Milos Spasic, MSc[1]
E-mail: spasic.milos93@gmail.com
Marko Velickovic, MSc[1]
E-mail: marvel@uns.ac.rs
Djurdjica Stojanovic, PhD[1]
E-mail: djurdja@uns.ac.rs
[1] Faculty of Technical Sciences
Trg Dositeja Obradovica 6, 21000 NOVI SAD

THE IMPACT OF DOUBLE-PARKED DELIVERY VEHICLES ON TRAFFIC CONGESTION IN URBAN AREAS

Key Words

Traffic congestion; Urban freight transport; Double-parking; Sustainable city logistics

Abstract

Road traffic congestion generates many problems in urban areas, such as delays, increased fuel consumption, contribution to air pollution, etc. Urban goods delivery operations typically occur on the streets, which significantly contributes to the occurrence and amount of congestion. This paper investigates the negative external impact of double-parked delivery vehicles in order to perform loading operations when there are no separate loading areas. Therefore, the data on the vehicles affected by the double-parked delivery vehicles are needed for the purpose of the research. The data collection is conducted by video recording of delivery operations on the streets of Novi Sad (Serbia). The results of the analysis show that the total annual delays are 264,4 hours on two-lane street and 866,5 hours on four-lane street. The above results are related to the current state in year 2019 (base scenario). The delays for the year 2029 (projected scenario) are estimated to increase for about 135% on two-lane street and 90% on four-lane street. The research results will be discussed in the context of the sustainable urban logistics development.

1. INTRODUCTION

Sustainability of the system involves the use of existing resources to meet the current needs of people, but in a way to ensure that the needs of the future population can be met. Sustainable logistics, aims to meet the needs for moving material goods at the right time, in the right place with limited impact on the social, environmental and economic aspects of human society [1].

Congestion is one of the main problems which do not contribute to sustainable city logistics principles. The urbanization trend tends to increase the number of people in urban areas and, consequently, to increase the demand for goods. Therefore, there is an increasing risk of traffic congestion in large urban areas due to higher demand for goods transport.

The aim of this research is to determine the impact of double-parked delivery vehicles on congestion in medium-sized cities. In order to reach the aim, we analyzed the relation between the duration of delivery vehicles on-street parking and their impact on other vehicles in the traffic flow. The time lost by the delivery vehicle can be seen as internal effect because it is accounted by transport company. However, the time lost by other road users because of the double-parked delivery vehicles is an external effect. The impact on other vehicles in the traffic flow is observed through the dwell time behind the double-parked delivery vehicle.

In the second Section, the sustainability basics and traffic congestion are described. The third section the research methodology is explained in the third Section, and in the fourth Section the results of the research are shown and discussed. The Section 5 gives concluding remarks of the research conducted in this paper.

2. SUSTAINABLE LOGISTICS AND TRAFFIC CONGESTION

In recent decades, there has been an increasing absorption of natural resources as a consequence of poor planning. The increasing population growth is uncontrollably affecting the destruction and pollution of the environment. The increasing negative impact on the environment will result in an increased decline in food supply and an increased energy consumption in the following decades [2]. It is necessary to find solutions to ensure the growth and development of the human population, but at the same time to ensure the conservation of natural resources. Conservation of resources, prevention of negative impact on the environment and bringing the best balance in the development of human society are possible only by applying the principles of sustainable development [1]. Sustainable development represents meeting the needs of current generations without compromising the ability of future generations to meet their needs [3].

In order to ensure a sustainable transport system, it is necessary to ensure sustainability throughout the supply chain from the first producer to the final consumer. Demand for transport is increasing and thus there is an increasing need for the introduction of sustainable supply chains and sustainability in all logistics

processes [4]. The problem of sustainable development is directly linked to the development of the economy and society.

The logistics branch that deals with sustainability of urban areas is named city, or urban logistics. Cities, as places of concentration of economic activities, are the basic areas in which the sustainability of the logistics system can be implemented. In order to ensure the sustainability of logistic activities in the city area, primarily urban freight transport, various measures have been defined. These can be divided into political measures initiated by local government and measures initiated by companies involved in the implementation of logistics activities [5].

Urban freight transport is one of the causes of traffic congestion. Parking, loading and unloading vehicles are challenging parts of urban delivery, due to the lack of space. Also, the double-parking of the delivery vehicles for loading/unloading processes causes traffic congestion in cities by interrupting the traffic flow and temporarily reducing road capacity. Better planning for moving and stopping trucks allows a potential reduction in congestion in cities [6]. Therefore, it is necessary to understand this problem and measure its impact.

3. RESEARCH METHODOLOGY

The initial phase of the research involves data collection. The first step is to choose representative streets where data should be collected. One of the most important criteria for selecting a street is the type, number and density of the facilities. Commercial establishments such as consumer goods retail outlets, computer equipment stores, bakeries and other similar objects require product delivery several times a week, and some of them require daily deliveries. Also, facilities such as coffee bars and restaurants also require frequent delivery of food and beverages and frequent collection of return materials. For these reasons, city streets that have a large number and density of described facilities should be preferred.

Delivery vehicles that do not have reserved space for loading and unloading operations most often stop on the roadway, thus occupying the surface intended for the movement of vehicles. This problem often occurs in densely populated urban areas. Therefore, the city centre and areas near by the central district should also be preferred for the survey location.

The extent of impact on other road users is in direct correlation with number of traffic lanes per direction of traffic movement. Therefore, the data sample should be collected from the different lane-per-direction structure of the street.

Next step of the research is to choose the periods of the day when the data should be collected. The two characteristic periods for traffic congestion are: peak and off-peak period. The peak periods occur when people are traveling to work (morning peak period) and when people are returning home from work (afternoon peak period). The off-peak periods are periods other than peak periods. The data was collected from both periods because of the different traffic patterns.

There are different ways of the sample collection from the field. The preferred collection method for this research is video recording of the delivery operations. After the field collection is finished, the recordings can be analyzed multiple times. This is why this method of sample collection ensures the high quality and completeness of the data collected.

Based on the video, the double-parking times and the number of delivery vehicles in the observed streets were determined. Also, the number and the time spent by the vehicles that had to stop behind the double-parked delivery vehicle is determined, as well as the number of vehicles that overtook the double-parked delivery vehicle without being affected.

The selection of the surveyed street was made on the basis of various criteria, such as: the number of traffic lanes, the location of streets, the number of retail and commercial establishments in the observed streets, such as the protocol reached during the day.

We analyzed the case study of Novi Sad. There is a number of streets that fit the criteria described in the methodology section and two streets have been selected for the purpose of research:

- The Danila Kiša Street;
- The Novosadskog sajma Street.

Danila Kiša Street is a two-lane street (one traffic lane per direction of movement) and the street is 480 meters long. The street is located near by the central city district and there are various types of facilities. There is organized parking on the Danila Rain Street parallel to the roadway but there is no reserved parking space for goods delivery vehicles. From the source [7] one can obtain the flow of vehicles in the observed street at the busiest hour and it amounts to 307 veh/h.

The Novosadskog sajma is a four-lane street (two traffic lanes per direction of movement). This street is also located in the vicinity of the central city area, its length is 850 meters. At the part where the video recording took place there are two cafes, two grocery stores, three bakeries, a bus stop and two access streets. In the observed part of the street the traffic flow is 781 veh/h [7].

Data were collected by recording videos over 3 periods during the day. For both observed streets, the data were measured in three 2-hour periods:

- period 1 - the morning peak from 08:00 to 10:00,
- period 2 - off-peak period from 12:00 to 14:00, and
- period 3 - afternoon peak from 16:00 to 18:00.

4. RESULTS AND DISCUSSION

4.1. The two-lane street analysis

For the analysis purpose, all the vehicles in the traffic flow were divided into two categories: affected and non-affected vehicles. Affected vehicles are those that had to stop behind the delivery vehicle. Non-affected vehicles are those that had a

free lane from the opposite direction and could overtake the double-parked delivery vehicle without stopping. This data is shown in Figure 1.

In order to identify the magnitude of the problem observed, we determine the number of vehicles in a period of time affected by the double-parked delivery vehicles. The data shown in Figure 2 present the total number of affected vehicles divided by the total time the delivery vehicles were double-parked in each period. In such a way the number of vehicles per hour affected by the double-parked delivery vehicles is obtained.

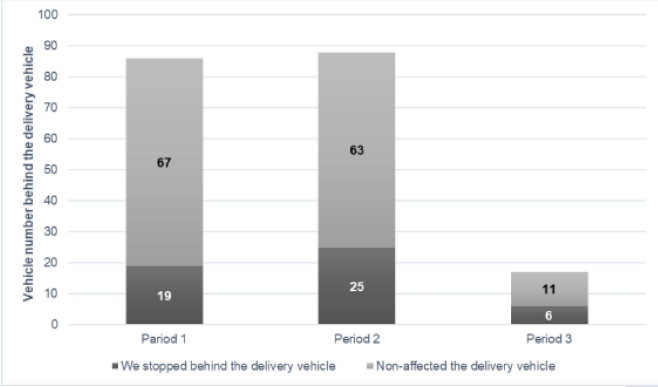

Figure 1. The delivery vehicle double-parking impact on two-lane two-way street

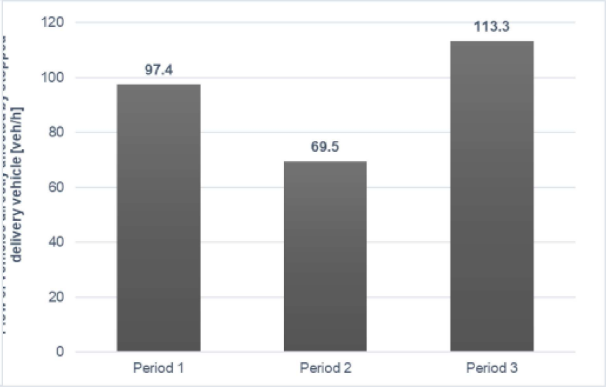

Figure 2. Affected vehicles per hour of double-parking on two-lane two-way street

4.2. The four-lane street analysis

In this case, the vehicles were also grouped into two categories: affected and non-affected vehicles. This data is shown in Figure 3.

The data shown on Figure 3 and Figure 4 are similar like the data on Figure 1 and Figure 2. The difference is that data shown on Figure 3 and Figure 4 are related to four-lane two-way street.

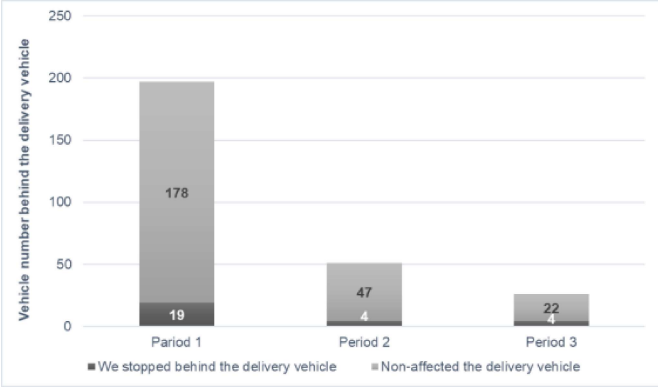

Figure 3. The delivery vehicle double-parking impact on four-lane two-way street

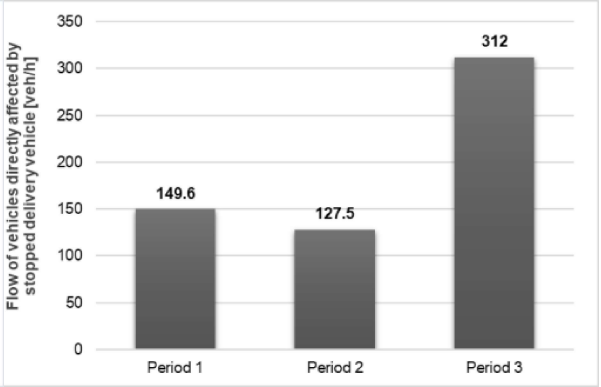

Figure 4. Affected vehicles per hour of double-parking on four-lane two-way street

4.3. Comparative analysis and forecasts

In order to analyze obtained results, comparative analysis is conducted for both survey locations. For each of the streets, the current situation and the situation in the planning period for 2029 are shown in Table 1. Predictions were obtained from source [7].

The symbols used in the Table 1 have the following meanings:

- total time lost by all vehicles per day (Td);
- the total additional distance that all vehicles could have traveled within a day without being affected by the delivery vehicle (Ld);
- total time lost by all vehicles observed for the whole year (Tg);
- the total additional distance that all vehicles could have traveled over a period of one year without being affected by the delivery vehicle (Lg).

Table 1. Parallel representation of the obtained results in the existing and forecasted state

Street name		**Danila Kiša**		**Novosadskog sajma**	
Observed condition		Current state	The future state	Current state	The future state
Peak hour flow [veh/h]		307	721	781	1477
AADT [veh/day]		2558	6011	6508	12308
Total daily	Td [h]	1,01	2,38	3,32	6,3
	Ld [km]	50,23	118,1	164,7	311,5
Total annualy	Tg [h]	264,4	621,2	866,5	1644,3
	Lg [km]	13110	30824,1	42987,8	81301,5

Based on this analysis, we can notice a significant increase in time loses both in two and four-lane streets. In two-lane street, all the forecasted losses are increased by a growth factor of 2.35, while in the four-lane street a smaller growth factor appears, but it is also very significant. In four-lane two-way street all the losses are increased by 1.9 times. This problem will create higher losses in the future, both in time and in the driving distance that is not realized.

When the loading/unloading time of the delivery vehicle is known, as well as the number of vehicles affected by each delivery vehicle, the impact of the delivery vehicle double-parking on the average time lost of the vehicles affected by the delivery vehicle can be determined. Table 2 shows time losses of the vehicles affected by the double-parked delivery vehicles.

Table 2. Impact of the duration of the delivery vehicles on the losses of other vehicles

Delivery vehicle double-parking time	Peak period	Off-peak period
< 1 min	–	0
1 – 3 min	15,43 sec	1,49 sec
3 – 5 min	22,11 sec	8,67 sec
5 – 10 min	17,5 sec	20,67 sec
> 10 min	37,2 sec	45,2 sec

The analysis confirmed that the time losses of other road users is related to the double-parking time of the delivery vehicle, i.e. the longer the double-parking of the delivery vehicle is, the time losses of the other road users are higher. When the retention of a delivering vehicle is longer than 5 minutes, a greater time loss occurring during the emergency period than during the peak period can be observed. In the extraordinary period there is a linear relationship between the retention time of the delivered vehicles and the resulting time losses, while in the peak period this is not the case.

When looking at two-lane two-way street, these time losses are about 265 hours per year in the current state, and according to projections of the future state for 2029 they will be about 135% higher. If we look at a four-lane two-way street, the total time losses occurring annually are about 865 hours, and by 2029 they are forecasted to be about 90% higher. At high-flow streets, these daily and annual time losses are expected to be much higher.

5. CONCLUSION

The impact of double-parked delivery vehicles on congestion, as one of the external effects of urban freight transport, was confirmed by using the case study of Novi Sad. This research has determined the magnitude of the problem on two-lane and four-lane urban streets in peak and off-peak periods. The results of the research give a good basis for modeling the impact of delivery vehicles on traffic congestion in urban areas. The results obtained can be useful for urban transport planners and city logistics researchers.

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