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Organizational and infrastructural solutions in creating competitive advantage of sustainable urban transport – Gdańsk case study

Abstract
The paper presents conclusions of the survey conducted in Gdańsk in October 2017. The study aimed to compare travel times between the largest residential districts in Gdańsk and the area of the business-academic center. The research was aimed at showing time losses on the commuting trips and their organizational and infrastructural causes, which lead to the extension of the actual travel time. Based on the identified time losses and their causes, recommendations regarding further organizational and investment work were presented to improve the competitiveness of public urban transport and bicycles in relation to the cars.

Keywords
Sustainable urban transport • organizational solutions in urban transport • urban transport infrastructure • bicycle commuting

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Introduction

Both the UN (United Nations 2017) and the European Commission (European Commission 2007; European Commission 2011) agree that the biggest problems of modern cities are caused by excessive individual motorization. All diagnoses and reports included in strategies for the further development of urban areas emphasize that it is necessary to limit car traffic in cities and take actions towards so-called "sustainable mobility" (European Commission 2013; The Charter of European Planning 2013; Fiorello et al. 2016; Hautala et al. 2014; Van Audenhove et al. 2014). This requires, above all, organizational and infrastructural changes, land use changes, and changes in the commuting behavior of residents (Banister 2005; Banister 2008; Słodczyk 2012; Broniarska & Zakowska 2017).

Despite all those postulates about sustainable mobility, cities are constantly struggling with the problems of congestion, smog, and pedestrian safety due to excessive individual motorization of their residents. Extensive promotional campaigns and regulatory actions aimed at discouraging car usage consistently fail to achieve the desired results. According to the latest Road Traffic Survey in Gdańsk in 2016, there was once again an increase in the share of individual motorization in daily commuting, with a slight increase in the share of bicycles and a drop in the number commuting by public transport. This situation arises from the fact that alternative ways of getting around the city are still not competitive in relation to commuting by one's own car, especially when the time of travel and the ease of going from "door to door" are taken into account. This factor invariably affects the mobility decisions of residents, despite the significant reduction in the permissible speed of cars within the city limits (Gdańskie Badanie Ruchu 2016).

A short literature review of urban transport choice

Addressing unsustainable patterns of travel requires a detailed understanding of travel behavior and the reasons for choosing one mode of transport over another (Anable 2005). The European report "The Future of Transport" (2011) investigated factors that discourage car users from using public transport. A large majority (71%) of car users felt that public transport was not as convenient as a car. Similarly, in the Gdańsk Traffic Research report in 2016 (Gdańskie Badanie Ruchu 2016), respondents declared that the main reasons for choosing a car were: greater convenience (40.40% of respondents), travel time (25.90% of respondents) and the need to transport purchases (20.2% of respondents). In research on commuting behavior of Gdynia inhabitants conducted over many years by the research team of Wyszomirski, car users consistently indicated time as the most important determinant in everyday mobility, justifying the choice for traveling by car (ed. Wyszomirski 1999).

The duration of the journey should be considered "door to door", i.e., the cumulative time of all displacement phases: to reach the stop, wait for the vehicle, transit, and transfer to the destination. The number of necessary transfers and transfer conditions also directly affect the comfort of traveling (ed. Wyszomirski 1999; Szołtysek 2011; Broniarska & Zakowska 2017; Kujala et al. 2018). Guglielmetti Mugion et al (2018) also found in their research that "the main components of bus and subway service quality are represented by the following aspects: security, reliability, comfort, travel time and waiting conditions".

Unfortunately, the time which residents spend using various modes of public transport is constantly increasing as urban sprawl

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increases. This is a nuisance and a disadvantageous and socially unacceptable phenomenon. Commonly accepted conclusions from transit research indicate that the travel time of everyday commuting should not exceed half an hour (Dziadek 1991; He, Zhao & He 2016; Vincent-Geslin & Ravalet 2016). For traveling by bicycle, Grava says that "there is general consensus that very few people would ride more than 16 km on a regular basis each day, which can be covered in less than 1 hour. Anything below 8 km can be considered a comfortable distance that should represent no difficulty for most cyclists" (Grava 2002, p. 80).

For years, Gdańsk has been very much in favor of tram and bicycle communication. The Gdańsk Traffic Research report in 2016 (Gdańskie Badanie Ruchu 2016) showed that 5.9% of all daily transport trips were made by bicycle, a higher rate than in previous years. At the same time, the city has been investing heavily in tram connections; however, the rate of public transport usage in daily commuting has decreased. These results give rise to the hypothesis that the lack of time competitiveness of public transport and bicycle commuting in relation to traveling by car is the reason for the change.

Methodology

The aim of this study was to answer the question of why public transport and cycling are still less competitive in Gdańsk than individual motorization, by mainly considering the time factor during trips "from home to work" and "from work to home". The research was also aimed at identifying other possible causes of the situation and proposing solutions that could improve the competitiveness of sustainable means of daily communication.

For this research, connections to the academic-business center were selected from the five largest residential districts: Chełm (Orunia Górna), Piecki Migowo, Gdańsk City Hall, Zaspa, and Żabianka-Jelitkowo. The academic-business center designated for the study is the area of the Oliwa district, where the University of Gdańsk campus and two large office complexes (Olivia Gate and Alchemia) are located. An estimated 11,000 people work in this area in addition to the thousands of students who travel there every day.

Commuting times were measured in the first week of October 2017. The month of October is considered the most representative in terms of weather and transportation conditions for the whole year (Raport o korkach w 7 największych miastach Polski Warszawa, Wrocław, Kraków, Poznań, Gdańsk, Łódź, Katowice 2016). The measurement of travel time was made using the application Google Maps (2017) for both car and bicycle journeys. In addition, actual bicycle journeys were measured on the selected routes using the Locus Map Free – Outdoor GPS *nawigacja i mapy* (2017) application. To indicate the time of travel for public transport, the application *Jakdojadę: rozkłady jazdy, bilety* (2017) ("How to get there: timetables, tickets") was used.

Measurement was carried out for one week between 7.30-8.00, 13.00-14.00 and 16.00-16.30. According to the Traffic Report in the 7 largest Polish cities, these times represent the morning rush hours, the hour of the lowest daily traffic, and the period of the largest afternoon traffic (Raport o korkach w 7 największych miastach Polski Warszawa, Wrocław, Kraków, Poznań, Gdańsk, Łódź, Katowice 2016). The travel time analysis did not consider the distances traveled.

For cars, every route chosen for the analysis was the fastest at the given time interval according to Google Maps (2017); however, Table 1 catalogs the shortest possible route distance between the starting points and destination, even if this was not the route taken for the analysis. For public transport, the various connection options shown in the *Jakdojadę: rozkłady jazdy, bilety* (2017) app were considered. All the route options are included in Fig. 1. For the bicycle journey analysis, the shortest routes available using bicycle paths were chosen.

The analysis did not take into account the time necessary to walk from home to the car or to the tram/bus stop, due to the fact that these times vary widely depending on the individual commuter. One point located in the center of the housing estate by the tram stop was chosen as the starting point of every route. There is a parking lot directly at the destination point, so the "door to door" access was considered for car travels. (However, it should be kept in mind that there are fewer parking spaces than employees, which can cause additional walking time from more distant parking lots). The study did factor in the time to walk from the railway/tram/bus stop to the destination point.

The results

In order to present the travel routes that were identified during the study, a graphic description proposed by Sierpiński (2012) was used. Figure 1 presents travel diagrams for those routes indicated in the *Jakdojadę: rozkłady jazdy, bilety* (2017) app as the fastest solutions for the traveler during the examined time.

Table 1 presents the obtained measurement results of the estimated travel time on the studied routes. The table shows the minimum and maximum travel time for each time interval. For public transport, the total travel time was presented, as well as the time devoted to the transition between stops or from the stop to the destination and, separately, the additional waiting time associated with transferring to another mode of transport.

As observed for all routes, the car was the fastest, regardless of the time of day or day of the week. In all cases, the duration of the entire public transport journey lasted the longest. In many cases, the time to cycle was shorter than public transport, although longer than by car.

Factors that have been identified as barriers that increase the time of cycling are, of course, the linear structure of the city and the landform. Gdansk has very diverse geographic features, including its landform. Elevation in the city ranges from -1.6 to 180.1 AMSL (Geoportal 2017). The lowermost areas are along the Gulf of Gdansk, making up the city's lower terrace. The unofficial boundary of the lower and upper terrace reaches the absolute altitude of 20 AMSL (Biuro Rozwoju Gdańska 2017). Due to the sprawling space and low density of buildings in the city, most districts are very far apart. This results in long distances to traverse, often exceeding the acceptable 8 km. This is especially true for newer residential districts located on the upper terrace. An additional barrier to traveling by bike between the districts of the upper and lower terrace is the necessity of going up long and high access roads, which can extend the travel time up to 10-15 minutes. However, it is worth noting that after eliminating the upper terrace, all other destinations are within the acceptable distance and time of cycling (see routes 3, 4 and 5). It should be noted, as well, that the lower terrace is an area without high elevation. Therefore, districts located on the lower terrace of the city meet favorable conditions for cycling: no large elevation gains, distances up to 8 km, and travel times up to 20 minutes. However, another identified barrier to bicycle transport on the lower terrace is the lack of adequate infrastructure. In truth, the range of bicycle routes is extensive; however, their structure and quality are not conducive to convenient and fast bicycle commuting. The longer journey time is influenced by intersections with traffic lights, inconvenient bicycle paths at the approach to intersections that require a significant reduction of speed, the collision of the bicycle path with a pedestrian crossing, and, above all, the lack of bicycle paths on both sides of multilane streets. Most bicycle routes go along one side of the street only and from time to time change to the other side. This makes it necessary to cross the street, even if

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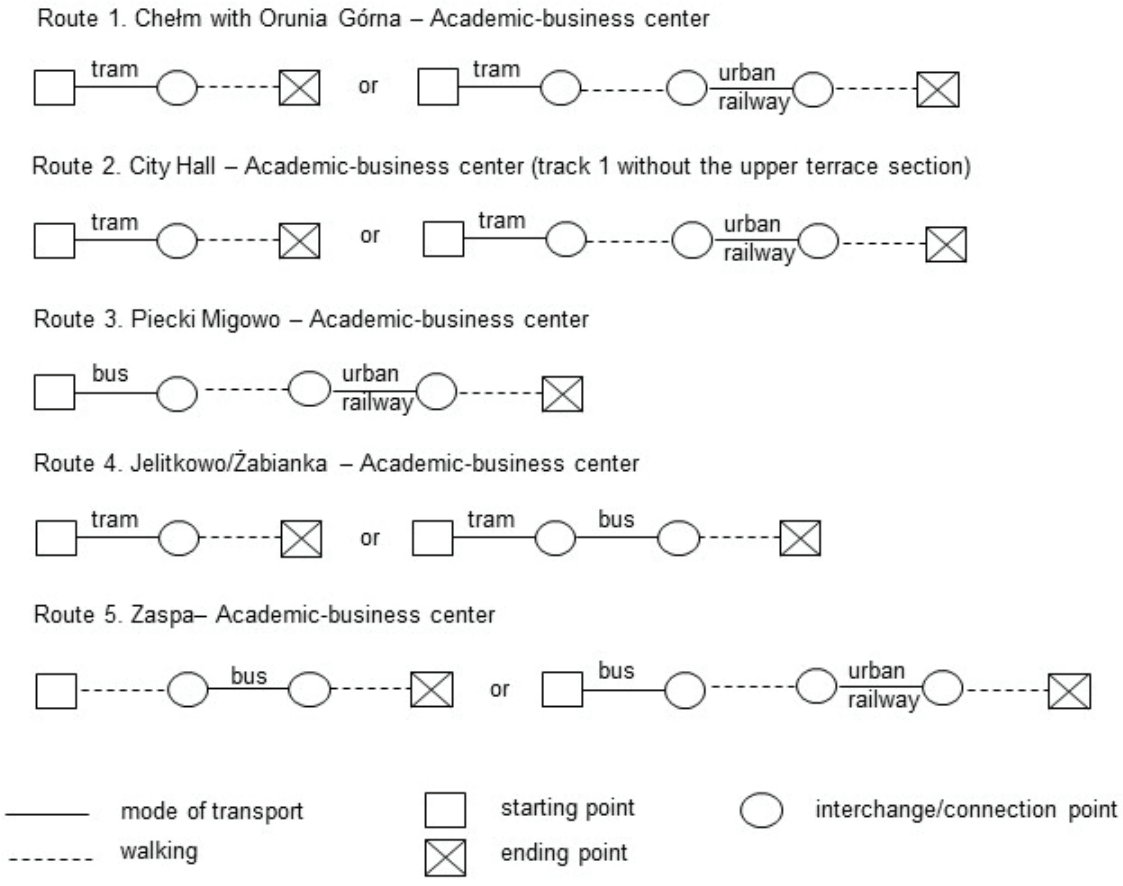

Figure 1. Studied travel routes
Source: Own elaboration based on Sierpiński (2012)

the route to the destination would be more direct without it. Table 2 lists the number of intersections with traffic lights that require waiting, as well as the number of compulsory trips to the other side of the street that would not be necessary if the bicycle path ran along both sides of the street.

Figure 2 presents an example of a new intersection that included cycling infrastructure at the design and build stage. The grey line shows the way through this intersection for cars, while the black line indicates the bicycle path. The course of the cycle road extends the time to pass through this intersection by as much as 2.5 minutes in relation to the time it takes the car. The extended time is the result of needing to reduce speed before many curves and stops on the route, as well as needing to cross the tram track and having to wait at additional traffic lights.

Traveling by public transport turned out to take the longest in all examined cases. The length of travel time by urban transport was influenced by the linear structure of the city and the distance traveled, coupled with the lower operating speed of the trams or buses compared to cars. Besides such limitations as the need to stop at traffic lights and in traffic jams (buses), having to pause at designated stops also extends the travel time. However, the biggest disadvantage is the distance between the bus or tram stop and the buildings located in the area of the academic-business center. It can take up to 13 minutes to walk from the Rapid Urban Rail station or the tram stop to the office buildings. None of the stops is directly located at the entrance of either the campus or office buildings.

The fastest public transport solution involved connections using the Rapid Urban Railway, which was the fastest means of public transport in Gdańsk. Nevertheless, the total travel time is not spectacularly shorter due to the long time necessary to connect from the bus or tram stop to the urban rail station. This is the result of a lack of integration of the bus, tram and railway stations. A passenger wishing to get to the urban railway platform must travel long distances from the interchange stop and always has an additional barrier in the form of high stairs.

Conclusion and recommendations

As a result of the study, it was found that the alternative means of transportation in Gdańsk are not competitive with the car. There are several reasons for this situation. Among them are how the city developed historically, with a linear structure, the construction of mono-functional districts, and natural barriers (the location between the Gulf of Gdańsk and moraine hills). And although historical and natural factors are not influenced by modern city authorities, these groups have influenced the expenditures on infrastructure for many years. Until recently, there was no policy for creating sustainable transport and mobility options. Investments in new or extended tram lines in recent years have linked distant districts with the city center, but this has not translated into an increase in public transport usage

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Table 1. Collected results of travel time measurement

Routes	Course	Road distance (km)	Car (travel time in minutes) (min-max)			Bicycle (travel time in minutes) (min-max)			Public transport				
									Total travel time in minutes (average for each time interval)			Average waiting time (minutes)	Average walking time (minutes)
			7.30-8.00	13.00-14.00	16.00-16.30	7.30-8.00	13.00-14.00	16.00-16.30	7.30-8.00	13.00-14.00	16.00-16.30		
1.	Chełm (Orunia Górna) – Academic-business center	13.20	18 - 34	21 - 23	20 - 40	49	49	49 - 51	Tram 59 - 1.02 Tram/ urban railway 47 - 52	Tram 1.00 Tram/ urban railway 58	Tram 1.00 Tram/ urban railway 58	Tram 0 Tram/urban railway 3	Tram 13 Tram/urban railway 13
2.	City Hall – Academic-business center (route 1 without the upper terrace section)	8.90	11 - 13	12 - 13	12 - 33	28	28	28 - 33	Tram 40 Tram/ urban railway 32 - 34	Tram 40 Tram/ urban railway 29 - 34	Tram 40 Tram/ urban railway 29 - 31	Tram 0 Tram/urban railway 3	Tram 13 Tram/urban railway 13
3.	Piecki Migowo – Academic-business center	7.00	10 - 17	12 - 14	11 - 27	24	24	24 - 32	Bus/ urban railway 32 - 43	Bus/ urban railway 33 - 35	Bus/ urban railway 30 - 31	Bus/urban railway 2	Bus/urban railway 15
4.	Żabianka-Jelitkowo – Academic-business center	3.39	7 - 9	9	10 - 12	15	15	14 - 15	Tram 29 - 31 Tram/ bus 21 - 25	Tram 29 Tram/ bus bd	Tram 28 - 30 Tram/ bus 23	Tram 0 Tram/bus 3	Tram 13 Tram/bus 8
5.	Zaspa – Academic-business center	3.35* / 4.30	7 - 10	8	8 - 16	10	10	10 - 14	Bus 22 - 24 Bus/ urban railway 24 - 30	Bus 26 - 29 Bus/ urban railway 28 - 29	Bus 26 Bus/ urban railway 24 - 37	Bus 2 Bus/urban railway 3	Bus 11 Bus/urban railway 15

' part of the route is without a bicycle path*
Source: Own elaboration

in daily commuting overall. For each studied route, there were not enough intermodal nodes that would enable an efficient transfer between different means of transportation. Particularly lacking are the nodes that would allow quick and barrier-free transfer to the urban railway.

These problems have only recently been noticed, and only in part. However, the construction of an additional Rapid Urban Railway station with the new interchange Gdansk Śródmieście was included in the new investment plans for Gdańsk. The new interchange solutions considered part of the intermodal postulates of integration with other means of public transport. The newly built station is integrated with a tram and bus stop, in such a way that transferring between the stops requires only a change in levels between platforms. The newly established transfer node improves connections from the distant southern districts of Gdańsk to the city center and the academic-business center.

A strong bicycle community in Gdańsk is working to improve the cycling infrastructure within the city, but bicycle paths commissioned even recently do not meet the criteria for efficient movement using them. At the same time, many modernization works are being undertaken on existing bicycle routes as a result of financing from the Gdańsk Participatory Budget. New projects funded by the Participatory Budget are meant to streamline crossings at intersections, level the road surface along the whole path to ensure the movement of bicycles is more fluid, and bring more attention to intersections with cars, such that drivers are forced to limit their speed. For cycling routes located on streets, other solutions have been adopted to ensure a safe bicycle space in accordance with the standards of bicycle route design adopted in Europe or North America (see more NACTO 2011). Wherever possible, conflicts with pedestrian routes were removed and traffic lights were eliminated. Additionally, starting in November,

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Table 2. Barriers on bicycle paths

Track	Course	Number of intersections with traffic lights	Number of intersections where the bicycle path switches to the other side of the street
1.	Chełm (Orunia Górna) – Academic-business center	21	2
2.	City Hall – Academic-business center (route 1 without the upper terrace section)	13	2
3.	Piecki Migowo – Academic-business center	12	4
4.	Żabianka-Jelitkowo – Academic-business center	11	5
5.	Zaspa – Academic-business center	7* 6	-

' part of the route is without a bicycle path*
Source: Own elaboration

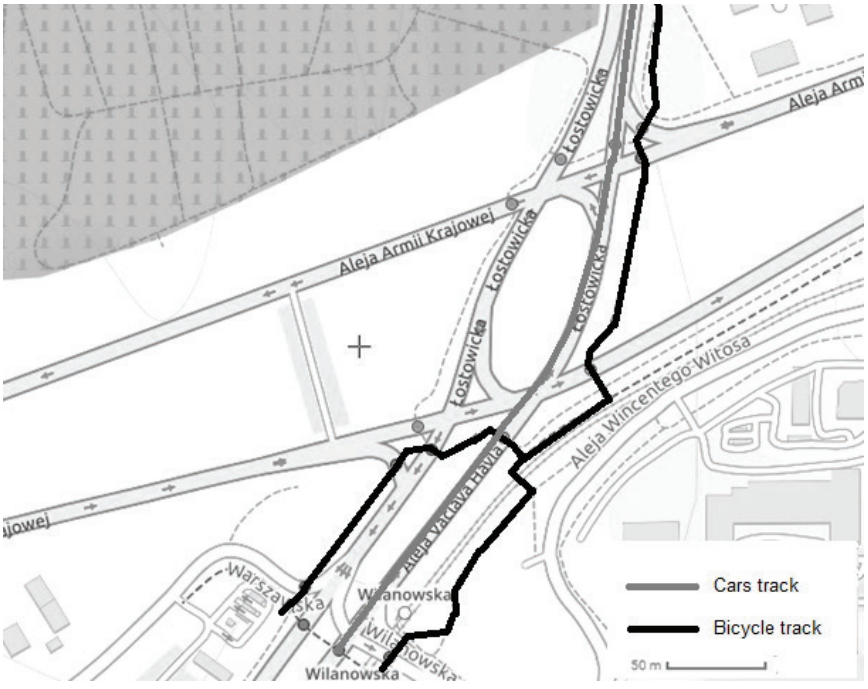

Figure 2. Cross road traffic for cars and bicycles. Source: Own elaboration based on OpenStreetMap Scribble Maps. Available from <https://www.scribblemaps.com>. [10 September 2018]

the Gdańsk Metropolitan Bike System (MEVO) is to be launched based on bicycles with electrically powered drive. The creators of the project assume that the bike with electric drive will be better suited as a complement to public transport in the region with differentiation in landform elevation (Metropolitan Area Gdansk Gdynia Sopot 2018).

In terms of recommendations, a positive trend would be for new cycling routes to be created at the same time as road and tram infrastructure investments. This would serve to meet the textbook criteria for planning sustainable urban streets. As observed, development measured only as the number of kilometers of bicycle routes and tram track will not contribute to the increase in the use of these forms of everyday mobility. Organizational and multimodal solutions, including integrated ones, are also important so that sustainable means of communication can become competitive in relation to the car.

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