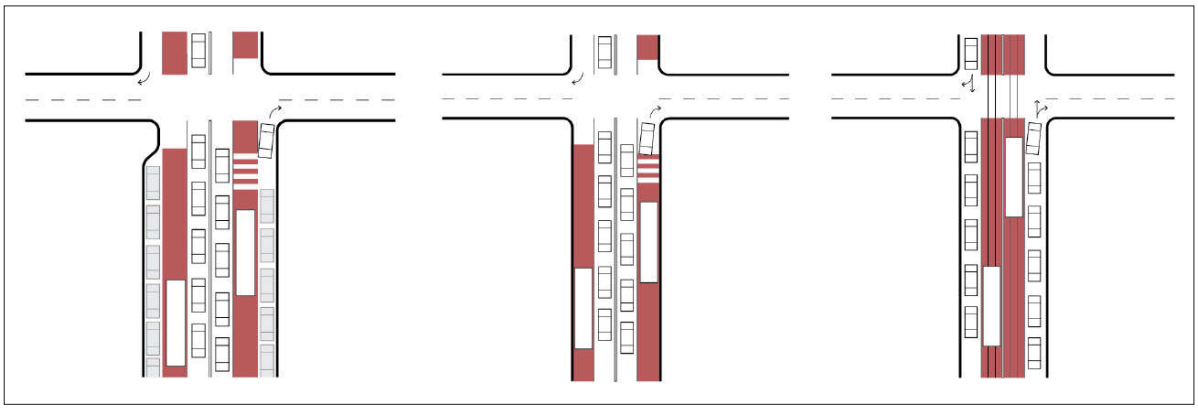

Figure 1 Offset bus lane, curbside bus lane, centre bus lane [2]

Figure 2 Contraflow bus lane [2]

Also known as “floating” or “parking-adjacent” lanes, offset bus lanes place buses in the rightmost moving lane, but are offset from the curb by street parking, curb extensions, or raised cycle tracks. Curbside bus lane (Fig.1, middle) is a lane adjacent to the curb allowing passengers to board directly from the curb, but it is subject to the interference and conflicts

of right-turning vehicles. Intensive right turn volume can reduce bus speed and increase travel time. When the middle traffic lanes are used exclusively for public transport (Fig.1, right), an additional space for bus stops should be provided in both directions which would enable safe and timely boarding of passengers. In this case, other vehicles should be prohibited from left-turning on intersections. Beside these solutions, an exclusive bus lane can be in contraflow of other traffic and used on streets where general traffic is limited to one way, but transit operations benefit from bi-directional transit routing (Figure 2). Regardless of the solution to be implemented in the existing urban network, an analysis of possible impacts of the new regulation measure on the quality of traffic flow should be performed.

3 Case study

The impact and efficiency of the conversion of the existing traffic lane into an exclusive bus lane was analysed on the section of Poljička Street in Split. Poljička Street is, according to its functional categorisation, a major urban arterial, but also a state road connecting the ferry port of Split onto the network of state and county roads and A1 highway. The main incoming and outgoing traffic flows take place on this street, as well as the entire traffic related to southern and eastern city boroughs. For that reason, there is a considerable number of public transport line and intense pedestrian traffic flow in addition to intensive traffic of personal vehicles. The conversion of the lane would be executed bi-directionally so that the curb traffic lane, out of three existing traffic lanes, would be used by the public transport vehicles. The purpose of this conversion would be to reduce the travel time and increase the level of public transport quality and service. The analysed 2.4 km Poljička Street section where an exclusive bus lane would be introduced is illustrated in Figure 3.

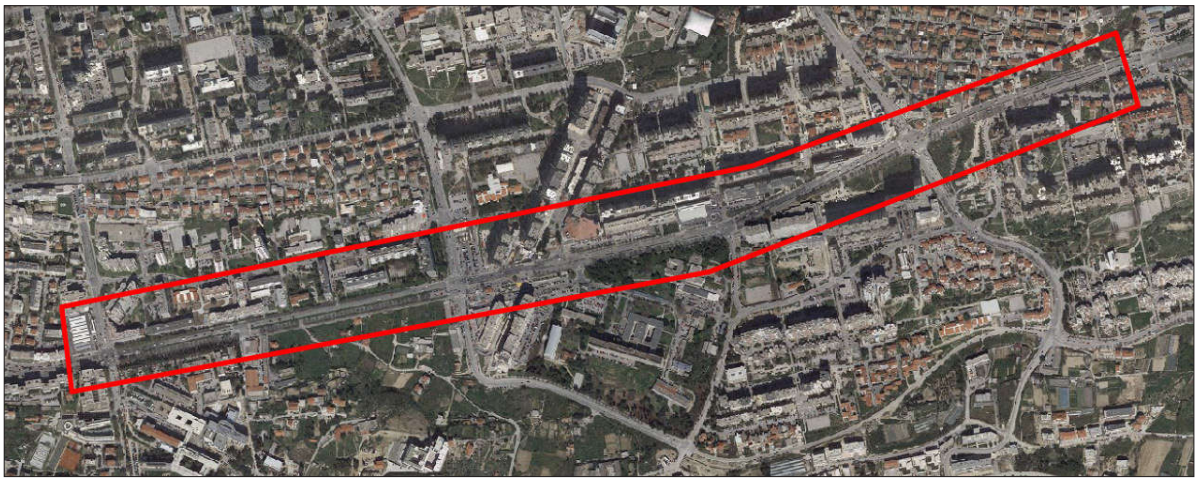

Figure 3 Area of analysis

3.1 Applied methodology

The microscopic simulation model CORSIM [3] was used for the analysis and evaluation of different variants of the traffic flow. The use of the simulation model provides an insight into the testing and evaluation of new approaches to traffic management and design solutions before the shortcomings of new solutions are reflected in practice. In addition to numerical data, the simulation provides an animated display which enables the visual perception of traffic flow quality.
In order to determine the impact of lane conversion, the performance measures were compared for the variants with and without an exclusive lane for the existing traffic volume and the traffic volume increased by 20 %. The repurposing of one lane for public transport improve

the travel time of these vehicles, however, the new traffic regulation may also impact the quality of flow in the adjacent lanes. The quality of traffic flows on intersections is defined by the LOS based on control delay. Control delays for approaches were obtained by CORSIM simulation model, and the LOS (A to F) was determined on the basis of the criteria according to HCM 2010 (Highway Capacity Manual 2010) [4]. In addition to average control delay per vehicle, the average travel speed of personal vehicles and the average travel time of buses on the section were also used as the relevant performance measures for indicating the functionality of lane conversion.

3.2 Required input data

The following procedures related to the collection of required data were used for the simulation model design:
- traffic counting on intersections of the analysed area;
- determining the peak period and the volume and distribution of traffic in the peak hour;
- collecting data on bus lines of public transport, their frequency and the average dwell time;
- the network model design with the data on geometry, traffic volume and the signal time plan for each intersection.

The data on the daily distribution of traffic volume were used for determining the morning and the afternoon peak hour. In the existing traffic regime, there are five bus stops on each side of the analysed section which are used by 4 to 5 city lines. All city lines are modelled in the simulation according to their trajectories and travel time, and the average dwell time of 30 seconds. The designed model of the existing condition is shown in Figures 4 and 5.

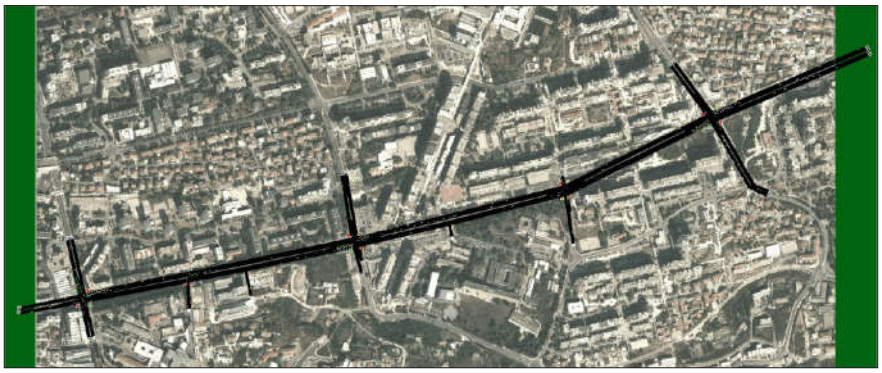

Figure 4 Analysed section model

Figure 5 Part of the model with the display of bus stops and line routes

3.3 Simulations and performance measures

After modelling the network and entering all necessary input data, 20 simulations of traffic flow in a peak hour were made (particularly for morning and afternoon peak hour). The results of the model were compared to the measured traffic flows and speeds, followed by the calibration of specific model parameters (influence of pedestrians, saturation headway, start-up lost time, etc.), which consequently led to the satisfying quality of the model in terms of the described existing conditions. The calibrated model was used for defining the impact such traffic regulation, i.e. the introduction of an exclusive lane, would have on the functioning of the intersection and the quality of the traffic flow on the observed urban arterial. The following variants were analysed:

- Variant 1 – without a bus lane and the existing traffic volume;
- Variant 2 – with a bus lane and the existing traffic volume;
- Variant 1.1 – without a bus lane and the traffic volume increased by 20 %;
- Variant 2.1 – with a bus lane and the traffic volume increased by 20 %.

Since the traffic volume has a tendency of annual increase and taking into account the tourist season when the Poljička Street is used as the major communication with the ferry port, the simulations of the traffic flow with an assumption increase by 20 % were also made. For each of these variants, the analysis included the average speed of vehicles, the average travel time of city buses, and the average delay and the level of service of all intersection approaches. Tables 1 to 3 present the example of obtained results (for variant 1 in the morning peak hour for both directions).

Table 1 Average speed of adjacent vehicles

Direction	Average Speed Of Vehicles [km/h]
West – East	27
East – West	20,00

Table 2 Average travel time of bus lines

Direction	Bus Line					
	3	5	8	11	15	17
	Average Travel Time of Busses [sec]					
West – East	395	395	362	217	362	206
East – West	495	495	425	227	267	220

Table 3 Intersection control delay and level of service

Existing State – Morning Peak Hour									
Intersection		Intersection Approach							
		West		East		North		South	
		LOS	Control Delay [sec/veh]	LOS	Control Delay [sec/veh]	LOS	Control Delay [sec/veh]	LOS	Control Delay [sec/veh]
R1	Poljička – Dubrovačka	C	26	D	36	C	30	D	38
R2	Poljička – Put iza nove bolnice	C	22	B	14			C	24
R3	Poljička – Bušićeva	C	31	D	38	D	36	C	26
R4	Poljička – Put Trstenika	C	23	B	11	C	26	C	28
R5	Poljička – Velebitska	C	30	E	79	C	32	F	130

The same data were collected for all analysed variants and both peak periods. Considering the resulting average speed of travel, it is 20 and 27 km/h for the morning peak hour due to a series of signalized intersections, where the lower average speed occurs in the east-west direction as a result of a larger traffic volume caused by coming to work. In the afternoon period, the average travel speeds are approximately the same for both directions (23.8 and 24 km/h). The same conclusion is obtained for the average bus travel time. The results of the analysis indicate that two intersection approaches provide an unsatisfying LOS, however occasional congestions which do not last longer than two green phases are expected on an urban intersection during peak hours.
The designed and calibrated simulation model, with all the pertaining attributes for the existing conditions of traffic flows, served as a basis for the simulation of other variants and the comparison of results. The resulting performance measures for morning peak hour are presented in Figures 6 and 7.

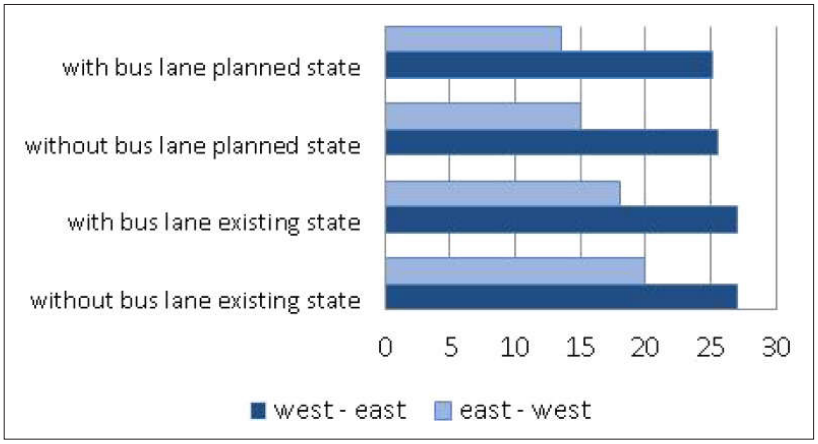

Figure 6 Average travel speed of vehicles (km/h), morning peak hour

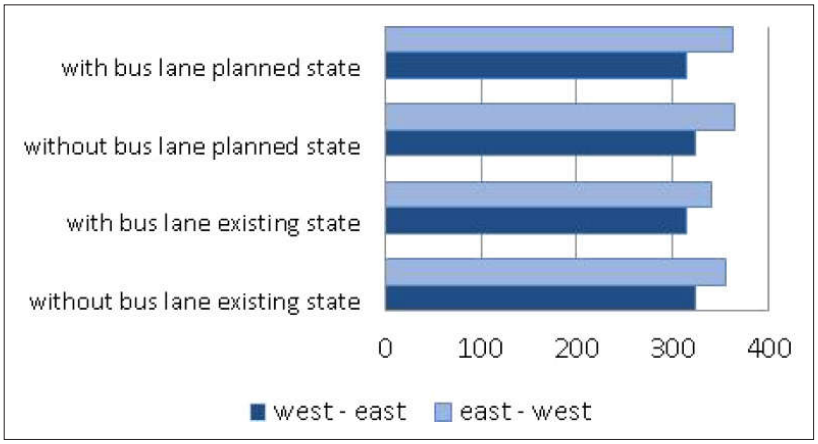

Figure 7 Average travel time of buses (sec), morning peak hour

Based on the obtained data for variants 1 and 2 (existing traffic volume), it can be concluded that the conversion of the curb lane into an exclusive bus line enables only slightly shorter bus travel times and reduces the travel speed of personal vehicles in the adjacent lanes by approximately 10 %. All intersections provide the same LOS in both variants. It is due to the fact that the curb lane is used in the same way in both analysed variants. Namely, the site visit has determined that this lane, besides the buses, is mainly used by right turners, because the other vehicles want to avoid the waiting caused by pedestrian crossing in the same green phase. This would not change even in the case of an exclusive bus lane, because additional lanes for right turning are not provided, hence the performance measures only slightly differ.

The increase of the traffic volume by 20 % in both variants causes traffic congestion and unacceptable delays on the intersection of Poljička and Velebitska Streets in the morning and the afternoon peak hour, which cannot be avoided even by optimising the traffic light operation, hence the lane conversion does not meet its purpose in this case either. The purpose of a more efficient and attractive public transport would be met by applying the transit signal priority, where the buses in a separate approach lane at intersections get the green signal before other lanes, so that they can proceed through the intersection ahead of other traffic [5].

4 Conclusion

The introduction of an exclusive bus lane is one of the possible measures used in many cities for the improvement of the public transport efficiency and quality. In order to determine whether such a measure will result in improvements and how much impact on the traffic quality of adjacent lanes will be, it is desirable to perform a traffic analysis prior the implementation. This paper presents the results of such an analysis by using the CORSIM simulation model on an urban arterial in Split where the introduction of an exclusive bus lane was planned. Upon comparing the obtained performance measures, it can be concluded that the introduction of the exclusive bus lane would not significantly reduce the quality of traffic flows on the adjacent lanes. In terms of better quality and faster public transport, it has been established that the introduction of the exclusive bus lane would not make a considerable improvement, i.e. it would provide only slightly shorter bus travel times.
The exclusive lane would have a full effect if traffic management adapted to the ultimate goal of a more efficient public transport by applying intelligent transportation system which ensures signal priority to public transport vehicles, but also if the bus lines became more frequent to the extent that users prefer to choose the public transport rather than a personal vehicle. This would reduce the traffic volume and congestion problems as well as the problem of finding a parking space in the city area. All in all, the traffic analysis can always provide some answers before making any final decisions or spatial interventions. In any case, the traffic analysis can always provide some answers before making any final decisions and spatial interventions.

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