IDENTIFYING THE DWELL TIME CHANGE WITHIN THE OPERATED VEHICLE VIEW

MILOŠ POLIAK[1], PETER MEDVIĎ[2], PETER BLAHO[3]

University of Zilina
ZSR, a.s.

Summary

In public transport, especially in bus services, the number of passengers decreases, largely because individual car transport are able to provide a higher quality passenger transport. Passengers choose the mode of transport based on the shortest travel time. This is why the share of individual car transport is growing, especially in suburban bus transport, but also in urban transport in smaller towns. Given that the travel time is more important for a traveler compared to the cost of transport, the aim of this contribution is to verify the hypothesis that shorter stopping times are needed for vehicles with a smaller capacity. When verifying the hypothesis, the authors will also address the issue of the impact of the number of vehicle doors and total capacity on the total travel time of the passenger.

Keywords: dwell time, public transport, type of vehicles, number of passenger

1. Introduction

Mass passenger transport has a major role to play in fulfilling the basic functions of populated areas and cities. With the current growth of individual car traffic, it is necessary to look for ways to improve the quality of public transport, its technology, technology and organizations, so as to favorably influence the division of labor for mass passenger transport. It is in the interest of protecting the environment, communication capacities, the economy of society, energy savings, and so on. [1]

Transport, and hence public transport, is a business. They are governed by business principles, and need to be organized in that direction. At present, when the level of motorization increases and the urban public transport ratio of 65:35 (in 2002) to about 25:75 (2018) decreases, it is necessary and necessary to improve the quality public transport in order not to worsen this current situation, but at least to maintain the current level. [1]

---

[1] University of Zilina, F PEDAS, Katedra cestnej a mestskej dopravy, Univerzitná 8215/1, 010 26 Žilina, e-mail: milos.poliak@fpedas.uniza.sk

[2] University of Zilina, F PEDAS, Katedra cestnej a mestskej dopravy, Univerzitná 8215/1, 010 26 Žilina, e-mail: peter.medvid@fpedas.uniza.sk

[3] Železnice Slovenskej republiky, Oblastné riaditeľstvo Žilina, 1. mája č.34, 010 01 Žilina, e-mail: blaho.peter@zsr.sk.

The forecast for the development of transport in Slovakia says that passenger transport will continue to dominate individual car transport, which will retain over 70% of the number of passengers transported, while reducing the share of public transport, which will drop to 26%. [2]

Public transport has a steadily decreasing trend in the number of passengers carried, and no improvement can be expected in the next years. The consequences of such developments are already evident today, increased accidents, increased emissions, congestion, noise and, ultimately, the overall slowdown in traffic. Despite all this, however, it is naive to assume that public transport is so attractive that users of individual car traffic have gone into its system. The car provides the passenger with a sense of personal freedom, independence from the timetable and route of the vehicle. Nowadays, it is possible to go the car to any place where the roads are built, and in time for the passenger. When traveling by car, passengers have no time lost when purchasing travel documents, waiting for public transport, on terminal stop or moving from public transport to the destination of their journey. The indisputable advantages of individual car transport multiply the convenience of the transported person, which is created by the interior and the complementary equipment corresponding to the capabilities of the car owner. From the point of view of the quality of life of the population, especially in larger urban agglomerations, however, the growth of individual car transport can not be supported. In addition, the socio-economic aspect must be taken into account. [3, 10]

The transport requirements are increasing and the demands for the quality of the relocation, together with the development of individual cities, areas, with the fulfillment of their functions, and with a change in the lifestyle of the inhabitants, especially the travel time and travel speed, are increasing. Mass passenger transport makes it possible to provide, in many cases, comparable quality and fast transport services such as individual car transport. Its extraordinary benefits to the company stem mainly from: the conversion into one transported person shows a lower fuel and energy consumption, less transportation space, a lower social cost, and a significantly less negative impact on the environment. [4]

The preference of public transport in the densely populated area and on the city's communications network is an important technological element in transport management and organization. It uses certain legislative measures and restrictions on the preference of public transport over other transport, for example road freight. [12]

The perception of the attractiveness of the public transport system is a criterion which is to a large extent subjective. Therefore, it is possible to establish 6 basic areas or requirements that must be met in order for the public transport system to be perceived as attractive and of high quality by the passenger-customer. [5, 13]

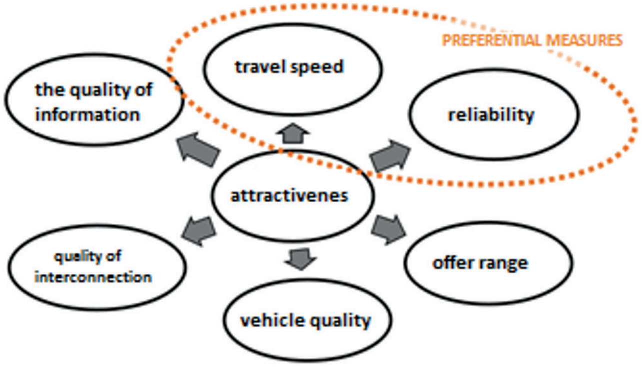

Fig. 1 The six basic areas of perception of the quality of public transport [5]

The time of stay at the stop also has a major impact on the passenger's travel time. By changing it, it is possible to change the travel time itself. Since small vehicles have fewer doors and their capacity is lower than for articulated buses, their waiting time at the stop is expected to be shorter. Also, smaller vehicles are lighter and their dimensions are smaller, which in turn can influence when entering or leaving a stop. [14]

The task is to identify the change dwell time when changing the operated transport means and whether it is possible to speed up the entire passenger transport and reduce its travel time in such a way. For the reason that the travel time is more important for a passenger compared to the transport price, the aim of this contribution is to verify the hypothesis that shorter stopping times are needed for vehicles with a smaller capacity. When verifying the hypothesis, the authors will also address the issue of the impact of the number of vehicle doors and total capacity on the total travel time of the passenger. [17]

2. Analysis of dwell time of the public transport vehicle at the bus stop

The dwell time of the vehicle at the bus stop is the time of delay of the vehicle (or set of vehicles) that makes the link on the bus line regarding with stop at the bus stop. The stop time is defined as the sum of the time needed to stop at a certain ride speed, the stopping time at which the passengers arrive and exit and the time required to leave the stopping area until a certain ride speed is reached.

The dwell time can also be defined as the time difference between passing a line section on which located is one stop, stopping at a bus stop and passing the same track without stopping at the stop.

Dwell time is an important operational cost factor that affects travel and circulation speed, time and speed of the link on bus line, running time, operating costs, and mass passenger transport capacity.

By shortening the stop time it is possible to achieve:

- increase in travel speed,
- shortening the subsequent traffic interval,
- increasing transport capacity.

Increasing travel speed and transport capacity by reducing dwell time is significantly more efficient and more advantageous in terms of transport safety than increasing technical speed or acceleration and deceleration values. Increasing speed, acceleration and deceleration puts high demands on the performance of traction engines installed, on the quality of the road and its directional and height lines, on vehicle construction, on fuel consumption and energy. [4]

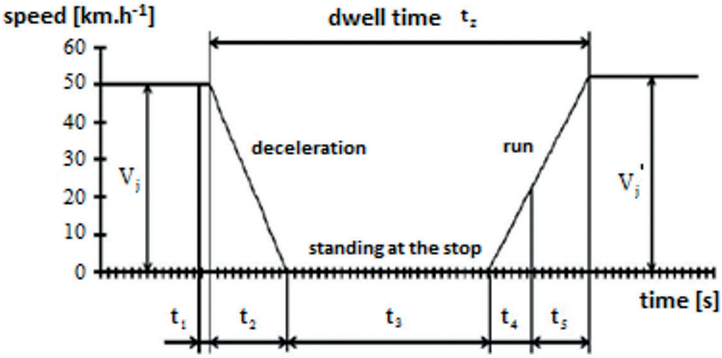

Fig. 2. Dwell time in public transport [4]

The individual time slots are characterized as follows:

t_z	dwell time [s]
t_1	the time required to reach the distance corresponding to the driver's response and the technical characteristics of the brakes from the moment of braking application to the start of braking [s],
t_2	the time needed to stop the vehicle while changing speed from $Vj > 0$ to $Vj = 0$ [s],
t_3	the stand-alone time at the bus stop (time interval that includes door opening and closing, signaling, passenger arrival and exit, driver's rection before leaving the bus stop) [s],
t_4	the time required to leave the bus stop area [s],
t_5	the time needed to reach speed $V'j$ from the moment of leaving the bus stop [s],
V_j	the vehicle's driving speed at the start of braking [km.h^{-1}]. [4, 6]

Vehicle stands at the bus stop

At this time, we distinguish:

- Time dependent on the range of passengers changing (turn-around passengers at the stop). This time is a variable value dependent on the number of people get in to the vehicle and get off at the stop.
- Time independent of the range of passengers changing, which is related to the technical conditions of the stopping time, such as signaling, opening and closing of the doors. This time corresponds to the transport organization at the stop or station and the signaling system and is calculated according to the formula: [4]

$$t_3 = t_{nz} + {}^1t_c \cdot o_{nv} \tag{1}$$

where:

t_3 - dwell time at the bus stop (door opening and closing, signaling, passenger get on and get off, driver's reaction before leaving the bus stop) [s]

t_{nz} - part of dwell time at the bus tops independent of the number of passengers [s]

${}^1t_c$ - average entry and exit time of 1 passenger [s·person-1]

o_{nv} - number of enter and exit passengers at the bus stop [person]

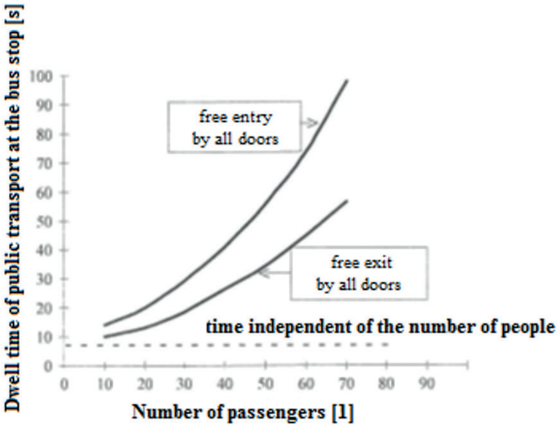

Fig. 3. Dwell time of public transport at the bus stop [4]

Impact of dwell time at the bus stop on the link time at the bus line

The link is intended for individual transport connections between certain places in the regular traffic service of these places by timetable or otherwise temporally and locally. As a link, we understand driving from a point on a line where the first boarding of the passengers is set to another location on the line where the get off of all passengers is determined. These places are final stops. The stops between these final stops are intermediate stops. [15]

Link time is the time period between the time of departure of the link from its first stop and the time of arrival to its final stop. Includes driving time and the sum of stop times for intermediate stops on the bus line route.

$$t_s = t_j + \frac{n_Z \,.\, t_Z}{60} \tag{2}$$

$$t_s = \frac{l_Z \,.\, 60}{V_t} + \frac{n_Z \,.\, t_Z}{60} \tag{3}$$

where:

t_s - the link time on the bus line [min]

V_j - driving time on the bus line [min]

n_z - the number of intermediate stops of one link on the bus line [-]

t_z - dwell time at the bus stop (mean value on the line) [s]

l_z - operating line length [km]

V_t - technical line speed [km.h^{-1}]

If it is considered that the dwell time will change for different vehicle types, this change can be expressed by the following equations:

- link time for the first type of bus: $t_{s_1} = t_{j_1} + \dfrac{n_z \,.\, t_{z_1}}{60}$ [min] (4)
- link time for the second type of bus: $t_{s_2} = t_{j_2} + \dfrac{n_z \,.\, t_{z_2}}{60}$ [min] (5)

To simplify the calculation, the same driving time will be considered, and therefore $t_{s_1} = t_{s_2}$. the resulting time change equation will have a shape after editing:

$$\Delta t_s = (t_{s_1} - t_{s_2}) \tag{6}$$

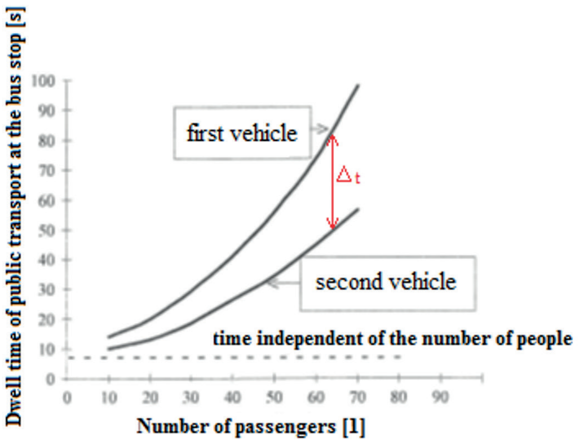

Fig. 4. Different times of vehicle standing at stop [4]

Factors that act on the dwell time resulting from the vehicle's technical parameters

Several factors influence the dwell time at the stop:

- *the time of changing passengers at the stop* – this is also dependent on the number of doors in the vehicle. Small buses operated in transport companies in Slovakia usually have 3 to 4 doors for changing passengers. For larger articulated vehicles, it is possible to use 4 to 5 doors at the get on and get off.
- *low-floor vehicles* – today low-floor vehicles are mostly used in urban public transport in Slovakia, which simplifies the exchange and shortened the time of changing passengers. However, in suburban bus services, the vehicles still have a floor height and the passenger is thus obliged to overcome a longer distance when entering and exiting the vehicle, and its time of enter or exit is prolonged.
- *Interior layout in the vehicle* – an important role in the dwell time at the bus stop is also the arrangement of the interior of the vehicle on fully occupied vehicles. In the case of inadequately designed interior, the passengers need to overcome obstacles unnecessarily long, which hinders them. In SOR vehicles, passenger seats are located on the stairs, the aisle remains very narrow between them, making it difficult for the passenger to pass from his place to the door.

Fig. 5. The interior of bus SOR NB 18 City in Košice

- *way of passenger dealing* – this factor also plays an important role at dwell time. If the passenger is required to enter only one door and must buy the ticket at the driver, the time is extended. If all the doors can be used by the passengers, they mark the ticket at the nearest marker – this way significantly reduces the time of the vehicle's stay at the stop.

There are other factors that also affect the dwell time. It is necessary to pay attention to them and to find out their impact, because it is only possible to concretize the individual factors and reduce their impact on this time.

The American literature on the patterns of stopping at the stop is rich. Lin and Wilson studied this time in LRT systems. They found that, in addition to the get on and get off of passengers, the delay time is also influenced by the number of passengers in the vehicle. They also tested nonlinear functions and found that they had better results than linear ones. Then Aashtiani and Iravani suggested several nonlinear time models, including the vehicle load factor and the number of doors. Rajbhandari et al. tested different models of linear and nonlinear regression from automatic passenger counting. They stated that additional variables, such as the number of vehicle doors and the method of passenger handling, will increase the explanation of the bus retention time. The work of Li et al (7), on the other hand, represents an interesting method for estimating the choice of passenger doors. [6]

3. Defining a research sample

The research sample for verification of defined hypotheses is the two cities in the Slovak Republic: Košice and Žilina, where various means of mass passenger transport are operated.

Dopravný podnik mesta Košice operates three types of buses on its lines. Representative of the small (solo) bus is SOR NB 12. Their total capacity is 101 passengers. Four doors are provided to the passenger for get on and get off.

Solaris Urbino 15 buses represent the medium type of buses. The total capacity of these vehicles is 145 seats. At present their Košice transport company owns 28 pieces. Passengers can use three doors for entry and exit.

Dopravný podnik mesta Košice also owns articulated buses - type SOR NB 18. The capacity of the vehicles is 148 passengers and they have five doors. We will find 56 such buses in the vehicles park of the Dopravný podnik mesta Košice.

Tab. 1 Characteristics of public transport vehicles in Košice

	Bus		
	SOR NB 12 City	**Solaris Urbino 15**	**SOR NB 18 City**
Type of vehicle	small	medium	articulated
Low-floor	yes	yes	yes
Number of doors [pcs]	4	3	5
Capacity of vehicle [passengers]	101	145	148

Fig. 6 Public transport vehicles (buses) in Košice [10]

In addition to bus transport, the transport company of Žilina operates trolleybus. Currently it operates 5 types of trolleybus and most of them have a low floor.

In the fleet there are small Škoda 30 Tr SOR and Škoda 26 Tr Solaris trolleybuses. Škoda 30 Tr SOR provides space for up to 95 passengers. The new addition to the car park, the Škoda 26 Tr type, provides seats for 92 passengers. Four doors for the Škoda 30 Tr SOR and 3 doors for the Škoda 26 Tr Solaris are available at the exit and the entrance of the passengers.

DPMŽ owns 3 types of articulated trolleybuses - Škoda 15 Tr, Škoda 31 Tr SOR and Škoda 27 Tr Solaris. The oldest type, Škoda 15 Tr, is the last type of trolleybus series that still has a high floor. These vehicles have capacity for 151 passengers and they have four doors. Gradually, these trolleybuses are replaced by Škoda 31 Tr SOR vehicles and the latest Škoda 27 Tr Solaris. Škoda 31 Tr SOR offers a seat for 167 passengers and 5 doors for entry and exit. Newer Škoda 27 Tr vehicles have a capacity of 132 passenger seats and 4 doors are used for passenger transport.

Tab. 2 Characteristics of public transport vehicles in Žilina

	Trolleybus				
	Škoda 26 Tr Solaris	**Škoda 30 Tr SOR**	**Škoda 15 Tr**	**Škoda 27 Tr Solaris**	**Škoda 31 Tr SOR**
Type of vehicle	small	small	articulated	articulated	articulated
Low-floor	yes	yes	no	yes	yes
Number of doors [pcs]	3	4	4	4	5
Capacity of vehicle [passengers]	92	95	151	132	167

Bus fleet of Žilina contain a various variety of vehicles. Local DPMŽ operates up to 9 bus types on public transport lines. This article focuses on the types of vehicles that were used during the analysis. DPMŽ operates mainly small buses on its lines and mainly uses Karosa B932, Karosa B952, Irisbus Citelis 12M, Iveco Urbanway 12M Hybrid, Solaris Urbino 12.

Vehicles Karosa B 932, B 952 have similar technical parameters and space for 95 to 99 passengers, they can enter and exit through 3 doors. These vehicles are the last type of buses in Žilina that have a high floor. Irisbus Citelis 12M and Solaris Urbino 12 buses also have the same capacity and have three doors for entry and exit. The latest vehicles in the bus transport vehicle are the Iveco Urbanway 12M Hybrid, which has a capacity of 71 passengers and has 3 doors for passenger exchanges.

Fig. 7. Public transport vehicles (trolleybuses and hybrid bus) in Žilina [10]

Tab. 3 Characteristics of public transport vehicles in Žilina

	Bus				
	Karosa B 932	**Karosa B 952**	**Irisbus Citelis 12 M**	**Solaris Urbino 12**	**Iveco Urbanway 12M Hybrid**
Type of vehicle	small	small	small	small	small
Low-floor	no	no	yes	yes	yes
Number of doors [pcs]	3	3	3	3	3
Capacity of vehicle [passengers]	95	99	99	99	71

4. Analysis of dwell times at bus stops

The section of Košice where the busiest bus stops in the city are located – a large number of passengers are coming or going. Seven stops – Palackého, Námestie Osloboditeľov, Krajský súd, Mlynská bašta, Tomášikova, Mier and Tesco, Džungľa, which are serviced by all types of public transport vehicles in Košice (small, medium, articulated) were included in the analysis.

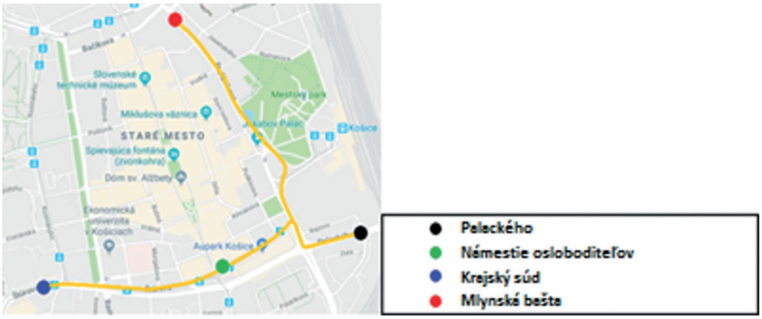

Fig. 8. Location of the bus stops in Kosice – the first part [9]

Fig. 9. Location of the bus stops in Kosice – the second part [9]

When analyzing the data obtained, the average values of the dwell time at the bus stop, which are shown in the following Tables 4 to 7, were calculated and their value is displayed in seconds. The time of the vehicle at the stop was counted from the arrival to the stop until his departure. The analysis included a total of 1440 dwell times per 15-bus lines.

Tab. 4. Dwell time average values of public transport vehicles in Košice at the bus stops Palackého, Námestie osloboditeľov and Krajský súd (time - in sec)

Dwell time [s]		**Name of the bus stop**								
		Palackého			**Námestie osloboditeľov**			**Krajský súd**		
		peak	**saddle**	**total**	**peak**	**saddle**	**total**	**peak**	**saddle**	**total**
type of vehicle	small	46.33	41.17	43.75	49.63	44.17	46.90	39.40	39.93	39.67
	articulated	45.97	43.67	44.82	53.51	45.21	49.36	43.32	38.03	40.68
	total	46.08	42.95	44.51	51.79	44.75	48.27	41.64	38.85	40.24

Tab. 5. Dwell time average values of public transport vehicles in Košice at the bus stops Mlynská bašta, Tomášikova (time - in sec)

Dwell time [s]		**Name of the bus stop**					
		Mlynská bašta			**Tomášikova**		
		peak	**saddle**	**total**	**peak**	**saddle**	**total**
type of vehicle	small	37.00	35.61	36.31	44.87	37.04	40.96
	articulated	40.10	39.20	39.95	46.18	37.58	41.88
	medium	39.33	35.80	37.57	42.73	37.20	39.97
	total	38.42	36.84	37.63	45.12	37.30	41.21

Tab. 6. Dwell time average values of public transport vehicles in Košice at the bus stops Mier a Tesco, Džungľa (time - in sec)

Dwell time [s]		**Name of the bus stop**					
		Mier			**Tesco, Džungľa**		
		peak	**saddle**	**total**	**peak**	**saddle**	**total**
type of vehicle	small	46.20	40.13	43.17	47.47	33.90	40.68
	articulated	47.11	40.27	43.69	49.56	37.80	43.68
	medium	44.00	43.47	43.73	46.27	37.67	41.97
	total	46.29	40.76	43.52	48.31	36.48	42.39

Tab. 7. Total dwell time average values of public transport vehicles in Košice at the analysis bus stops (time - in sec)

Dwell time [s]		**average value**		
		peak	**saddle**	**total**
type of vehicle	small	44.41	38.85	41.63
	articulated	46.54	40.25	43.44
	medium	43.08	38.54	40.81
	total	45.38	39.70	42.54

From average values, it can be seen that articulated vehicles have stayed at the bus stop for the longest, although occasionally there have been occasions when small buses have had this average time higher.

Peak - medium vehicles (Solaris Urbino 15) stayed shorter at bus stops (bus line 27) when their average stop time was 43.08 seconds. On the contrary, the longest delays were articulated vehicles - 46.54 seconds.

The total dwell time at all analyzed bus stops was 45.38 seconds in transport peak, at the transport saddle 39.70 seconds. This means that the number of passengers also plays an important role at these times.

Tables 8 to 10 contain the dwell time interval. It is also in seconds.

Tab. 8. Dwell time interval of public transport vehicles in Košice at the bus stops Palackého, Námestie osloboditeľov a Krajský súd (time - in sec)

Dwell time [s]		**Names of the bus stops**											
		Palackého				**Námestie osloboditeľov**				**Krajský súd**			
		peak		**saddle**		**peak**		**saddle**		**peak**		**saddle**	
		from	**to**	**from**	**to**	**from**	**to**	**from**	**to**	**from**	**to**	**from**	**to**
typ of vehicles	small	24	103	31	81	31	89	24	75	29	85	23	102
	articulated	32	77	28	71	35	93	20	66	29	75	27	53
	total	24	103	28	81	20	93	20	75	29	85	23	102

Tab. 9. Dwell time interval of public transport vehicles in Košice at the bus stops Mlynská bašta, Tomášikova, Mier a Tesco, Džungľa (time - in sec)

Dwell time [s]		**Names of the bus stops**							
		Mlynská bašta				**Tomášikova**			
		peak		**saddle**		**peak**		**saddle**	
		from	**to**	**from**	**to**	**from**	**to**	**from**	**to**
typ of vehicles	small	29	59	25	51	29	70	30	60
	articulated	33	54	30	51	32	71	31	47
	medium	30	47	31	42	32	66	28	48
	total	29	59	25	51	29	71	28	60

Tab. 10. Dwell time interval of public transport vehicles in Košice at the bus stops Mier a Tesco, Džungľa (time is - sec)

Dwell time [s]		**Names of the bus stops**							
		Mier				**Tesco, Džungľa**			
		peak		**saddle**		**peak**		**saddle**	
		from	**to**	**from**	**to**	**from**	**to**	**from**	**to**
typ of vehicles	small	29	79	30	67	27	69	28	48
	articulated	34	82	30	75	22	81	30	65
	medium	32	70	34	61	30	61	30	69
	total	29	82	30	75	22	81	28	69

Tab. 11. Dwell times - total intervals of public transport vehicles in Košice at this analysis bus stops (time - in sec)

		peak		**saddle**	
		from	**to**	**from**	**to**
type of vehicle	small	24	103	23	102
	articulated	22	93	20	77
	medium	30	70	28	69
	total	22	103	20	102

Dwell time intervals indicate that the articulated vehicles were slower at the stop. The largest range, however, was recorded in small vehicles where peak values ranged between 24 and 103 seconds and in the saddle it ranged from 23 to 102 seconds. The shortest delay at the stop was on the articulated vehicle, the peak – 22 seconds and the saddle – only 20 seconds. On the contrary, the longest delay was in small vehicles, when lines on bus line 20L abstained 102 or 103 seconds.

In July 2018, a survey was conducted in Zilina to find out the values of the time of changing passengers for different types of vehicles. Bus vehicles, as well as trolleybus vehicles, were included in the analysis. Public transport stop Železničná stanica (The railway station) was selected as the location of the survey with respect to the frequency of the links. The exchange time was measured from the door opening until the door is completely closed.

Tab. 12. Analysis of the time of the passengers changing in Žilina

Type of vehicles	**Size**	**Low-floor**	**Numbers of doors [number]**	**Length time of the passengers' changing [s]**		**Passenger changing – Number [passengers]**		**Average exchange time per 1 passenger [s]**
				from	**to**	**from**	**to**	
Karosa B 932, B 952	small	no	3	6	26	2	19	2.85
Irisbus Citelis 12M	small	yes	3	10	19	4	13	2.03
Solaris Urbino 12	small	yes	3	9	14	3	11	1.79
Iveco Urbanway 12M Hybrid	small	yes	3	3	20	1	15	2.03
Škoda 26 Tr Solaris	small	yes	3	9	18	4	13	1.72
Škoda 27 Tr Solaris	articulated	yes	4	10	32	7	25	1.41
Škoda 30 Tr SOR	small	yes	4	8	17	4	12	1.67
Škoda 31 Tr SOR	articulated	yes	5	6	24	3	16	1.78

The passenger changing interval ranged from 3 to 32 seconds at the Železničná stanica (Railway Station) stop. The range of passengers was between 1 and 25 passengers. Based on these data, the average changing time per 1 passenger was established. This was highest for the Karosa B932 and B952, which reached a value of 2.85 seconds. On the contrary, the shortest was the most recent Škoda 27 Tr Solaris vehicles, when this average was just 1.41 seconds. For Karosa B932 and B952 vehicles, this high time is mainly due to the fact that the vehicles do not have a low floor, so this time of the passengers is prolonged.

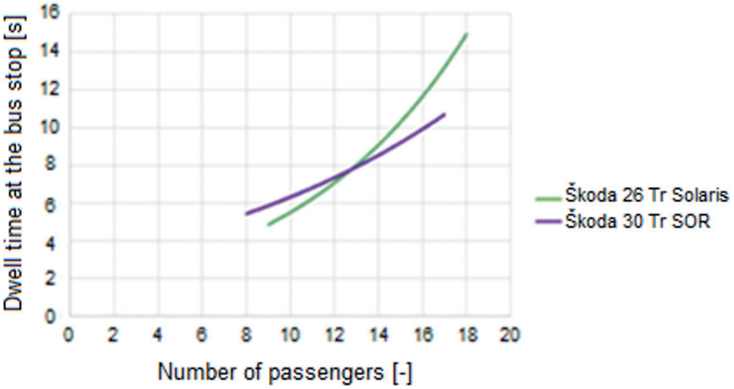

Fig. 10. Dwell time of public transport vehicles in Žilina at the bus stop – small trolleybuses

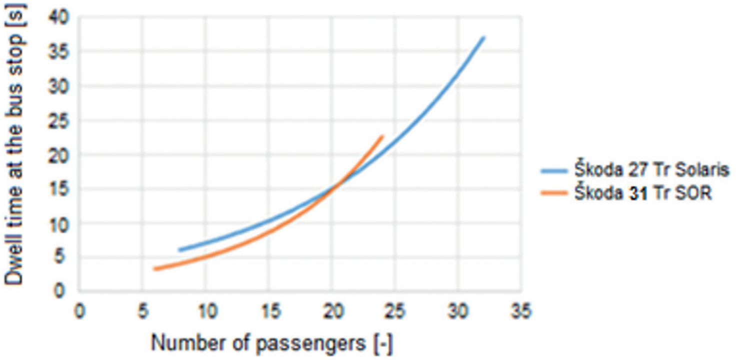

Fig. 11. Dwell time of public transport vehicles in Žilina at the bus stop – articulated trolleybuses

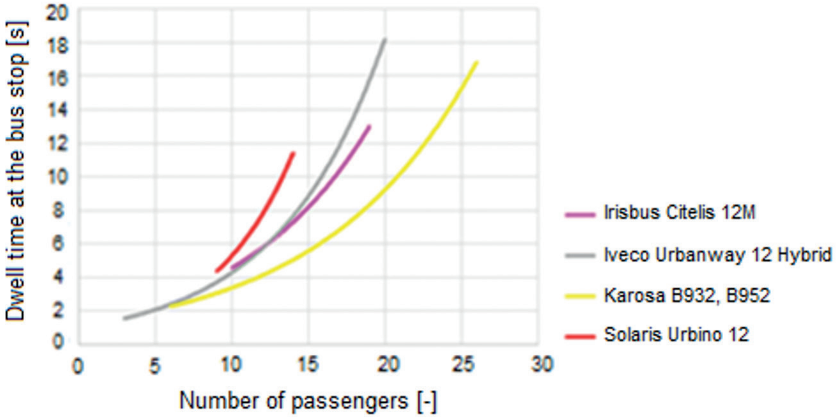

Fig. 12. Dwell time of public transport vehicles in Žilina at the bus stop – small buses

Picture no. 10 to 12 represent the dependence of dwell time at the stop on the number of passengers. The chart shows the vehicles that were analyzed in this article. It can be seen that this time is different for each vehicle. The longest time is for the Karosa B932 and B952.

5. Conclusion

Based on the research that this contribution has made, it can be said that the hypothesis defined in the introduction of the contribution can be considered as verified. The dwell time of vehicles at the stop has been identified as a measure that should be monitored and managed to improve the performance of urban public transport. Since the dwell time values were almost always higher for articulated vehicles, it can be assumed that this time increases with increasing capacity, vehicle length and higher number of passengers. However, this is also related to other technical parameters of vehicles, different number of doors. There is also a low-floor factor at this time. From the results of the analysis from the city of Žilina it can be seen that the exchange of passengers took longer for vehicles with a high floor (stairs). [11, 16]

Another significant factor is the vehicle capacity (number of passengers). The number of passengers greatly affects the total dwell time. From the outputs of this analysis it can be seen that in some cases the situation has arisen that small vehicles have stayed at the same bus stop longer than articulated vehicles (especially at the peak). It can also be argued that the more passengers are in the vehicle, the longer the waiting time is longer. This means that passengers are changing for longer periods, also because a large number of passengers have to use a smaller number of doors to exchange than, for example, in the case of a articulated bus. [16]

The dwell time at the stop, it is also necessary to distinguish time dependent and time independent of the range of passengers. The carrier can decide not only on the basis of the number of doors, but also on the length of opening and closing of the door, duration of signaling. The longer this time will be, the time of the vehicle will be extended again at the stop. Even the method of passenger handling itself has a great impact on the dwell time of vehicle at the stop.

Based on the results of the analysis, it can be stated that the dwell time is influenced by many factors, not only the type of vehicle on the bus line. It would not be right to claim that simply by deploying small vehicles would increase the quality of passenger transport. However, it is important to monitor the values of the dwell time at the stop because of the analyzes carried out, it would be possible to predict their development and this would allow decision-makers to improve bus planning and the overall reliability of buses. As a result, the model could be updated in the specified timeframe due to possible changes in traffic and new infrastructure. The carrier would thus be able to respond appropriately to changes in demand and would be able to shorten travel time by appropriate means of transport. [1]

References

[1] Lokšová Z. Kvalita v hromadnej osobnej doprave [online]. In Doprava a spoje. Žilina: Fakulta prevádzky a ekonomiky dopravy a spojov, KCMD 2007. [cit. 2018- 07-01]. Online available: ‹https://fpedas.uniza.sk/~dopravaaspoje/subory/2007/1/loksova.pdf›.

[2] Počet prepravených osôb a výkony v osobnej doprave [online]. Online available: ‹https://www.enviroportal.sk/indicator/detail?id=761›.

[3] Tisoňová G. Stav a vývoj verejnej osobnej dopravy [online]. In Horizonty dopravy. Žilina: Výskumný ústav dopravy. 2008. [cit. 2018-07-01]. Online available: ‹http://www.busportal.sk/modules.php?name=article&sid=3884›.

[4] Surovec P. Technológia hromadnej osobnej dopravy - cestná a mestská doprava. Vyd. EDIS: Žilinská univerzita, 1998, 153 s. ISBN 80-7100-494-4.

[5] Preference VHD. Online available: http://preferencevhd.info.

[6] Kupčuljaková J. Čas zastávky ako významný prvok cestovného času v MHD. In CMDTUR 2016. Žilina: Fakulta prevádzky a ekonomiky dopravy a spojov, KCMD 2016. s. 222-229. [cit. 2018- 06-30].

[7] Online available: http://imhd.sk/ke.

[8] Online available: https://www.google.sk/maps.

[9] DPMK internal documents.

[10] Jaskiewicz M., Koralewski G., Stoklosa J. Adaptation of City Buses to the Needs of Airport Terminal Passenger Transport. Conference: 11th International Scientific and Technical Conference on Automotive Safety Location: Casta Papiernicka, SLOVAKIA Date: APR 18-20, 2018 XI INTERNATIONAL SCIENCE-TECHNICAL CONFERENCE AUTOMOTIVE SAFETY, Published: 2018.

[11] Moravcik Ľ., Jaskiewicz M. Boosting Car Safety in the EU. Conference: 11th International Scientific and Technical Conference on Automotive Safety Location: Casta Papiernicka, SLOVAKIA Date: APR 18-20, 2018 XI INTERNATIONAL SCIENCE-TECHNICAL CONFERENCE AUTOMOTIVE SAFETY, Published: 2018.

[12] Posuniak P., Jaskiewicz M., Kowalski K. et al. Child restraint systems: problems related to the safety of children transported in booster seats (without integral safety belts). In Conference: 11th International Scientific and Technical Conference on Automotive Safety Location: Casta Papiernicka, SLOVAKIA Date: APR 18-20, 2018 XI INTERNATIONAL SCIENCE-TECHNICAL CONFERENCE AUTOMOTIVE SAFETY, Published: 2018.

[13] Gnap J., Kubanova J. Selected Options for Modelling of Transport Processes Particularly in Relation to Intermodal Transport. In Conference: 18th International Scientific Conference on LOGI, Ceske Budejovice, Czech Republic, date: OCT 19, 2017 Sponsor(s): Inst Technol & Business Ceske, Dept Transport & Logist; Univ Pardubice, Jan Perner Transport Fac; Coll Logist Prerov, 18TH International Scientific Conference-Logi 2017, Book Series: MATEC Web of Conferences, Volume: 134, Article Number: 00015 Published: 2017.

[14] Jurecki R., Stanislaw S., Lech T., Jaskiewicz M. Driver's reaction time in a simulated, complex road incident, In TRANSPORT, Volume: 32, Issue: 1, Pages: 44-54, Published: 2017.

[15] Stopka O., Kampf R. Determining the most suitable layout of space for the loading units' handling in the maritime port. In TRANSPORT, Volume: 33, Issue: 1, Pages: 280-290, Published: 2018.

[16] Stopka O., Chovancova M., Kampf R. Proposal for Streamlining the Railway Infrastructure Capacity on the Specific Track Section in the Context of Establishing an Integrated Transport System. In Conference: 18th International Scientific Conference on LOGI, Ceske Budejovice, Czech Republic, Date: OCT 19, 2017 Sponsor(s): Inst Technol & Business Ceske, Dept Transport & Logist; Univ Pardubice, Jan Perner Transport Fac; Coll Logist Prerov, 18th International Scientific Conference-Logi 2017, Book Series: MATEC Web of Conferences, Volume: 134, Article Number: 00055, Published: 2017.

[17] Konecny V., Gnap, J., Simkova I. Impact Of Fiscal Decentralization On Motor Vehicle Taxation In The Slovak Republic. TRANSPORT AND TELECOMMUNICATION Journal, Volume: 17, Issue: 1, Pages: 28-39, Published: 2016.