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Transport demands in suburbanized locations

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Abstract. The aim of this paper is to describe the suburban residents' transport demands from the viewpoint of consumption costs in the case of regular commuting. The surveyed suburbs have different transport patterns, because these suburbs are influenced by the catchment area of the city of Prague that is a dominant city of the region, and many of the suburban settlements do not behave as traditional municipalities. Most of the existing transport links are carried out in relation to the city of Prague on radially oriented roads. The traffic intensity is often at the roads' full capacity or the roads are even congested along the ride to the city. These congestions have a negative impact on the city's environment and increase the consumption costs of passenger car transport as well. This contribution describes the transport demands based on the traffic surveys that were carried out within 15 suburban settlements during the morning peak hours and during ordinary working days. These selected settlements are located at different distances from the city and include different types of buildings and build-up areas. Thus, the authors gained a high quality sample for statistical assessment. On the basis of traffic surveys, the authors found the total amount of transport demands which were generated by selected settlements. The obtained results have proved the low competitiveness of public transport in suburban conditions from the viewpoint of travelling speed and transport costs as well, because there are no competitive advantages in this issue.

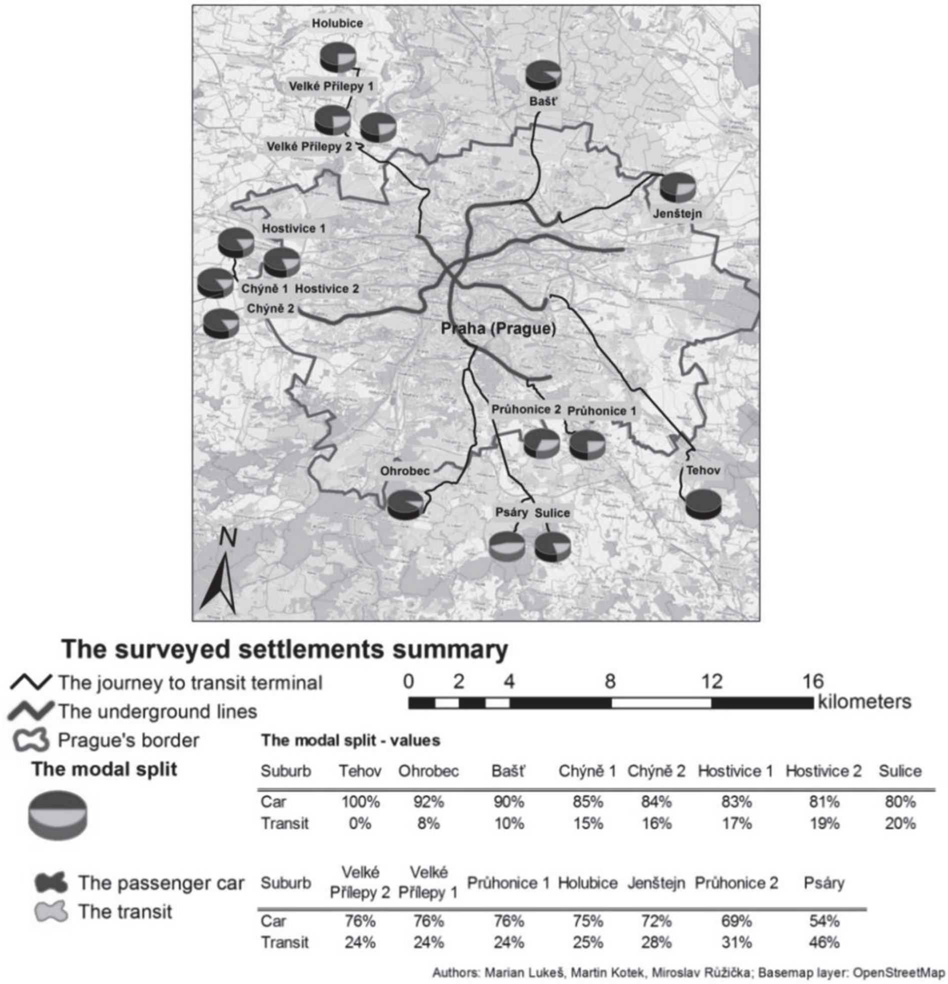
Key words: transit, public transport, passenger car, suburban settlement, suburbanization.

INTRODUCTION

Designing of transport demands in a suburban location is connected to the development of suburban settlements. This trend is apparent from Western Europe in the 60s and earlier from the USA. Dislocation of settlements from urban areas brings increased automobile traffic intensity into the suburban locations. This tendency has had a negative impact on urban traffic in cities and passenger car traffic has a negative influence on public transport (transit). Furthermore, suburban bus transport began to cope with the problems caused by the growing number of passenger cars as well – it has been connected with the development of suburbanization and desurbanisation (Holmgren et al., 2008). This reason has led to the next logical step, i.e. passengers (they used the public transport until this time) have preferred passenger car transport. It could offer them better comfort than the public transport vehicles stopping in the same congestions as their cars. A passenger's decision regarding which transport mode would be used depends on the travel costs, travel time of the journey, traveling comfort, and other personal preferences (Litman, 2004; Mishalani & McCord, 2006). The final decision is the mix of the abovementioned conditions which are either accepted or not. The role (or challenge) of transit is to offer transport within the range of acceptability for the majority of passengers and to become the best alternative. Typically, it is a compromise between travel time (or travel speed, consequently) and travel costs preferences (Litman, 2006). The dependency on usage of passenger cars is growing and is not sustainable at the current pace of growth (Lowson, 2004). Nowadays, we can see how the newly constructed high-capacity road infrastructure changes the landscape. Recreational places become multilevel crossroads or car-oriented shopping malls. This trend to build more and more high-capacity roads (since the initial transport infrastructure is not able to satisfy the increased transport demands) does not solve the problem. As it is evident from examples from many countries, systematic construction of high-capacity road transport infrastructure stimulates other transport demands of passenger cars (induced transport demands) (Small & Winston, 1999). It should be mentioned in this context that it is possible to perceive public transport usage as one of the elements to eliminate the negative impact of motorisation on the environment. The high passenger car dependence is significant especially in suburban conditions and the initial position of public transport is more difficult. The strategic goal is to perceive the public transport as competitive with passenger car transport and offer to passengers an alternative form of attractive public transport (Jakob et al., 2006).

MATERIALS AND METHODS

The 15 localities of suburban settlements were chosen with the aim to describe the transport behaviour of suburban residents. These suburban settlements are influenced by the catchment area of the city of Prague that is a dominant city of the region. The suburban settlements were localized up to 17 km from the city of Prague (the centre). These suburbs were chosen evenly in different directions from the centre of Prague (map on Fig. 1) without direct commuter train connection, thus public transport is organised as suburban bus transport only. The suburban settlements represent different types of buildings, sizes of areas, levels of public facilities, etc. The results of the inquiries provide a wide range of data (building square, public facilities, number of households, cars, residents, etc.) for statistical processing. The traffic surveys were carried out during the morning peak hours (from 6 to 9 am) during ordinary working days. On the basis of these traffic surveys, the authors found the total amount of transport demands which were generated by selected settlements. The traffic surveys were focused on passenger car transport demands, public transport demands, pedestrians, and cyclists. The passenger car transport survey included the following items: type of car (8 classes), directionality, and occupancy. Travel time (by GPS locator) and fuel consumption of gasoline combustion engine (by fuel gauge) were measured under real conditions of traffic flow by measuring cars. The public transport surveys included the following items: directionality, travel time, departure time difference from schedule, occupancy, number of outgoing/incoming passengers, and type of fare. Travel time, time difference from schedule and occupancy were measured under real conditions of traffic flow on a public bus transport. The transport surveys were focused on evaluation of commuting from the selected suburban settlements to the city of Prague. It was sufficient to evaluate journeys from the settlements to the nearest available underground stations (public transport terminals) for the purposes of the research – specifically to the ‘Park and Ride’ parking lots. These radial journeys and modal splits of all surveyed settlements are shown on Fig. 1. The traffic survey was also focused on assessment of the public transport accessibility and on the accuracy of the public transport service in the suburban settlement. Assessment of the public transport accessibility was carried out by measuring the walking distance to the bus stop within each surveyed suburb. The accuracy of the public transport (accuracy of bus connections) was assessed by the time gap between the real departure and scheduled time of departure at the bus stop. The scheduled time of departure is offered by the public transport carrier for its bus lines. This time gap was compared with the Standards of the Bus Service Accuracy, which are provided by the Regional Organiser of Prague Integrated Transport. In this context, it should be notied that all of the surveyed settlements are covered by Prague’s Integrated Transport system.



The modal split - values

Suburb	Tehov	Ohrobec	Bašť	Chýně 1	Chýně 2	Hostivice 1	Hostivice 2	Sulice
Car	100%	92%	90%	85%	84%	83%	81%	80%
Transit	0%	8%	10%	15%	16%	17%	19%	20%

Suburb	Velké Přilepy 2	Velké Přilepy 1	Průhonice 1	Holubice	Jenštejn	Průhonice 2	Psáry
Car	76%	76%	76%	75%	72%	69%	54%
Transit	24%	24%	24%	25%	28%	31%	46%

Figure 1. The modal split of the surveyed suburban settlements and the radial journeys to the city of Prague.

RESULTS AND DISCUSSION

Accessibility of public transport has an important place in the overall view of the attractiveness of public transport, compared to passenger car transport. Fig. 2 briefly describes the distance and time of the accessibility of public transport. The minimum and maximum walking distance values provide a 'design proposal' of how to locate bus stops in the whole settlement. Usually, settlements with a low value of minimum walking distances to the bus stop (up to app. 200 m) have implemented public transport inside themselves or bus stops were used for the settlement's transport needs nearby. Other suburban settlements, where the minimum walking distances are more than app. 200 m, were built without adequate public transport provision and the residents have to use the initial bus stops which are located in the original municipality. The surveyed settlements are often located in the surroundings of original municipalities or just in the countryside; exceptionally, they are located in the centre of municipalities. A good evidence of this fact is the situation in Tehov settlement, which is located completely outside of the original municipality, but the nearest bus stop is located in the centre of the original municipality. The values of time or distance accessibility are extremely high in Tehov settlement (see Fig. 2) and due to this fact the settlement's residents do not use public transport at all. An appropriate walking or cycling infrastructure has not been built in accordance with the construction of the suburban settlement and consequently, a good level of accessibility of the public transit stop is not offered. In many suburbs, it is difficult to reach the bus transit stop by overcoming roads without the elements of pedestrian infrastructure. The roads are crossed at pedestrian crossings over the road or pedestrian crossings are missing entirely. Parents of children do not want to let their children go to the bus stop alone without adult supervising (journey to school, for hobbies, etc.). The reason is the fear of collision with a vehicle. Thus, parents transport their children by private passenger car without public transport usage. In this case, public transport is not perceived as an alternative transportation mode. This fact increases the passenger car dependence to meet the transport demands of entire families. Children accept these parental habits and bring them into their further lives (Daniels & Mulley, 2013). Fig. 2 also illustrates the fact that the appropriate locations of bus stops influence the possibility to achieve shorter walking distances and a good level of public transport's accessibility. A large total surface area of a suburb should not be an obstacle for a good level of the bus stop's accessibility, in general. This fact was also confirmed by the low value of the determination coefficient between a suburban settlement's total area and the average distance of the bus stop's accessibility ($R^2 = 0.010$). For instance, the largest of the surveyed suburban settlements covers the total area of 101 ha and it has a good level of public transit bus stop's accessibility (average time of accessibility is app. 6 minutes by walking). On the other hand, an inappropriate bus stop's location with regard to the build-up area and street structure causes very long walking distances to the bus stop within small settlements (Velké Přílepy 1 settlement only covers the total area of 14 ha). It deteriorates the accessibility of public transit and its attractiveness for passengers in the favour of passenger car transport. It can be assumed that if the average time of bus stop accessibility is about 11 minutes, passenger car usage is perceived as the time saving choice and public transit becomes uncompetitive.

Another important issue in the transit competitiveness that should be taken into account is the accuracy of public transit. Assessment of the accuracy of public transit was carried out by comparing the time gap between real departure and the scheduled time of departure. This time schedule is offered by the public transport carrier and it is publicly accessible. Subsequently, this time gap was compared with the Standards of the Bus Service Accuracy, which are provided by the Regional Organiser of Prague Integrated Transport. According to these Standards, bus connection is considered accurate if the delay is in the range of 0–179 s for intermediate bus stops and in the range 0–59 s for initial bus stop. The standard is not met if 20% of the bus connections are out of this time tolerance for accurate bus service.

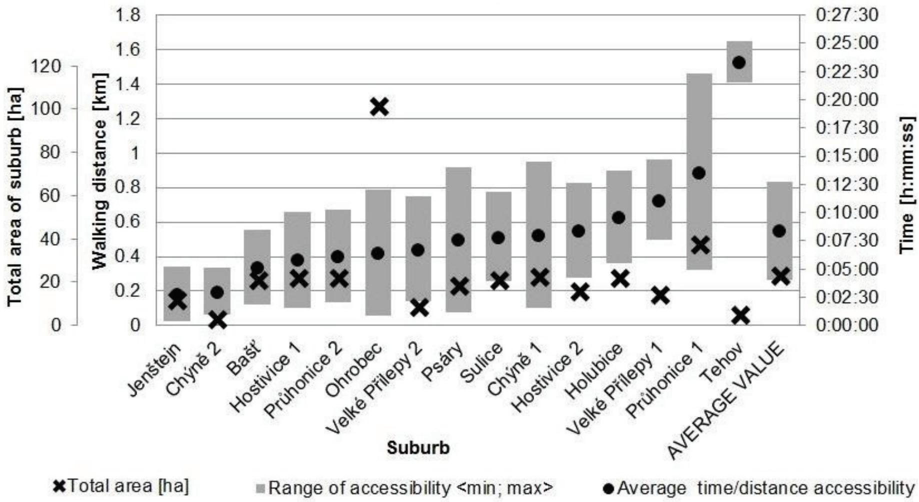


Figure 2. The time and distance accessibility of bus stops by walking.

From the above, it is apparent that departure of a bus connection before the scheduled time in not allowed (the so-called haste of bus connection). The obtained results have shown that only 2 surveyed settlements are on the satisfactory level of public transit accuracy (see Fig. 3) where the 'Standards of the Bus Service Accuracy' are fulfilled. In other suburban settlements, the ratio of inaccurate bus connections varies from 25–65% with regards to the offered bus connections. At this point, it should be noted that a bus stop has a guaranteed departure time in Velké Přílepy 1 settlement. Therefore, the accuracy parameter (0–179 s of delay) there should always be fulfilled. This is also confirmed by the accuracy analysis of transit connections on Fig. 4.

The results have proved a low association between offered public bus connections and the number of inaccurate bus connections by the determination coefficient ($R^2 = 0.382$), and the positive value of the Pearson's correlation coefficient has shown a positive correlation ($r = 0.618$). This fact points to a persistent problem and this problem cannot simply be solved by increasing the number of offered bus connections. It should be pointed out that the traffic survey was carried out in the morning peak hours from 6 to 9 o'clock during ordinary working days and most of the transport demands from the surveyed settlements occur during this period. The data presented in

Figs. 3 and 4 were obtained in this period as well. The accuracy analysis of the transit connections shows that the variations of haste and especially delays are high. For instance, the maximum delay reaches 18 minutes in Psáry settlement and the average value of delay is also quite high. The reason is the frequent occurrence of traffic congestions on the journey from Psáry to the city of Prague. Bus service is perceived as unreliable and therefore, consequently, with a very low competitiveness to passenger car transport. These deviations from the scheduled time are, in most cases, caused by traffic congestion on the roads. These congestions occurred in the places with lower traffic throughput than the immediate traffic intensity needs, typically intersections in the places of transition from extravilan to urban areas.

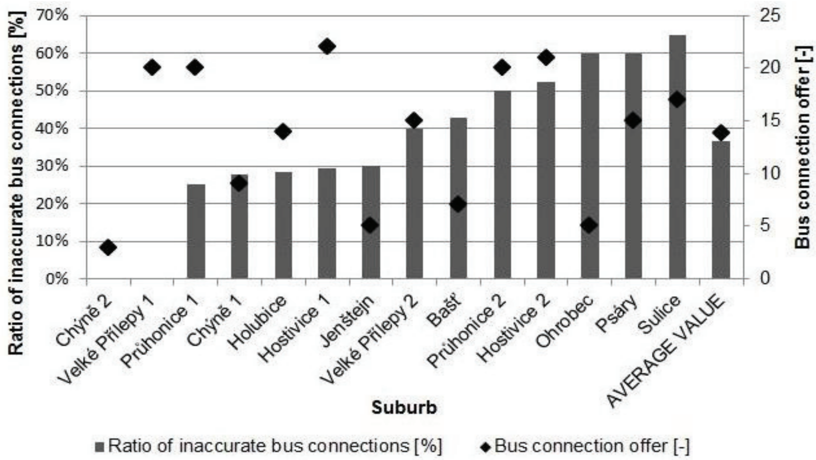


Figure 3. The accuracy of public transit in the morning peak hours.

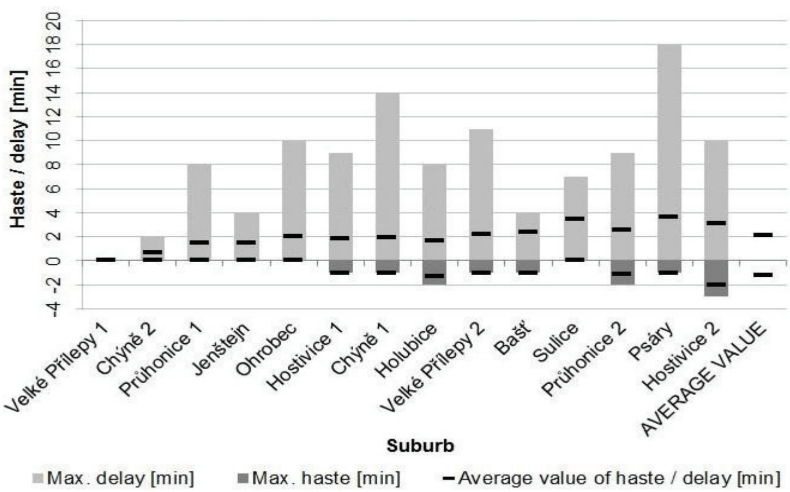


Figure 4. The accuracy analysis of bus connections.

The traffic surveys have proved a relationship between the public transit demand and the difference in travel costs by the determination coefficient ($R^2 = 0.630$) and the Pearson's correlation coefficient ($r = 0.794$). This difference in travel costs can be described as a difference of consumption costs (passenger car) and quarterly pass costs (public transit) per day. Passenger car travel costs were obtained on the basis of fuel consumption under real conditions of traffic flow and were calculated at the price of € 1.36 per litre of fuel. The authors are aware that fuel consumption costs are only part of the total costs that can be included in passenger car cost calculation. But on the other hand, consumption costs have a crucial impact on the total operation cost level and describe passenger car usage more properly (Frank et al., 2008). The results were only obtained from 6 suburbs (see Fig. 5), because the authors only gained comparable data of journeys by passenger car and public transport from these suburban settlements. In this case, the pattern of transport behaviour was applied when a passenger car was shared by 2 persons (driver and passenger) for a journey from a suburban settlement to the city of Prague and back. This pattern was also compared to a long-term fare, a quarterly pass in this case, for the purposes of daily commuting. 21 working days per month were considered in this calculation, which means 42 journeys per month and equivalently 126 journeys per quarter. It was found out that the travel costs for the long-term fare (public transport) are equal or even higher than the travel costs of a passenger car shared by 2 persons (for both directions). The public transit service does not provide any competitive advantage of lower price level or better travel time in this issue. The difference between the travel costs begins to grow in the favour of public transit with the growing travel time, because the fare (especially long-term fare) is insensitive to growing travel time due to congestions.

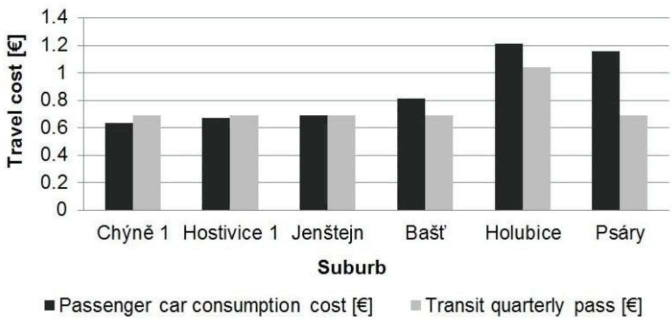


Figure 5. The travel costs per day – shared passenger car vs. transit.

CONCLUSION

This paper describes the patterns of travel behaviour in suburb areas. The survey carried out confirmed the original assumption that the modal split is set in the favour of passenger car transport and the surveyed suburban settlements have high car dependence nowadays. The transport behaviour of suburban settlement residents proves strong dependence on the city of Prague, because most of the transport links are related to the city. The traffic surveys have revealed the fact that good accessibility of public transport stops does not tend to increase the public transport demand in general. Insufficient connectivity of pedestrian infrastructure is an obstacle for public transport accessibility in many cases. Walking facilities (walk-sides or paths) should be perceived as an integral part of every residential area, including suburban settlements.

It should be mentioned in this context that the potential of cycling is not fully exploited in the suburb settlements. It is necessary to perceive the suburban settlements as specific regions with different transport behaviour and patterns compared to ordinary municipalities. There are no problems with parking of passenger cars in suburban settlements or parking fees. Residents are able to find parking lots nearby their households or parking lots are included in their private plots. These unbalanced positions of the passenger car transport and transit provide an advantage of better time accessibility on the passenger cars´ side in suburban settlement conditions. Nowadays, fares and tariff system settings are not a sufficiently motivating tool for increasing public transport usage. As it has already been shown, public transport usage is stimulated by the increase of passenger car travel time and consumption costs consequently. On the other hand, the travel time of public transport is always higher than a passenger car's travel time. It would be worth to implement effective tools of public transport preference in congested parts of the journey, since transit and cars share a common road for transport nowadays and there is no perspective of a railroad being built into the surveyed settlements. This would have a beneficial effect on the fluency of public transport vehicles. In contrast, efforts to increase car travel speed tend to increase passenger car usage and this again causes the problem of congested roads without a satisfactory solution.

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