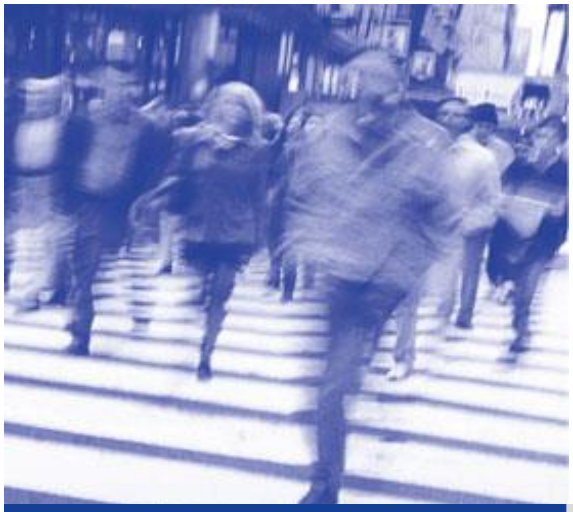

CiViTAS
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AACHEN • GDYNIA • KOPRIVNICA • PALMA

Report on HOV/ bus lanes in Gdynia

Implementation Status Report G3.5

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Marcin Wołek	
Responsible Co-Author(s):	
Jacek Oskarbski, Rafał Polakowski, Krystian Birr	
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Abstract

The measure G3.5 “Dedicated bus lanes/ HOV lanes control with the use of ITS” was developed in close cooperation of different partners of local consortium within the CIVITAS DYN@MO project.

The document provides a detailed analysis of the implementation and operation of the measure. For this, at the beginning, the background of the mobility and public transport market in Gdynia is being presented in order to provide the context and the initial environment for the implementation.

Vehicle travel time analysis for the selected sections supported by microsimulations were helpful tools for the decision making process for the final selection of the dedicated bus lanes in Gdynia.

A detailed analysis of the travel time of public transport vehicles was conducted for two bus lanes – on Władysława IV street and on Estakada Kwiatkowskiego. The quantitative analysis was complemented based on results from surveys conducted in 2014 and 2015. The results show growing public support for the idea of separated bus lanes in Gdynia.

The document presents the first stage of the bus lanes implementation process in Gdynia. The general assessment is positive although it differs according to the concrete case study. The general remark is, however, that only massive deployment of bus lanes integrated within the TRISTAR system and modern, reliable public transport vehicles could regain the mobility market for public transport in Gdynia.

Project Partners

Organization	Country	Abbreviation
City of Gdynia	PL	ZDIZ
Gdansk University of Technology	PL	GUT
University of Gdansk	PL	UG

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Date	Person	Action	Status	Diss. Level
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1 Introduction

The CIVITAS DYN@MO project, funded through the European Commission's CIVITAS Initiative between 2012 and 2016 brought together four partner cities: Aachen (DE), Gdynia (PL), Palma de Mallorca (ES) and Koprivnica (HR). The project's mission was to strengthen sustainable mobility through promoting non-polluting lifestyles, through social interaction and collaboration on the basis of the new media, and through integrated implementation of innovative transport services for active citizens of all ages. The strategic aims of CIVITAS DYN@MO were:

- to develop "Mobility 2.0" systems and services by applying "web 2.0"" technologies for connecting travellers, delivering information and services, as well as creating exciting new tools for direct interaction with citizens and customers,
- to implement city and citizen-friendly, electric mobility solutions, using new electric and hybrid vehicles (pedelecs, buses, vans and cars) in innovative service concepts,
- to engage in a dynamic citizen dialogue for mobility planning and service improvement.

Within WP3 entitled "Deployment of ICT and ITS", Gdynia implemented altogether five measures (Table 1).

Table 1. Gdynia's WP3 measures within the CIVITAS DYN@MO project

Measure number	Measure title
G3.1	Traffic model development to expand Gdynia's SUMP
G3.2	Automatic Traffic Incident Detection
G3.3	Weigh-in-Motion and Enforcement
G3.4	Mobility 2.0 communication
G3.5	Dedicated bus lanes/ HOV lanes control with the use of ITS

This report is about measure G3.5 entitled "Dedicated bus lanes/ HOV lanes control with the use of ITS". The main objectives of this measure were:

- Introduction of dedicated bus and high occupancy vehicle (HOV) lanes along major arterial roads
- Increase of the share of PT in the modal split Improvement of the quality and punctuality of PT travel and service
- Assuring that PT is more competitive to individual transport (due to shorter journey trips)

- Decrease of the number of car trips and cars

This report focuses on the introduction of dedicated bus and high occupancy vehicle (HOV) lanes along major arterial roads. Based on the studies that were conducted prior to the project, a pilot project lane (destined also for HOV vehicles if analysis justifies it) was to be chosen and implemented within CIVITAS DYN@MO. Within the pilot project a device was installed for detecting vehicles which do not comply with the regulations (the ones that are using the bus lane).

The expected outcomes of the measure in the mid- to long-term were:

- improvement of the overall quality of PT travel and service;
- more competitive PT compared to individual transport by shortening journey time when using PT.

2 Mobility and public transport in Gdynia

Spatial development and the increasing demand for travel in metropolitan areas result in an increase of the number of vehicles on the streets, which contributes to the depletion of bandwidth street sections, intersections and parking capacity. The most vulnerable area for congestion is the city centre, strongly affected by traffic from other, sometimes peripheral areas of Gdynia (Fig. 1).

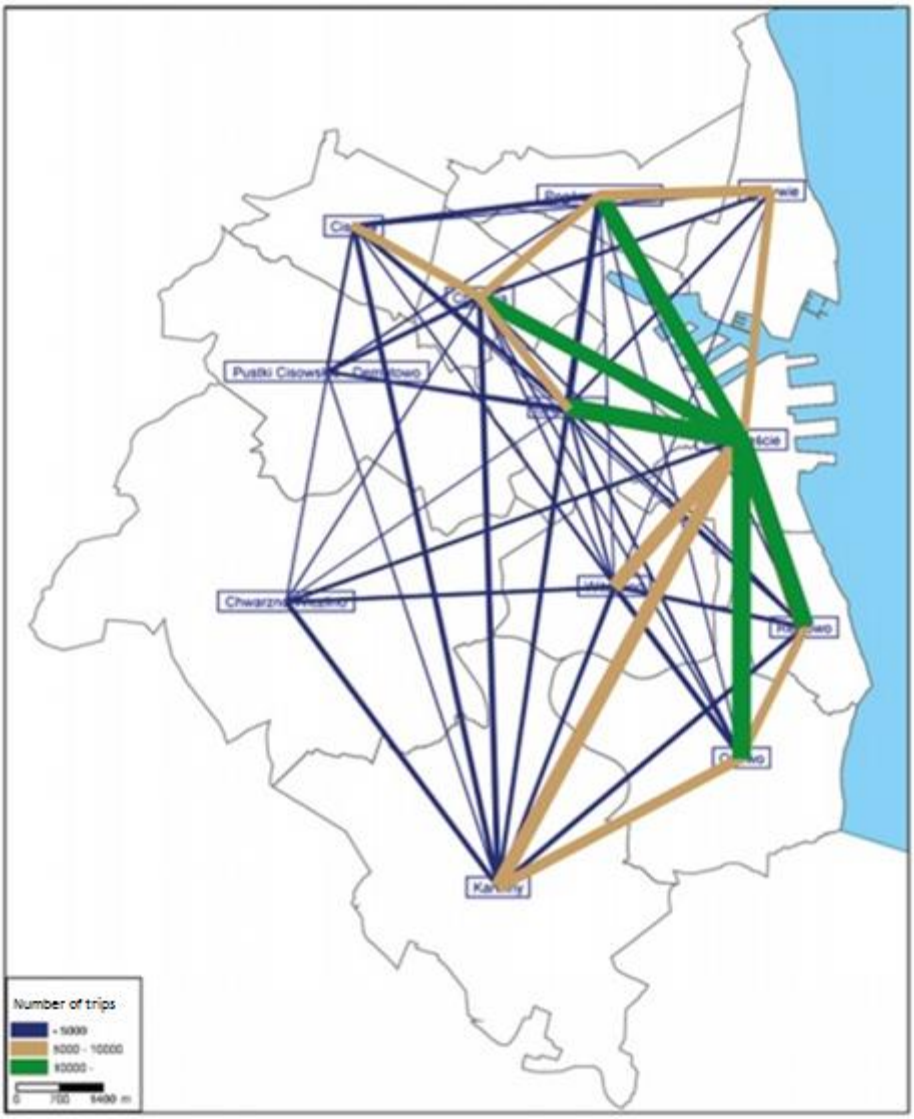

Figure 1. The spatial structure of travels by public transport in Gdynia in 2013 [peak hour, working day]

Source: http://www.gdynia.pl, [access 07.06.16].

The rise of individual motorisation determined the transport and mobility market in Polish cities for the last two decades. The number of individual cars has grown by 23% in Gdynia between 2009 and 2015 (Figure 2). 134,000 cars transform into an individual motorisation index of 542 cars per 1,000 inhabitants.

Figure 2. Number of individual cars in Gdynia in 2002 and in 2009-2015

Source: self-study based on data of Bank of Local Data, Polish Statistical Office 2015

An additional challenge for the City of Gdynia is the increasing motorisation in neighbouring communes (Fig. 3). Regardless of commune size, the individual motorisation indexes are comparable to Gdynia and sometimes even higher (e.g. in Żukowo and Sopot).

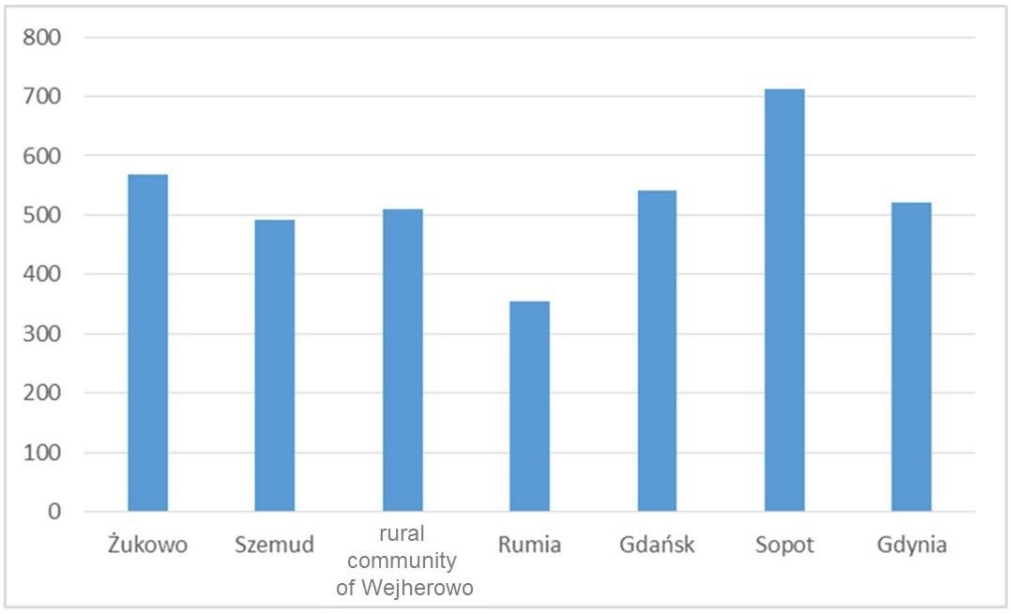

Figure 3. Motorisation index for chosen communes in 2015 (Gdańsk, Gdynia and Sopot: data for 2014)

Source: self-study based on data of Bank of Local Data, Polish Statistical Office 2015 and from district level administration of Puck, Kartuzy and Wejherowo. Lack of reliable data for Kosakowo.

Such growth in demand of individual cars for road infrastructure cannot be met efficiently without disturbing the quality of life, which is the most important aspect of Gdynia's Sustainable Urban Mobility Plan (SUMP) (Fig. 4).

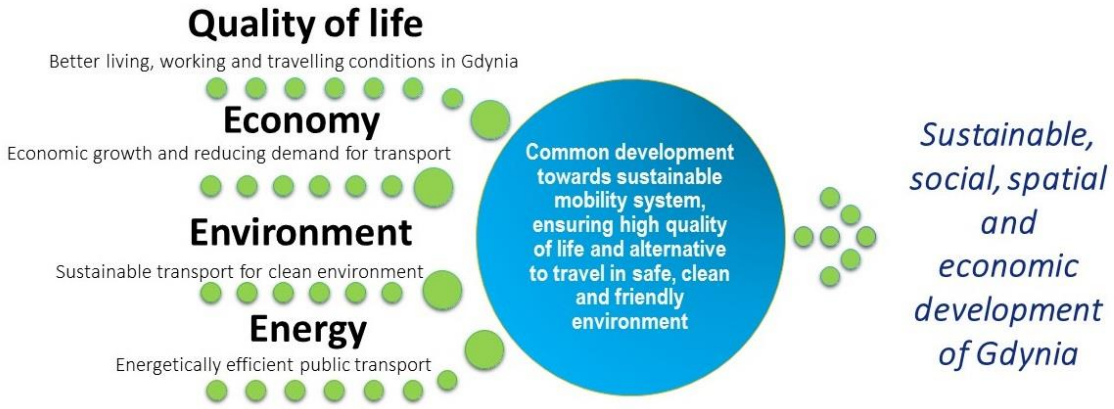

Figure 4. Common vision of sustainable urban mobility for Gdynia

Source: Sustainable Urban Mobility Plan for Gdynia. Gdynia City Council, 26.10.2016

Growing traffic results in congestion, increased pollution and noise, disturbing of punctuality of public transport making it a less attractive choice compared to the car. There is a spatial difference in distribution of individual cars in Gdynia (Fig. 5).

Research conducted by ZKM Gdynia (Gdynia's Public Authority) has showed that the share of households having at least one car increased from 56% in 2004 to 75% in 2015.

Gdynia's western districts, which are undergoing a strong spatial development, are characterised by a high share of households possessing at least one car (Chwarzno-Wiczlino, Dąbrowa, Wielki Kack, Mały Kack), while "older" districts, including the central area (Śródmieście with Kamienna Góra with best access to public transport, including rapid urban railway – SKM) have a lower motorisation rate of households. Demographic parameters of particular districts also are important: the western districts are relatively "young" and their citizens are active and characterised by a higher mobility index.

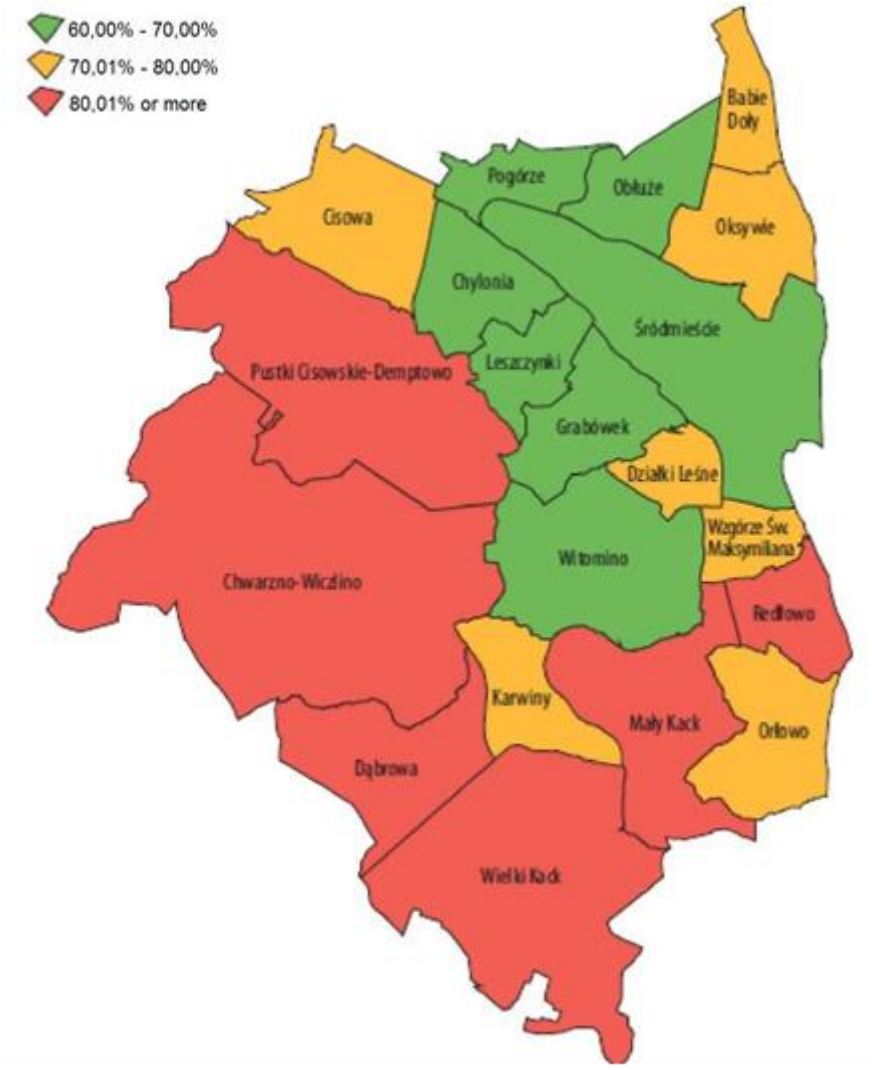

Figure 5. Individual motorisation by districts in Gdynia in 2015

Source: Sustainable Urban Mobility Plan for Gdynia. Gdynia City Council, 26.10.2016 and ZKM Gdynia

Gdynia's main road system is heavily occupied by individual traffic, and increasingly also by freight transport which services the sea port terminals located close to Gdynia's city centre. Data obtained from the TRISTAR system, the Tricity's integrated traffic management system, (Fig. 6) clearly show that there are critical points on Gdynia's road system.

Most intensive traffic was registered on Al. Zwycięstwa/Wielkopolska (59,900 vehicles/day), Ringroad/Morska (59,800 vehicles/day) and Morska/Trasa Kwiatkowskiego (57,500 vehicles/day).

Figure 6. Traffic on main road system in Gdynia [working day, data in thousand vehicles]

Source: Sustainable Urban Mobility Plan for Gdynia. Gdynia City Council, 26.10.2016 and ZDiZ Gdynia

All the issues mentioned above lead to a decrease of the attractiveness of public transport. Its share in the modal split (excluding pedestrians) has fallen from 52% in 2008[1] to 40%[2] in 2015.

The development of road infrastructure in many cases is limited, if not impossible, especially in urban centres, due to the extremely compact development and dense environment. In the long term, the development of further road infrastructure is not an effective solution because an extended street network fills up again and traffic conditions deteriorate.

One of the solutions, which entail a reduction in traffic congestion, improve safety, and the environment, is to develop and increase the quality of public transport. Especially, from a sustainability point of view, public transport is one of the most important elements of the transport system in cities. A proper network of connections and travel comfort can guarantee passenger satisfaction, and in result increase the share of public transport and improve traffic conditions for other road users[3].

In order to increase the attractiveness of public transport, within this CIVITAS DYN@MO measure priority has been given to public transport vehicles, more precisely, dedicated bus lanes were introduced, reorganising traffic to existing needs and conditions.

The research and analyses conducted at the start of the DYN@MO project indicated the need for public transport priority in the most important areas of the transport network in Gdynia. Currently, within the framework of the TRISTAR project, a system of priorities on signalised street junctions has been introduced. The developed concept for the determination of dedicated bus lanes demonstrates the possibility for giving additional priority to buses and trolleybuses. On the basis of experiences of numerous other cities, the research indicated that these two complementary activities will contribute to a significant improvement in the functioning of public transport in Gdynia via the enhancement of its reliability, choice, and hence its attractiveness.

[1] Preferences and transport behaviour of Gdynia's citizens in 2008. Marketing research report, ZKM Gdynia, Gdynia 2008.
[2] Preferences and transport behaviour of Gdynia's citizens in 2015. Marketing research report, ZKM Gdynia, Gdynia 2016.
[3] K. Birr et al.: Concept for HOV lanes/ bus lanes for the city centre and two incoming roads into the city centre. Working Document No. G3.5-WD1. Gdansk University of Technology, Gdansk-Gdynia 2014, November 2014. (not public)

3 Selection process for dedicated bus lanes in Gdynia[4]

3.1 Introduction

At the start of the DYN@MO project a study was conducted in order to identify the required traffic parameters on selected sections of the transport network of the city of Gdynia, hence constituting the basis for determining the validity of the designated dedicated HOV/bus lanes on these stretches.

The study covered measurements of the following parameters:

- travel time for individual transport vehicles,
- travel time for public transport vehicles,
- traffic volume,
- public transport occupancy rates.

The study was conducted at two measuring points (at the beginning and end of each section), using the external observation method on typical days of the week (Tuesday, Wednesday, and Thursday) for:

- morning peak hours (07:00-09:00)
- off-peak hours (10:30-12:30)
- afternoon peak hours (15:00-17:00)

For the analysis, nine sections of the transport network within the city of Gdynia were selected as exhibiting potential for implementing dedicated bus lanes (based on the number of journeys of public transport vehicles, significance of the section in the entire transport network of the city, and traffic volume):

1) Morska (Kalksztajnów - Działdowska) dir. Chylonia
2) Morska (Morska-Estakada bus stop - Grabowo) dir. Śródmieście
3) Morska (Akademia Morska bus stop – Warszawska) dir. Śródmieście
4) Wójta Radtkego (Plac Konstytucji - 3-Maja - Plac Kaszubski)
5) 3-Maja (Wójta Radtkego – Zgoda) dir. 10-Lutego
6) 10-Lutego (section: Skwer Kościuszki – Dworcowa) – both directions
7) Władysława IV (10-Lutego - Piłsudskiego) – both directions

[4] This chapter constitutes a synthesis of the paper by K. Birr et al.: Concept for HOV lanes/ bus lanes for the city centre and two incoming roads into the city centre. Working Document No. G3.5-WD1. Gdansk University of Technology, Gdansk-Gdynia 2014, November 2014. (not public)

8) Zwycięstwa (Wielkopolska - Droga Gdyńska) – both directions

9) Kielecka (Witomińska – gmach WSAiB) – both directions

Figure 7. Study area characteristics - analysed sections of the connection network

Source: K. Birr et al.: Koncepcja wyznaczenia dedykowanych pasów autobusowych w obszarze Śródmieścia Gdyni oraz na dwóch drogach dojazdowych do centrum [Concept for HOV lanes/ bus lanes for the city centre and two incoming roads into the city centre]. Working Document No. G3.5-WD1. Gdansk University of Technology, Gdansk-Gdynia 2014, November 2014 (not public)

3.2 Vehicle travel time analysis for the selected sections

The various figures presented in this chapter show the percentage share of travel times on individual sections, separately for individual transport and public transport. On the basis of the data analyses it was possible to observe what percentage of vehicles travelled along a give section at a specified velocity, broken down by times of day: morning peak hour, off-peak and afternoon peak hour.

Travel times depend on, for example, the number of signalised or non-signalised junctions, number of pedestrian crossings, duration of bus stop service, bendiness of the route, traffic conditions and traffic organisation on the roads leading to the junctions. A shift (presented in the figures below as time difference for cars and public transport vehicles) between the data for public transport and individual transport shows that travel over a given distance takes more time for public transport vehicles than for individual transport. This may stem from the stopping times at bus stops, including the waiting time to leave the bus stop. A clear difference can be observed for all sections except for that on 3-Maja Street. In this case, the lack of a time difference (“the shift”) probably stems from the lack of bus stops and the short length of the section. On Kielecka Street, the shift is visible despite the lack of junctions, bus stops and other restrictions.

The different time of day has also an impact on travel time and the difference between individual cars and public transport vehicles. In the morning peak hour it could be seen for the sections:

- Morska (Morska-Estakada bus stop – Grabowo)

For the afternoon peak hour, a clear difference occurs in relation to the remaining intervals for the sections:

- Morska (Kalksztajnów – Działdowska)
- Wójta Radtkego (Plac Konstytucji - 3-Maja – Plac Kaszubski)
- 3-Maja (Wójta Radtkego – Zgoda)
- 10-Lutego (dir. Skwer Kościuszki)
- Władysława IV – both directions
- Kielecka – direction Witomino
- Aleja Zwycięstwa – both directions

The distribution of travel time is similar for all intervals:

- Morska (Akademia Morska bus stop – Main railway station bus stop – Morska)
- 10-Lutego – dir. Main railway station
- Kielecka – dir. Wzgórze Św. Maksymiliana

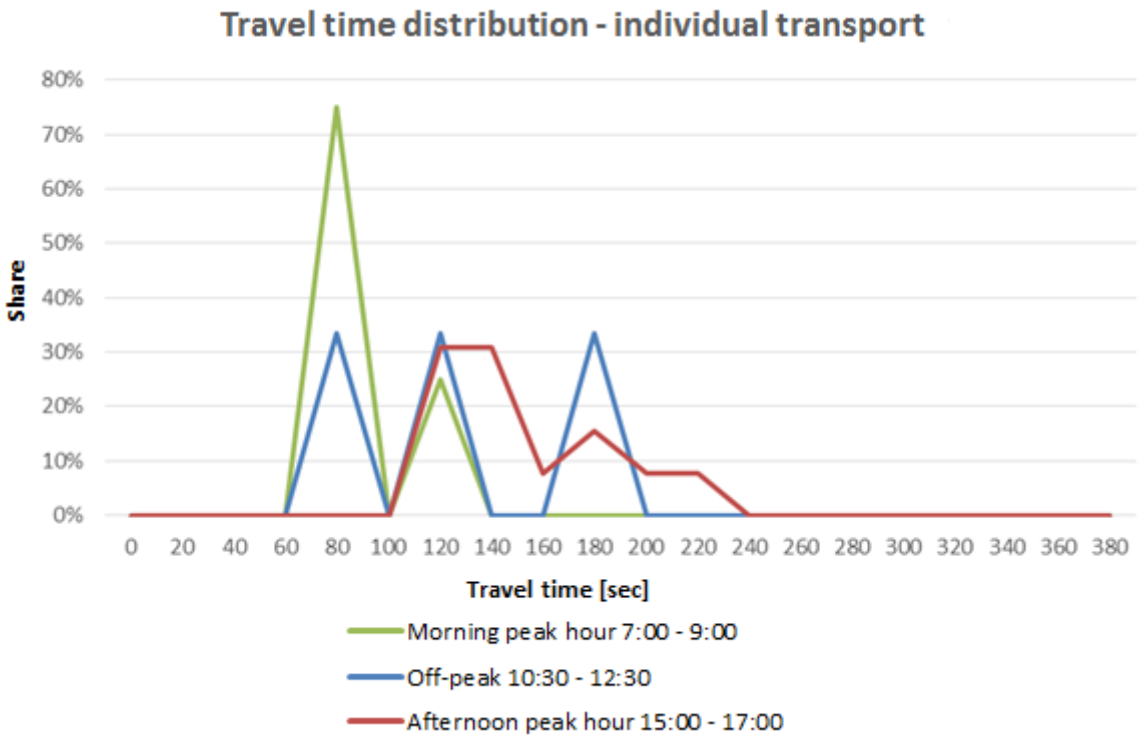

Figure 8. Travel time distribution – individual transport – Morska (Kalksztajnów – Działdowska, direction Chylonia)

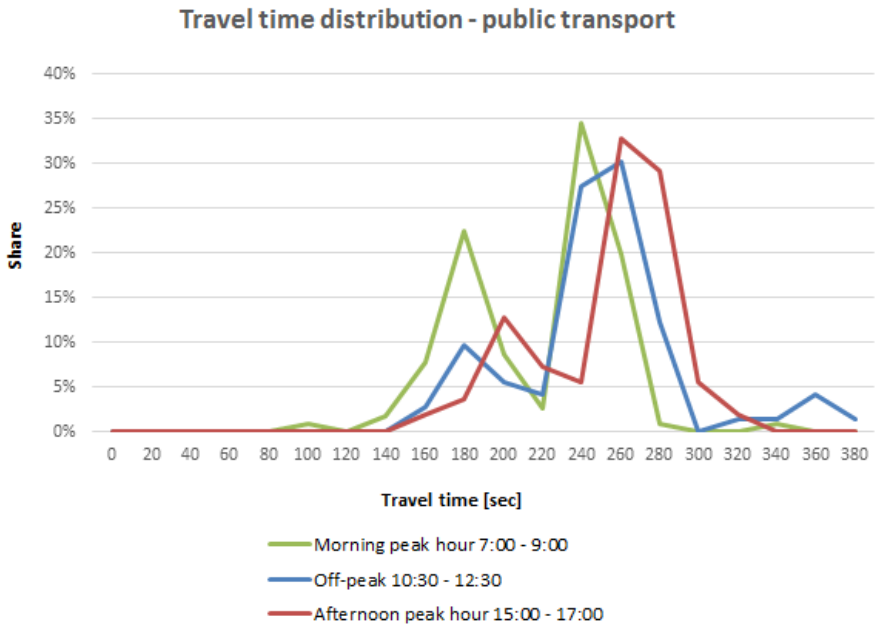

Figure 9. Travel time distribution – public transport – Morska (Kalksztajnów – Działdowska, direction Chylonia)

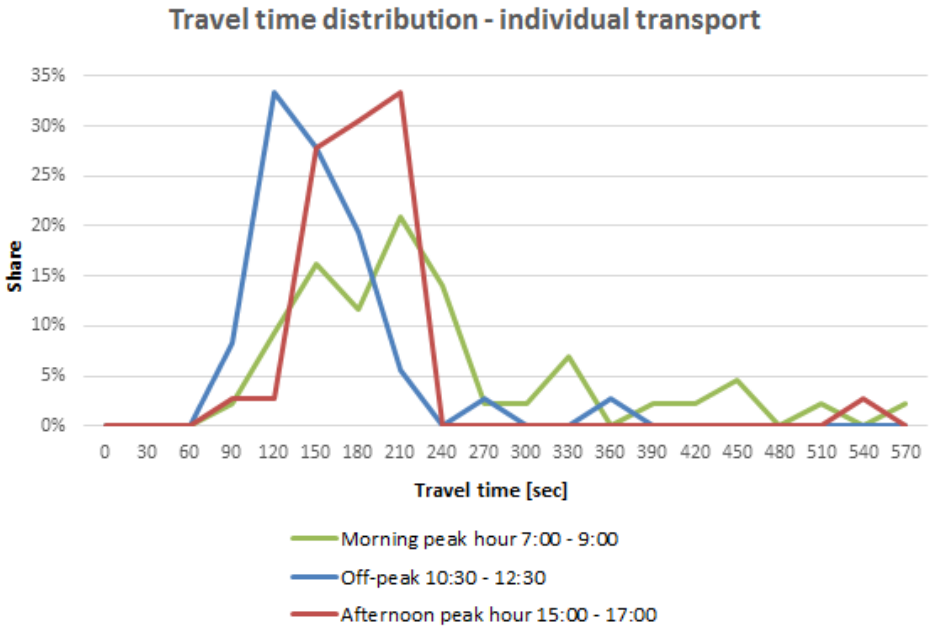

Figure 10. Travel time distribution – individual transport – Morska (Morska-Estakada bus stop – Grabowo, direction Chylonia)

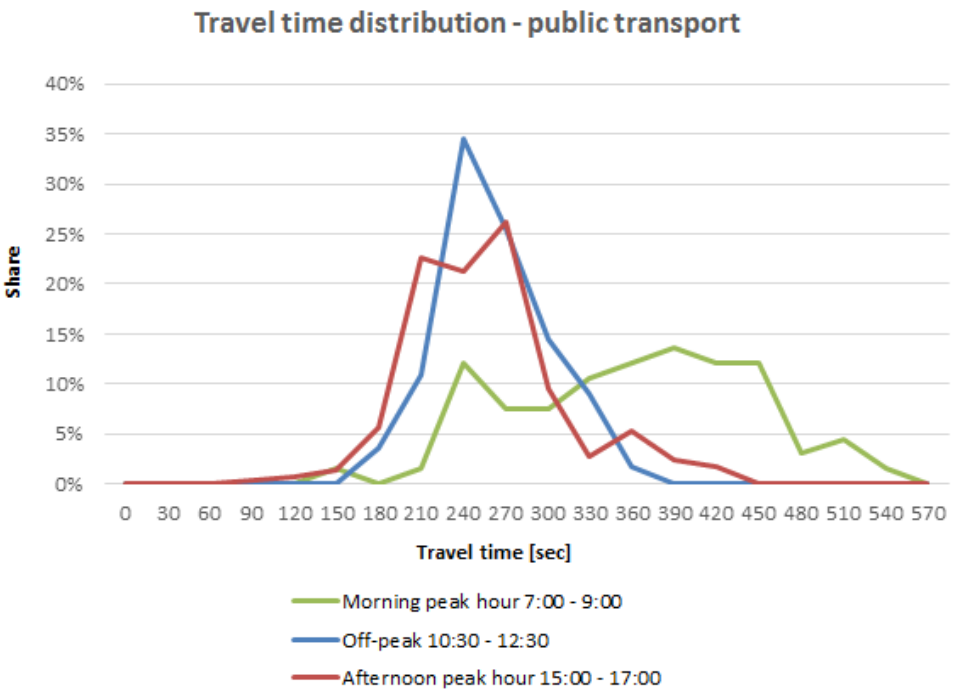

Figure 11. Travel time distribution – public transport – Morska (Morska-Estakada bus stop – Grabowo, direction Chylonia)

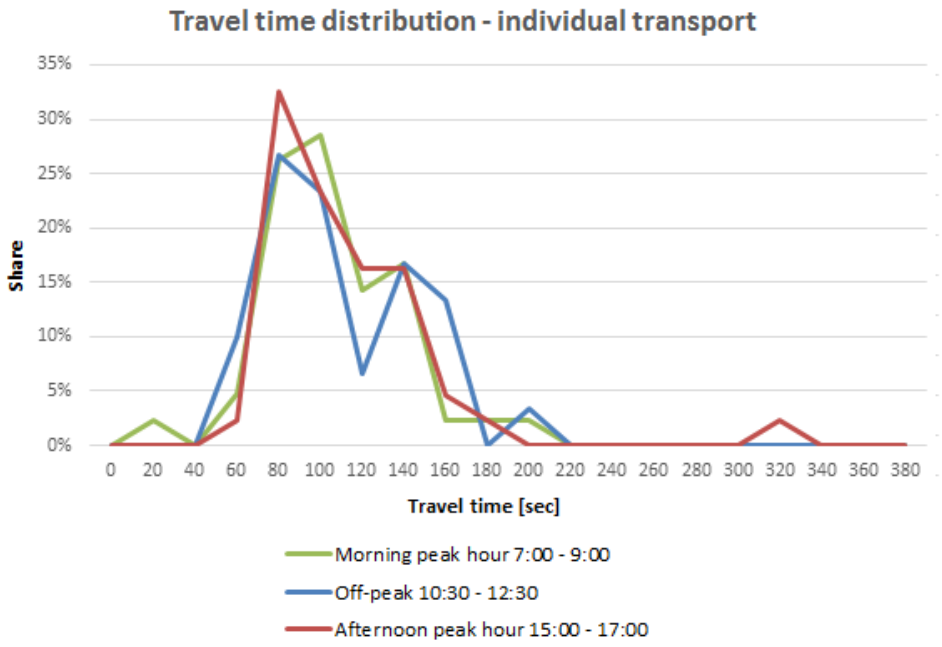

Figure 12. Travel time distribution – individual transport – Morska (Akademia Morska bus stop – Main railway station bus stop – Morska, direction Chylonia)

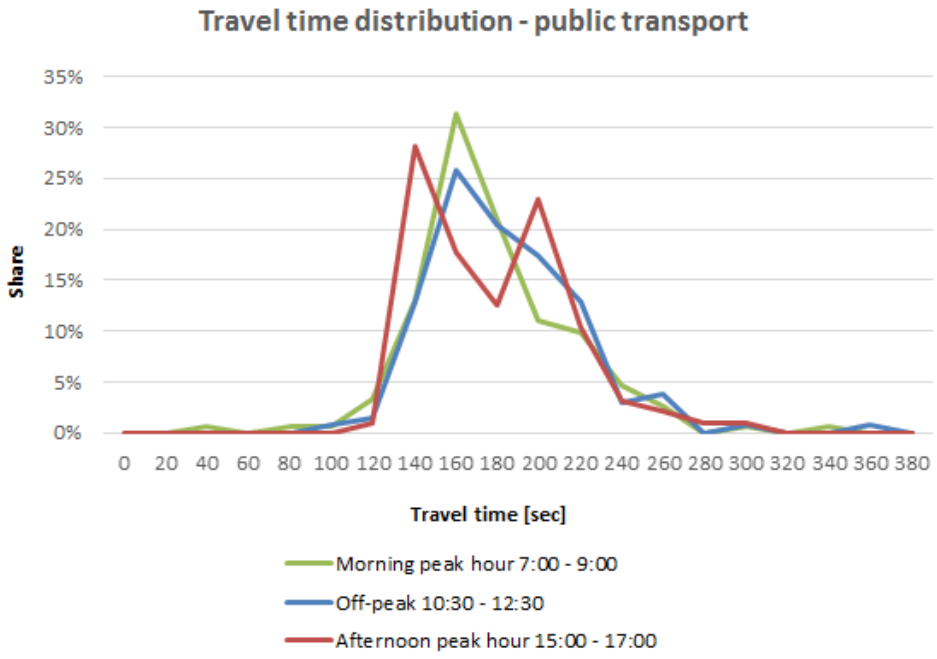

Figure 13. Travel time distribution – public transport – Morska (Akademia Morska bus stop – Main railway station bus stop – Morska, direction Chylonia)

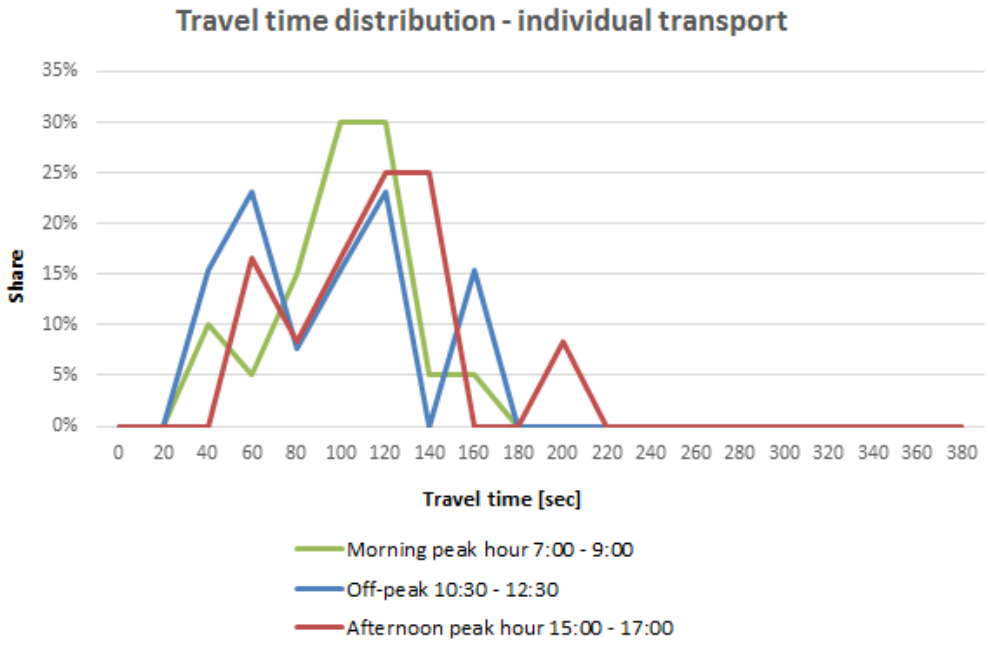

Figure 14. Travel time distribution – individual transport – Wójta Radtkego (Plac Konstytucji – 3-Maja – Plac Kaszubski) + as a variant contraflow lane on the section 3-Maja – Plac Konstytucji)

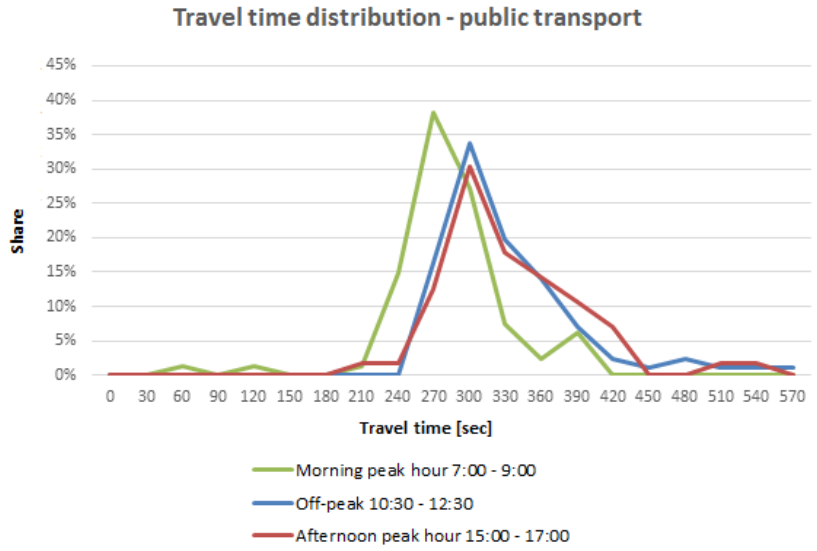

Figure 15. Travel time distribution – public transport – Wójta Radtkego (Plac Konstytucji – 3-Maja – Plac Kaszubski) + as a variant contraflow lane on the section 3-Maja – Plac Konstytucji)

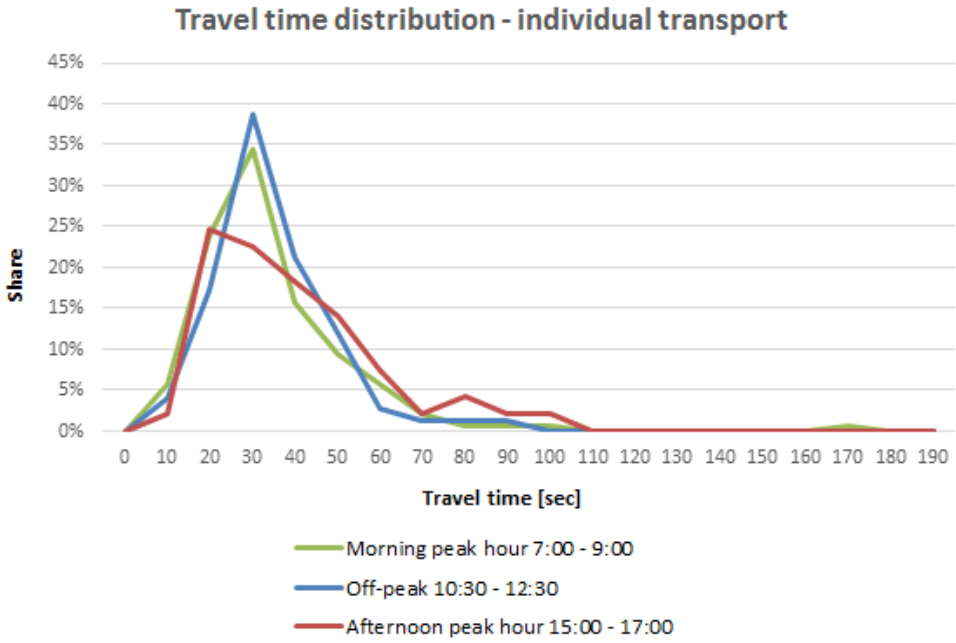

Figure 16. Travel time distribution – individual transport – 3-Maja (Wójta Radtkego – Zgoda)

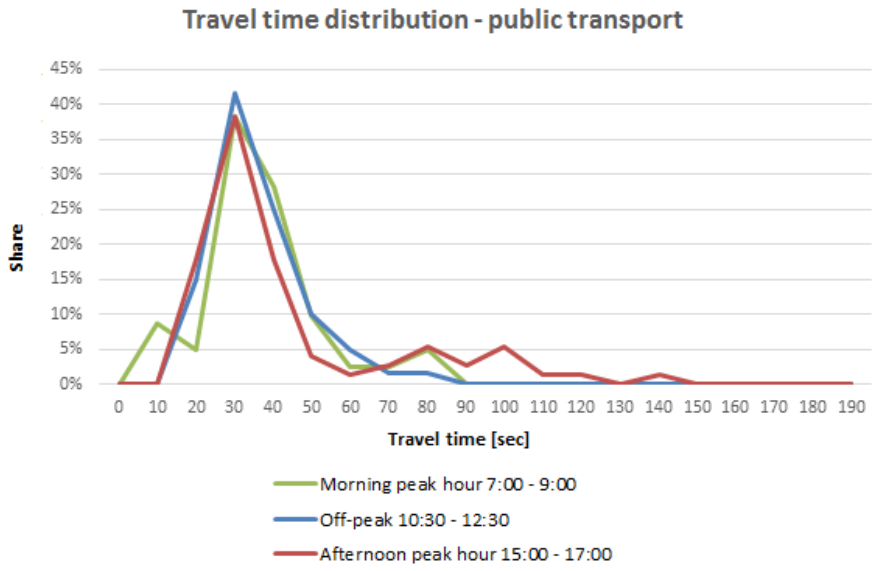

Figure 17. Travel time distribution -– public transport – 3-Maja (Wójta Radtkego – Zgoda)

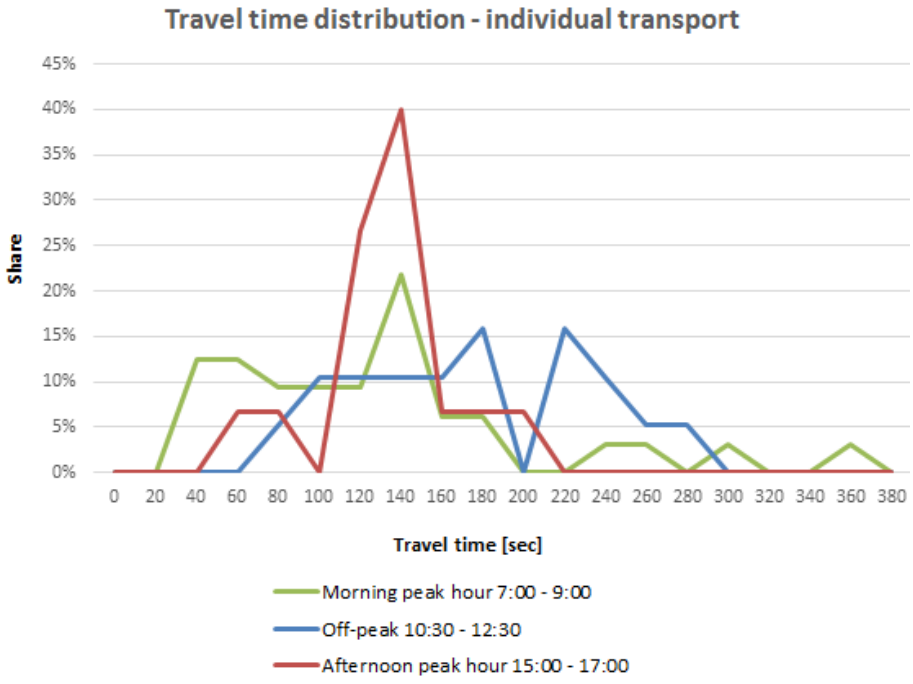

Figure 18. Travel time distribution – individual transport – 10-Lutego (Skwer Kościuszki – Dworcowa, dir. Skwer Kościuszki)

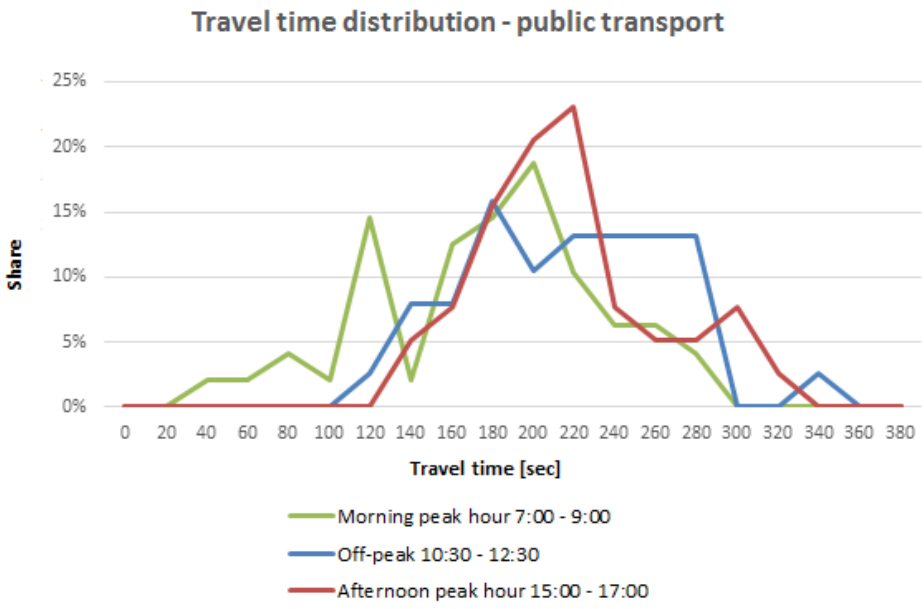

Figure 19. Travel time distribution – public transport – 10-Lutego (Skwer Kościuszki – Dworcowa, dir. Skwer Kościuszki)

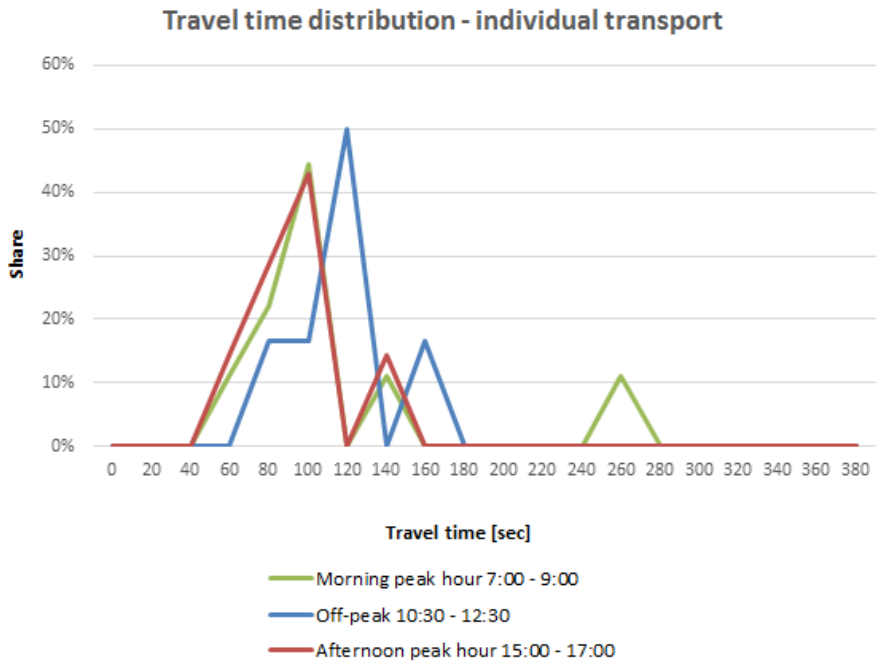

Figure 20. Travel time distribution – individual transport – 10-Lutego (Skwer Kościuszki – Dworcowa, dir. Main station)

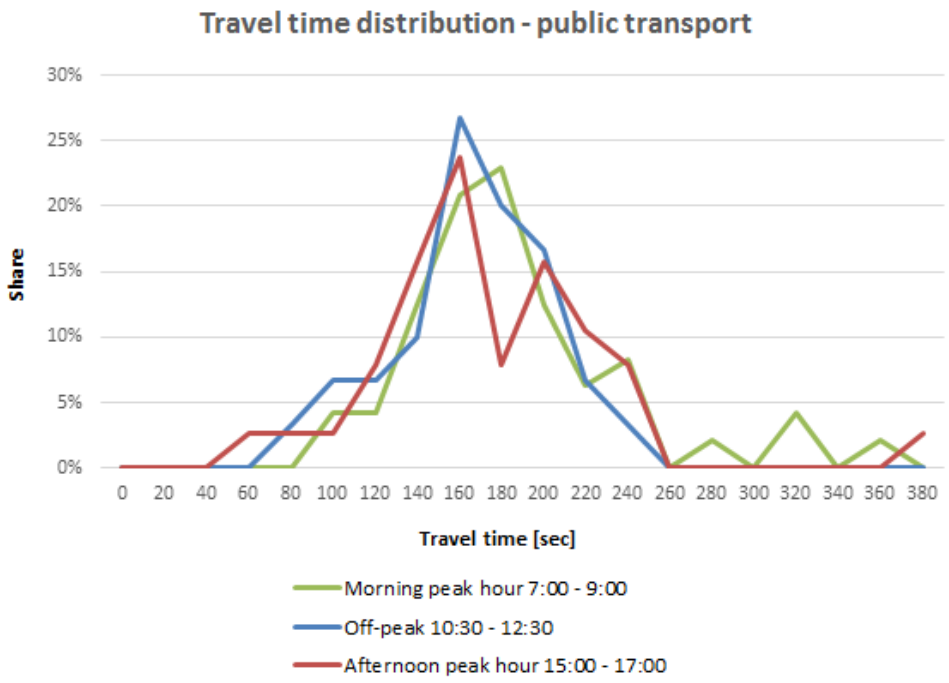

Figure 21. Travel time distribution – public transport – 10-Lutego (Skwer Kościuszki – Dworcowa, dir. Main station)

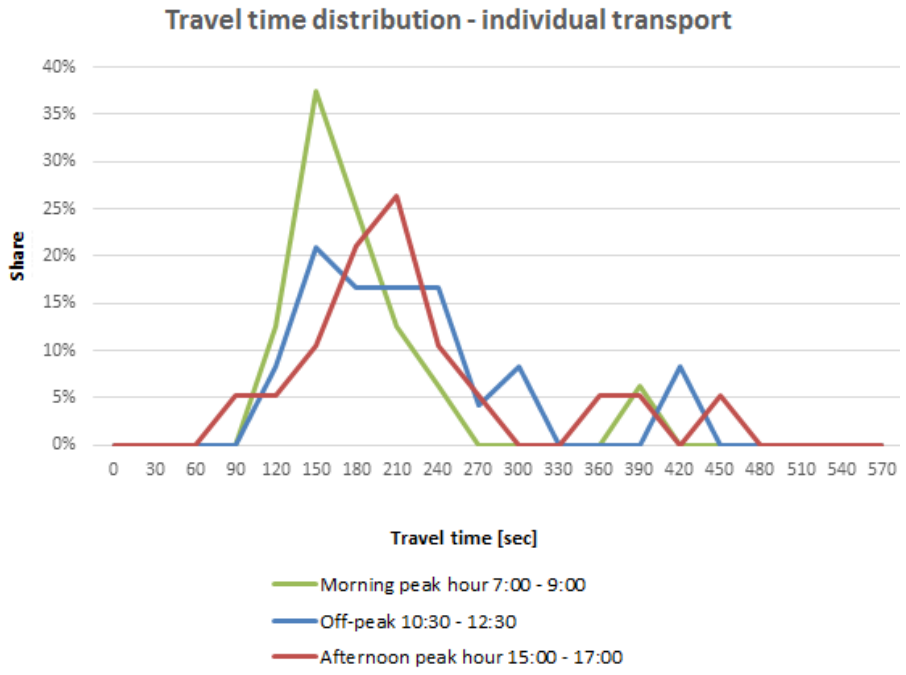

Figure 22. Travel time distribution – individual transport – Władysława IV (10-Lutego – Piłsudskiego, direction Śródmieście)

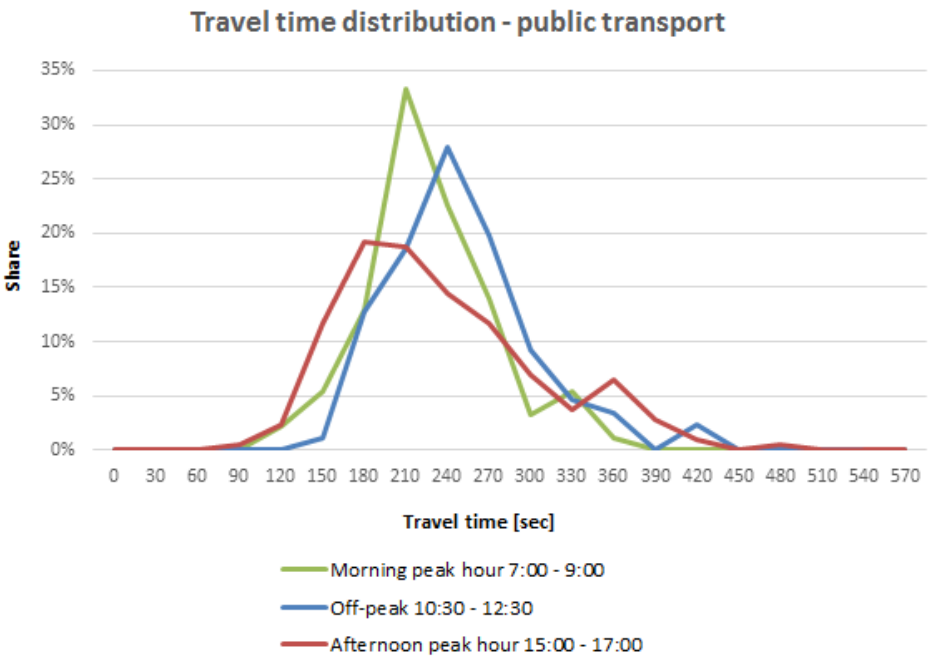

Figure 23. Travel time distribution – public transport – Władysława IV (10-Lutego – Piłsudskiego, direction Śródmieście)

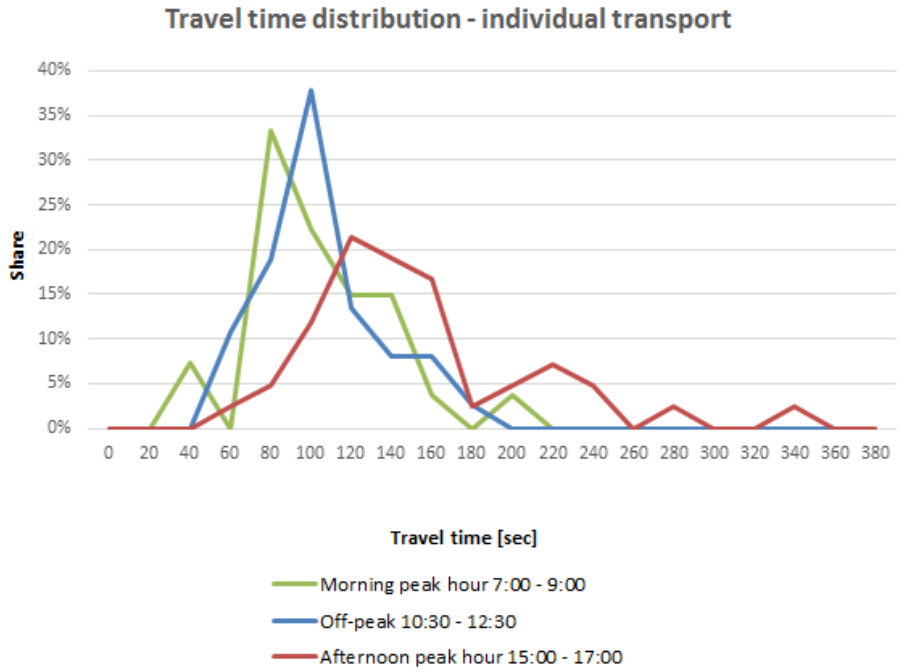

Figure 24. Travel time distribution – individual transport – Władysława IV (10-Lutego – Piłsudskiego, direction Wzgórze Św. Maksymiliana)

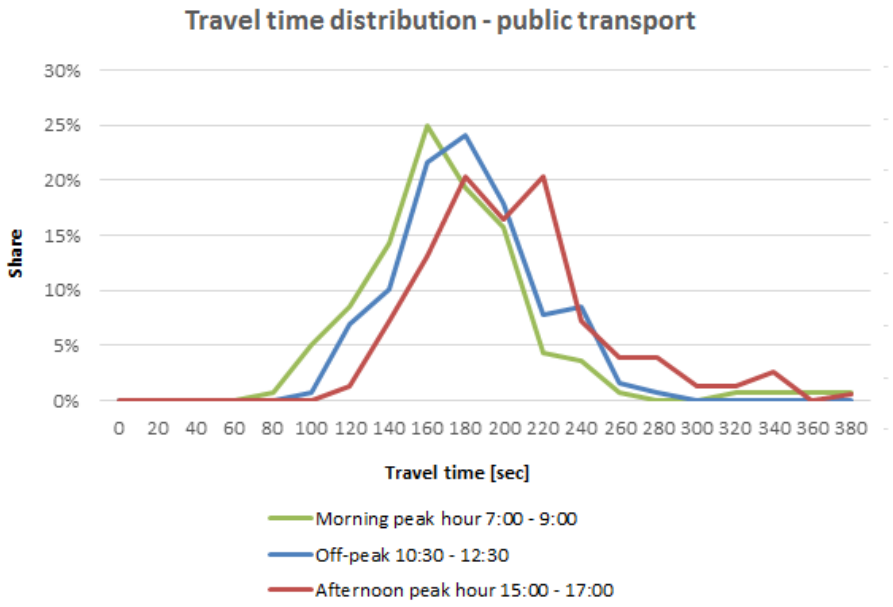

Figure 25. Travel time distribution – public transport – Władysława IV Travel time distribution – individual transport – Władysława IV (10-Lutego – Piłsudskiego, direction Wzgórze Św. Maksymiliana)

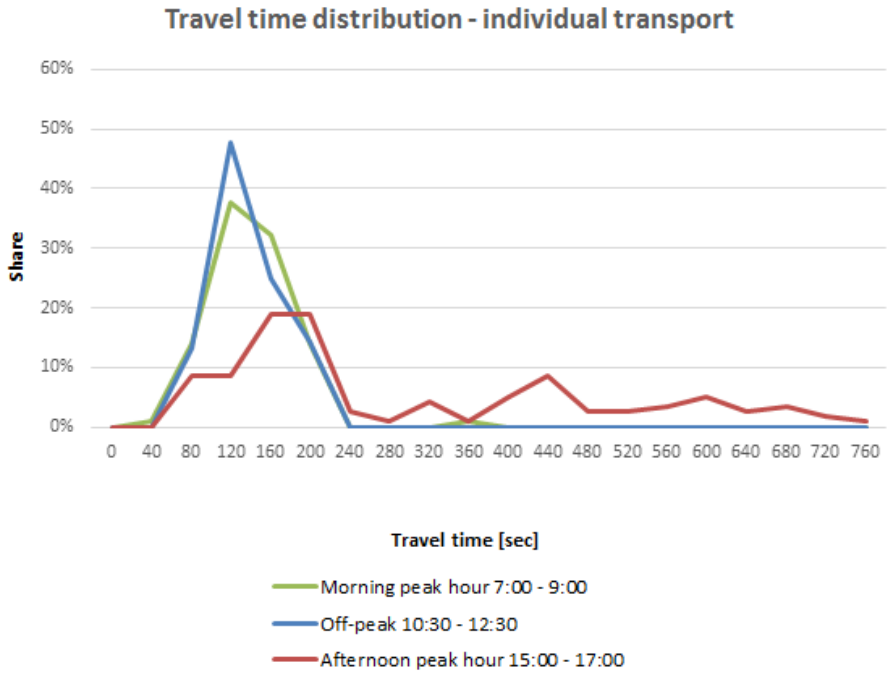

Figure 26. Travel time distribution – individual transport – Kielecka (Witomińska – gmach WSAiB, direction Witomino)

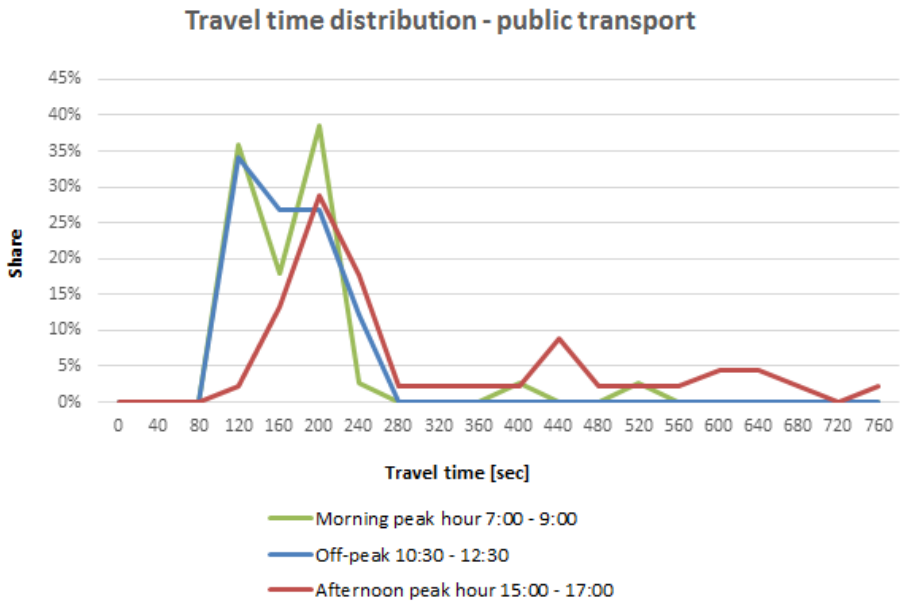

Figure 27. Travel time distribution – public transport – Kielecka (Witomińska – gmach WSAiB, direction Witomino)

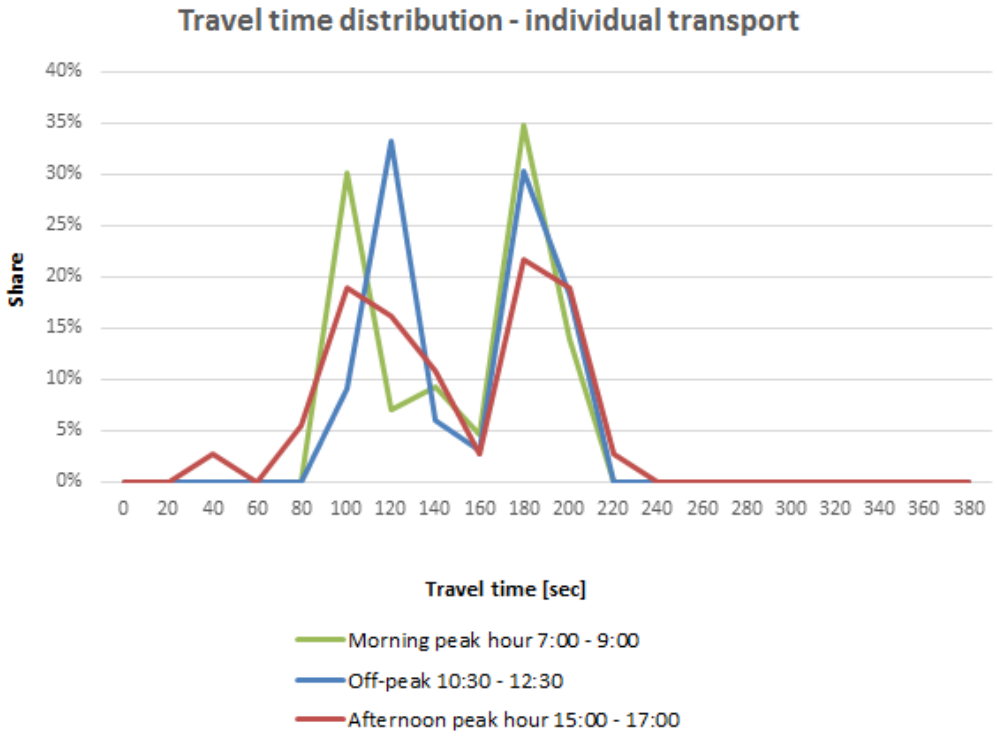

Figure 28. Travel time distribution – individual transport – Kielecka (Witomińska – gmach WSAiB, direction Wzgórze Św. Maksymiliana)

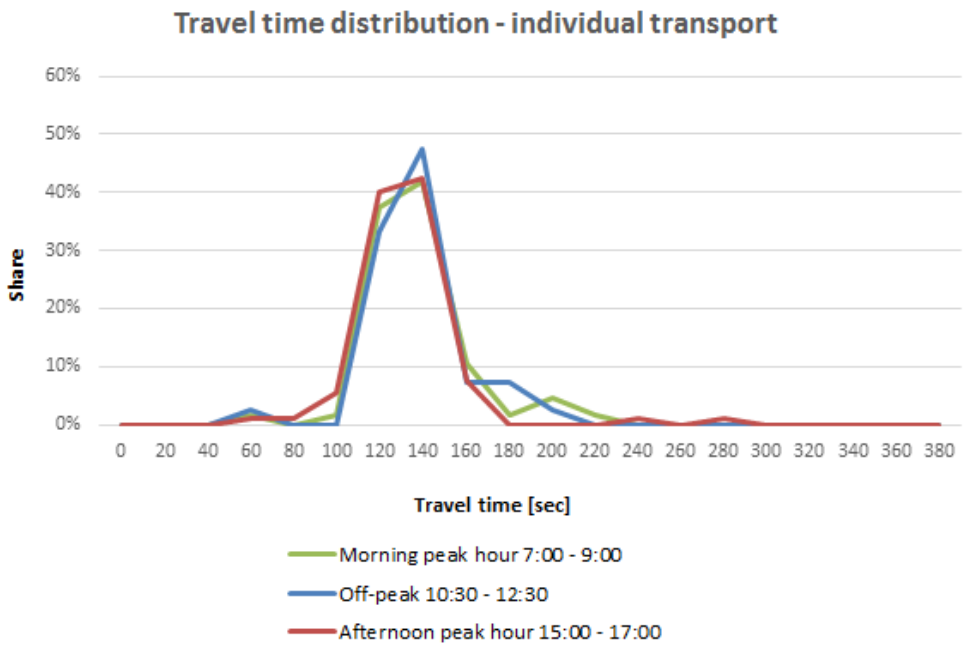

Figure 29. Travel time distribution – public transport – Kielecka Travel time distribution – individual transport – Kielecka (Witomińska – gmach WSAiB, direction Wzgórze Św. Maksymiliana)

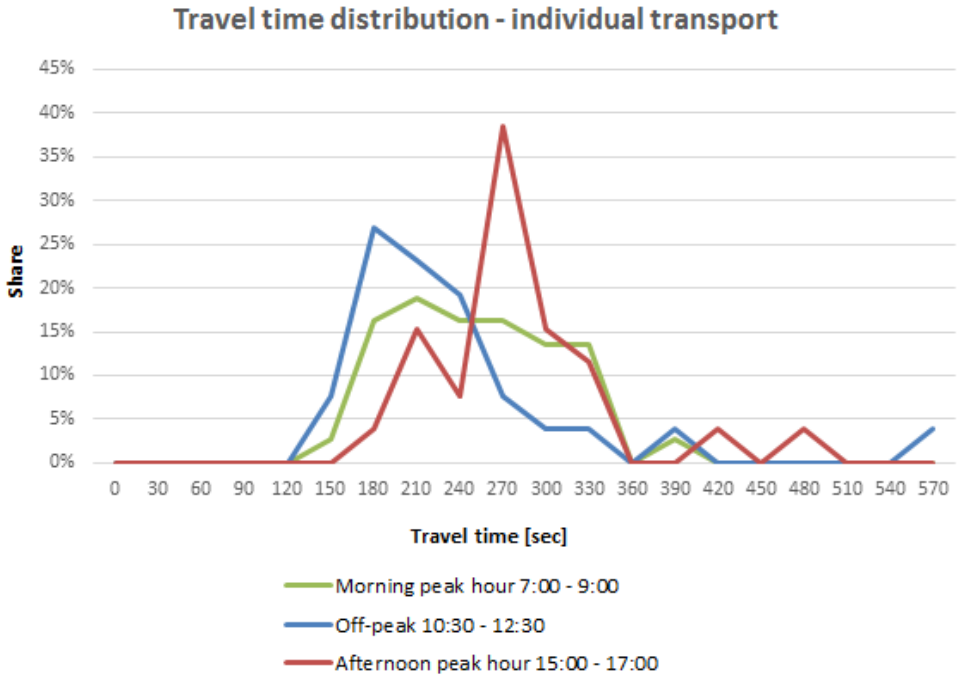

Figure 30. Travel time distribution – individual transport – Aleja Zwycięstwa I. Zwycięstwa (Wielkopolska – Droga Gdyńska, direction Wielkopolska)

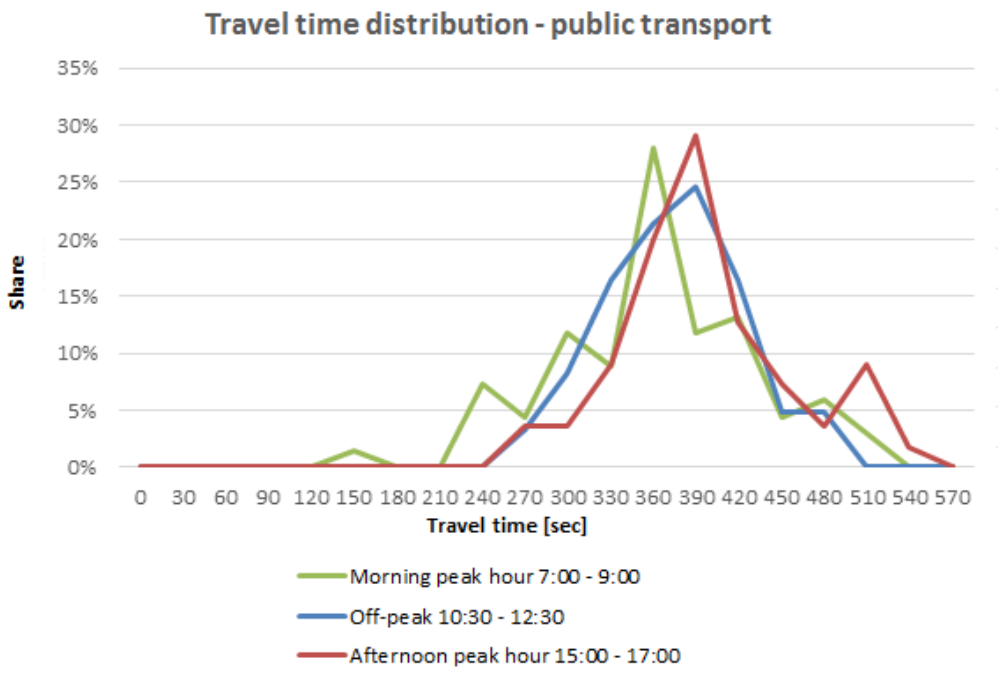

Figure 31. Travel time distribution – public transport – Aleja Zwycięstwa I. Zwycięstwa (Wielkopolska – Droga Gdyńska, direction Wielkopolska)

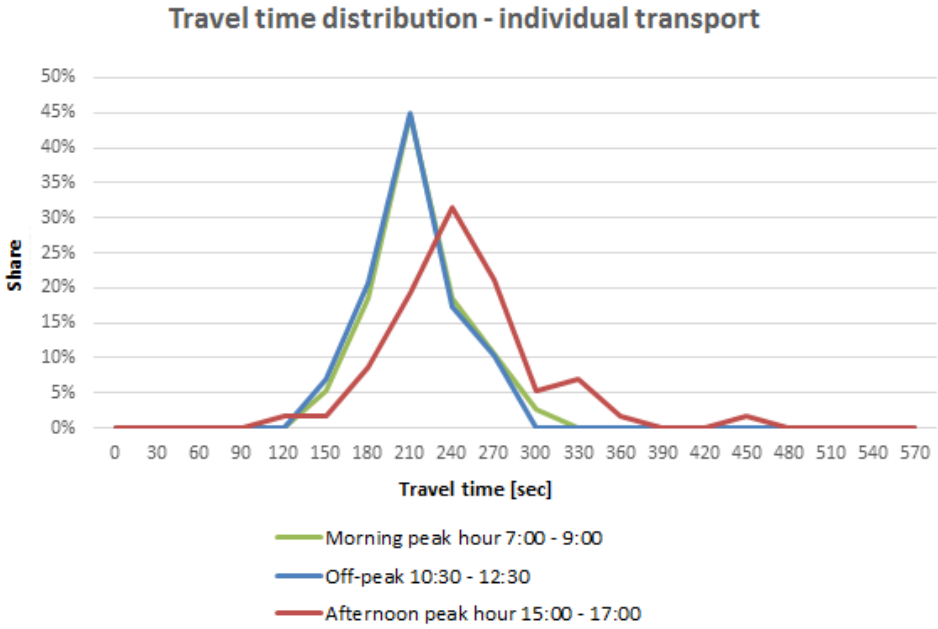

Figure 32. Travel time distribution – individual transport – Aleja Zwycięstwa (Wielkopolska – Droga Gdyńska, direction Wzgórze Św. Maksymiliana)

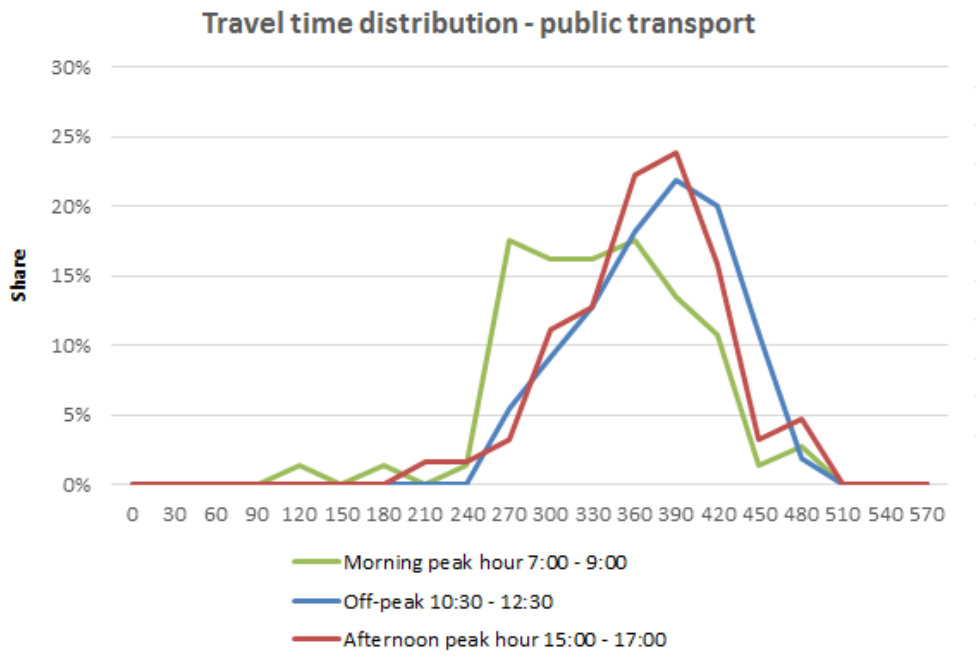

Figure 33. Travel time distribution – public transport – Aleja Zwycięstwa (Wielkopolska – Droga Gdyńska, direction Wzgórze Św. Maksymiliana)

3.3 Criteria for determining the location of bus lanes in Gdynia

In order to indicate the validity for the designation of dedicated bus lanes, in the first stage the degree of fulfilment of the following criteria was determined[5] [2]:

1) Minimum bus traffic volume should be: $Q_{KZ} > 10\ A/h$, that recommended for buses exceeds $Q_{KZ} > 20\ A/h$
2) Hourly public transport passenger flow should be higher than the hourly individual transport passenger flow per traffic lane, after deducting one bus lane:

$$Q_{KZ} \cdot n_{KZ} \geq \frac{Q_{SO} \cdot n_{SO}}{N-1} \quad (5.1)$$

where:

Q_{KZ} – bus traffic volume

n_{KZ} – mean bus occupation

Q_{SO} – public transport traffic volume

n_{SO} – mean passenger car occupation

N – number of lanes in one direction

Table 2. Results of the criterion for determining the location

Road name	Direction to	Criterion no. 1 A/h	Criterion no. 2
10-Lutego	Main railway station	21	FALSE
10-Lutego	Skwer Kościuszki	47	TRUE
3-Maja	Armii Krajowej	21	FALSE
Kielecka	**Witomino**	14	TRUE
Kielecka	Wzgórze Świetego Maksymiliana	12	TRUE
Morska 1	Chylonia	50	TRUE
Morska 2	Śródmieście	47	TRUE
Morska 3	Śródmieście	48	TRUE
Wójta Radtkego	Plac Kaszubski	58	TRUE
Władysława IV	**Wzgórze Świetego Maksymiliana**	51	TRUE
Władysława IV	**Śródmieście**	48	TRUE
Zwycięstwa	Wzgórze Świetego Maksymiliana	42	TRUE
Zwycięstwa	Wielkopolska	41	TRUE

K. Birr et al.: Koncepcja wyznaczenia dedykowanych pasów autobusowych w obszarze Śródmieścia Gdyni oraz na dwóch drogach dojazdowych do centrum [Concept for HOV lanes/ bus lanes for the city centre and two incoming roads into the city centre]. Working Document No. G3.5-WD1. Gdansk University of Technology, Gdansk-Gdynia 2014, November 2014 (not public)

[5] M. Bauer: Wydzielone pasy dla komunikacji zbiorowej w Krakowie, Conference materials, Kraków, XV Mobility forum, 2009.

All the analysed sections fulfilled the criterion for the minimum number of journeys, while the sections 10-Lutego, direction Main railway station, and 3-Maja, direction Armii Krajowej, did not fulfil criterion no. 2 following the assumed formula.

In order to determine which of the analysed sections would be the most suitable for the designation of a bus lane, meaning which one would be efficient in reference to the entire transport system of Gdynia, research was conducted using the macrosimulation transport model for Gdynia developed in DYN@MO measure G3.1, for which the resulting value is the change in the global travel time (person-hours) in the entire transport network. The specific assumptions and the analysis method are described in a project-internal Working Document[6]. The obtained results (Table 3) indicate that the most efficient sections with a dedicated bus lane in terms of efficiency calculated by the change (reduction) in the global travel time for the city were:

- Kielecka – dir. Witomino
- Morska (Kalksztajnów – Morska-Estakada bus stop) dir. Chylonia
- Morska (Morska-Estakada bus stop – Grabowo) dir. Śródmieście
- Władysława IV, dir. Wzg. Św. Maksymiliana,
- Władysława IV, dir. 10-Lutego.

Moreover, the simulations indicated an increase in the global travel time in the case of bus lanes used for the sections:

- Zwycięstwa, dir. Wielkopolska
- Zwycięstwa, dir. Wzg. Św. Maksymiliana,
- 10-Lutego, dir. Skwer Kościuszki.

Accordingly, these sections were omitted in the subsequent part of the analysis.

The Morska section, direction Śródmieście, was discarded due to the need to reconstruct some of its segments.

[6] K. Birr et al.: Concept for HOV lanes/ bus lanes for the city centre and two incoming roads into the city centre. Working Document No. G3.5-WD1. Gdansk University of Technology, Gdansk-Gdynia 2014, November 2014 (not public)

Table 3. Macrosimulation result values – investment state

Road name	Direction to	Peak (period of examined greatest loss of time)	Before												Change in the global time of travel on the network transport
			Section				Cross Section		Modal Split		Network				
			Pas-km	Pas-hr	Person-km	Person-hr	Number of passengers	Volume of traffic	PT	IT	Transport activity	Global time	Mean speed	Share of PT travel	
			[pas.km]	[pas.h]	[pers.km]	[pers.h]	[persons]	[persons]	[%]	[%]	[pas.km]	[pas.h]	[km/h]	[%]	[pas.h]
10 Lutego	Main Station	afternoon	129,6	7,2	335,9	17,0	471	865	35,0	65	485228,6	17820,4	27,23	39,04	-1,0
10 Lutego	Skwer Kościuszki	afternoon	277,6	22,3	322,8	25,3	762	1116	41,0	59	485273,2	17839,4	27,20	39,05	18,0
3 Maja	Armii Krajowej	afternoon	134,7	3,6	159,1	6,7	680	855	44,0	56	485185,6	17818,4	27,23	39,05	-3,0
Kielecka	**Witomino**	**afternoon**	**1016,4**	**28,8**	**904,4**	**54,3**	**741**	**660**	**53,0**	**47**	**485277,0**	**17789,3**	**27,28**	**39,05**	**-32,1**
Kielecka	Wzgórze Św, Maksymiliana	afternoon	847,1	52,9	909,0	54,8	618	663	48,0	52	485173,7	17813,0	27,24	39,04	-8,4
Morska 1	**Chylonia**	**afternoon**	**678,4**	**33,1**	**998,9**	**61,6**	**1680**	**2504**	**40,0**	**60**	**485055,2**	**17790,6**	**27,26**	**39,05**	**-30,8**
Morska 2	Śródmieście	morning	2170,5	113,7	3460,1	180,9	1713	2955	37,0	63	414300,9	13685,1	30,27	31,52	-31,4
Morska 3	Śródmieście	morning	2657,4	93,6	2997,5	116,5	2435	2525	49,0	51	414327,4	13708,2	30,22	34,69	-8,4
Wójta Radtkego	Plac Kaszubski	afternoon	224,7	16,9	83,8	5,6	765	239	76,0	24	485196,4	17818,4	27,23	39,05	-3,0
Władysława IV	**Wzgórze Św, Maksymiliana**	**afternoon**	**1328,1**	**51,8**	**1181,0**	**38,8**	**1608**	**1494**	**52,0**	**48**	**485245,0**	**17805,5**	**27,25**	**39,04**	**-15,9**
Władysława IV	**Śródmieście**	**afternoon**	**1168,7**	**44,6**	**1290,6**	**41,8**	**1354**	**1683**	**45,0**	**55**	**485268,4**	**17807,8**	**27,25**	**39,04**	**-13,6**
Zwycięstwa	Wzgórze Św, Maksymiliana	afternoon	2395,7	77,6	2087,6	58,3	1536	999	61,0	39	485615,3	17826,2	27,24	39,05	4,8
Zwycięstwa	Wielkopolska	afternoon	2408,8	94,3	2179,1	61,9	1491	986	60,0	40	485708,2	17846,9	27,22	39,04	25,5

4 Microsimulations of selected bus lanes

The concepts for the designation of bus lanes demonstrated in this study were analysed in the subsequent study stage with the use of microsimulations aimed at a detailed check of the influence of the proposed changes in traffic organisation (particularly for the method of lane designation in the hotspots) on the traffic conditions for all users of the transport network.

The software of PTV Vissim was used to prepare simulation model. It enables for precise emulation of traffic and simulation of interactions of its elements. It is the most commonly used software in the world to simulate traffic in a microscope. An important feature of the software is that it allows to capture all road users (pedestrians, cyclists, individual vehicle users, public transport users, etc.) in one model and verify their interaction.

PTV Vissim enable elasticity in fewa aspects, i.e. attributes assigned to drivers and vehicles enable individual parametrisation. In addition, a large number of interfaces ensure seamless integration with other systems used for traffic management. PTV Vissim provides extensive analysis capabilities, being a powerful tool for assessing and planning infrastructure for urban and non-urban transport. The software is well suited for creating different scenarios from which final decision could be made.

A model of the transport network was constructed to simulate traffic, at microscale. It depicts:

• existing and planned traffic organization,

• traffic lights,

• intensity and structure of road traffic,

• public transport lines,

• timetables for public transport vehicles,

• location of bus and trolleybus stops.

Two basic variants were used for the analysis:

• variant W0 - existing state,

• variant W1 - assuming the introduction of the dedicated bus lane.

The following streets have been analyzed at particular peak times:

• ul. Morska:

- Section 1 - afternoon peak,

- Section 2 - morning peak,
- section 3 - morning peak,

• ul. 10-go Lutego - afternoon peak,

• ul. Wladyslawa IV - afternoon peak,

• ul. Kielecka - afternoon peak.

Results of traffic microsimulation for selected streets in Gdynia

Average travel time and speed for selected sections under microsimulation analysis were presented in following table. There is significant travel time reduction for public transport vehicles (33%) and minor increase of travel time for individual users (ca. 4%) for Kielecka street. Also, on Wladyslawa IV, the reduction of travel time is significant for one direction. Moreover, it provides improvement for individual and collective transport. Least favourable effects would be observed in case of buslane introduction on 10-go Lutego street, bringing moderate shortening of travel time for public transport vehicles and travel time extension for cars.

Table 4. The aggregated results of traffic microsimulation for selected streets in Gdynia

Mode of transport	W0		W1		
	average travel time	average speed	average travel time	The difference in travel time: W1-W0	average speed
	[secs]	[km/h]	[secs]	[secs]	[km/h]
Kielecka street (direction: Witomino)					
individual	205,2	25,3	214,7	**-9,5 (-4,4%)**	24,1
public	193,3	26,8	145,1	**48,2 (33,2%)**	35,7
Wladyslawa IV (direction: Piłsudskiego)					
individual	251,2	32,7	222,3	**28,9 (13,0%)**	33,7
public	239,3	18,0	163,4	**75,9 (46,5%)**	22,1
10-go Lutego (direction: Skwer Kościuszki)					
individual	154,2	12,6	167,5	**-13,3 (-7,9%)**	11,6
public	227,7	8,5	195,1	**32,6 (16,7%)**	10

Source: self-study based on : K. Birr, L. Gumińska, J. Oskarbski, Analiza zasadności wyznaczenia dedykowanych pasów autobusowych w Gdyni. Deliverable nr G3.5-WD2, January 2015, s. 38

5 Research on citizens' preferences regarding implementation of dedicated bus/HOV lanes in Gdynia

Public consultations on buslanes implementation in Gdynia was organised in form of surveys. Their form enabled different social groups to participate and to collect their opinions in a more structured form (Table 5).

Table 5. Surveys on buslanes conducted in Gdynia within CIVITAS DYN@MO timeframe

Research	CIVITAS DYN@MO activity	Date	Form of contact	Number of respondents
Citizens' preferences regarding the introduction of bus lanes in Gdynia [ZDiZ, UG]	yes	2014	electronic	558
Transport preferences and transport behaviour of Gdynia's citizens.	no	2015	in-house interview	2000
Citizen's opinions on bus lanes and their utilisation	yes	2016	electronic	505

Source: self-study

Within the measure G3.5 "Dedicated bus/ HOV lanes control with the use of ITS", the City of Gdynia has conducted an online survey on citizens' preferences regarding the introduction of bus lanes in Gdynia, using Gdynia's Mobility 2.0 platform developed in DYN@MO measure G3.5 – the webpage www.mobilnagdynia.pl. The first survey was prepared and executed in November 2014. The survey involved 558 respondents (Table 5) of which 90% were living in Gdynia.

According to the survey results, 39% of respondents travel mainly by public transport and 34% travel mostly by car. 7% of respondents highlighted cycling as their main mode of travelling in the city.

76% of respondents consider bus lanes to have a positive impact on the quality of public transport in terms of travel times. According to 38% of respondents, bus lanes in Gdynia can positively influence travel choices of people when planning their trips.

On the other hand 38% of respondents think that bus lanes will entail restriction of the street's capacity for other road users and 16% of respondents consider bus lanes as needless cost for the city. A clear majority of respondents (77%) supported the concept of bus lanes implementation in Gdynia, 23% opposed it.

Among different options of authorising different users to access the dedicated bus lanes, 64% respondents agreed with allowing emergency vehicles to use the lanes. Next, school and tourist buses should be allowed to use the lanes (in the opinion of 42% respondents). Support for municipal service vehicles, taxis and bicycles was at the level of 25-30%.

Regarding the locations of the bus lanes, the most approved suggestion was to implement one on Morska Street – with 39-43% approval, however, depending on the section of the street. Above 30% respondents approved the idea of bus lanes on Zwycięstwa, Władysława IV Street and Kielecka Street (Fig. 34).

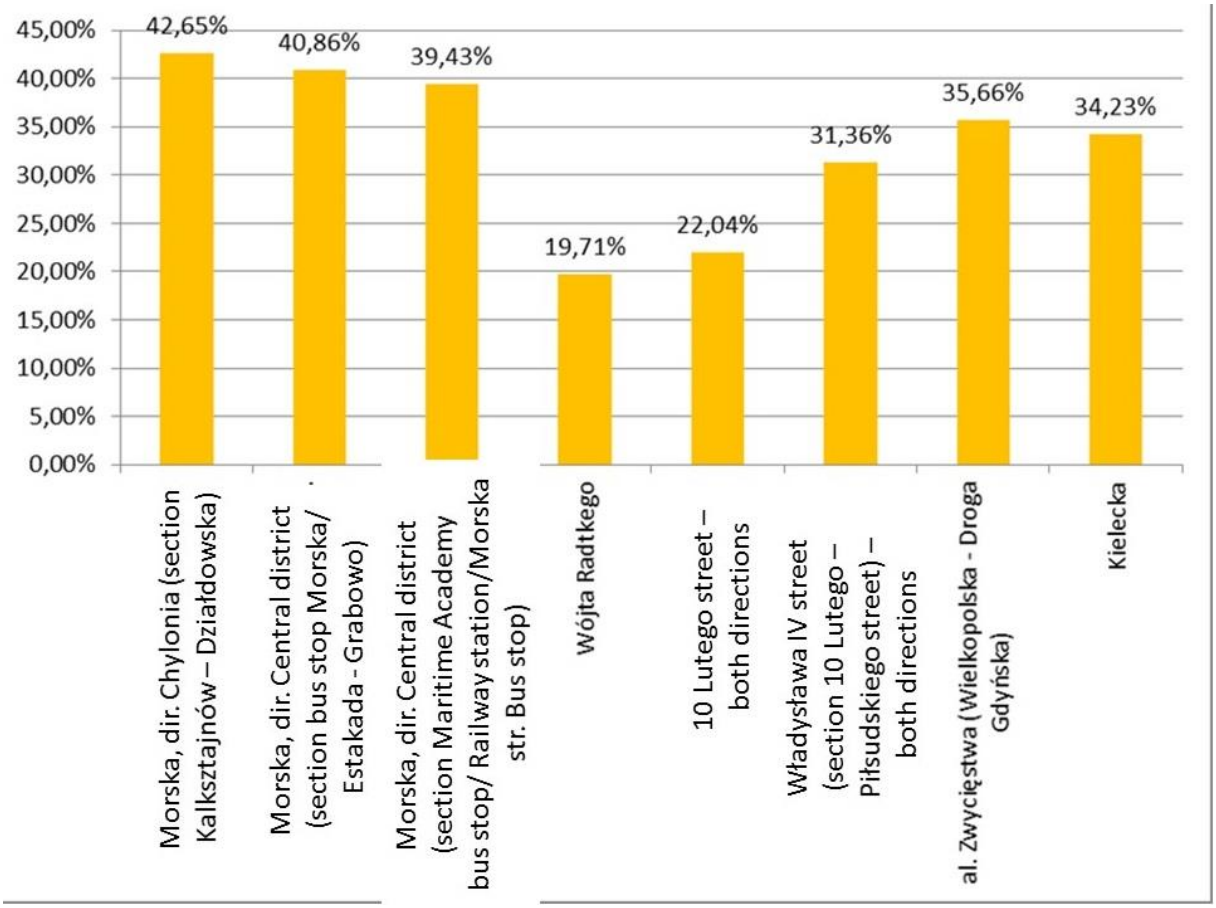

Figure 34. The level of support for selected road sections to be transformed into bus lanes in Gdynia in November 2014 [n=558]

Source: Survey and analysis of citizens' preferences regarding implementation of dedicated bus/HOV lanes in Gdynia. A study prepared by ZDiZ Gdynia and University of Gdansk within measure G3.5 of the CIVITAS DYNAMO project. Gdynia, November 2014, p. 12.

ZKM Gdynia – the city's public transport authority – has conducted marketing research on transport behaviour and preferences of Gdynia's citizens in 2015. The research took part among 2,000 citizens between 15 and 75 years of age. The method used was in-house interviews, and the sample reflected sex, age interval and district of living. One out of almost 40 questions was about the acceptance of dedicated lanes for public transport vehicles. The majority of respondents accepts separated bus lanes on 3-lane streets in Gdynia (73,2%), while only 29,4% accepts such separation on 2-lane streets. In the latter case, the majority of

respondents was against such a solution (56,4%)[7]. Taking into account the high value of Gdynia's motorisation index, the high share of negative opinions is not a surprise.

In August 2016 a survey on citizens' opinions about the functioning of HOV and dedicated bus lanes was conducted, using the Mobilna Gdynia online platform. Over 500 citizens participated in the survey, consisting of eight questions, including some with multiple choices. 93% of the 505 respondents were living in Gdynia.

43% of respondents used public transport often or always, while 31% used car in the same way (Fig. 35). It means that car drivers have a strong representation in this survey, although it is less than in the general modal split investigated in 2015 in the research conducted by ZKM Gdynia. 16% used equally public transport and car, and 4% used bike (while in general population share of bike was lower).

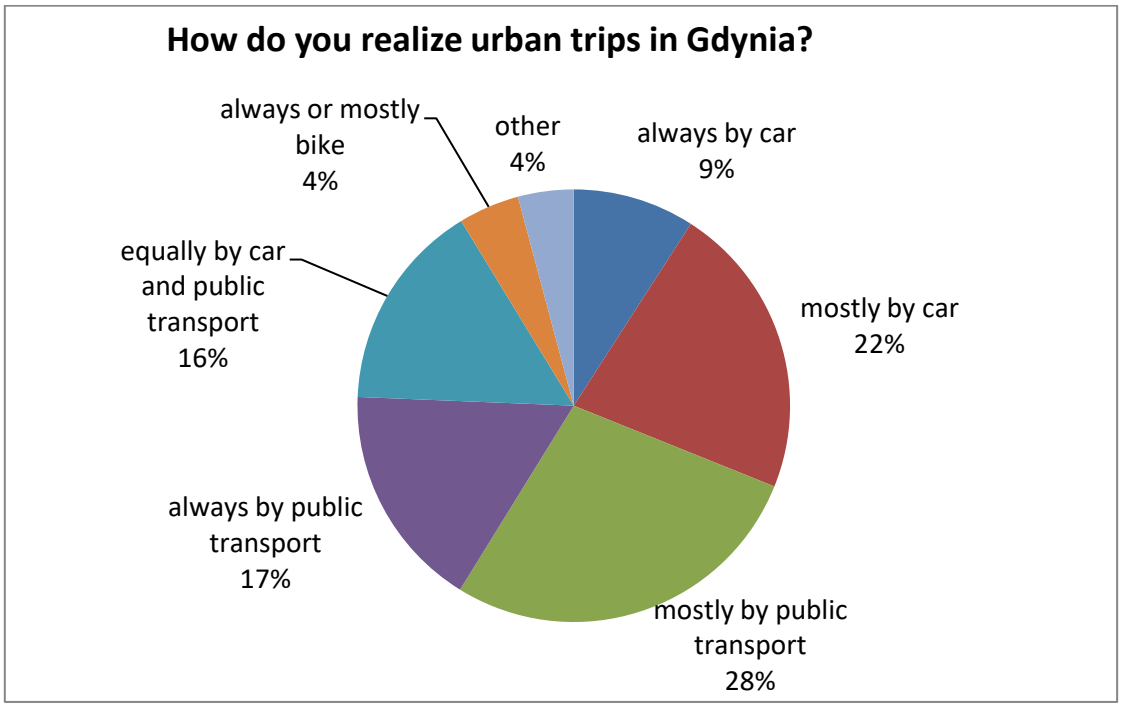

Figure 35. Means of transport used by respondents in urban trips [n=505]

[7] Preferencje i zachowania komunikacyjne mieszkańców Gdyni w 2015 r. Raport z badań marketingowych. ZKM Gdynia, University of Gdansk, Gdynia 2015, s. 29 [Transport preferences and transport behaviour of Gdynia's citizens in 2015. A marketing research report]

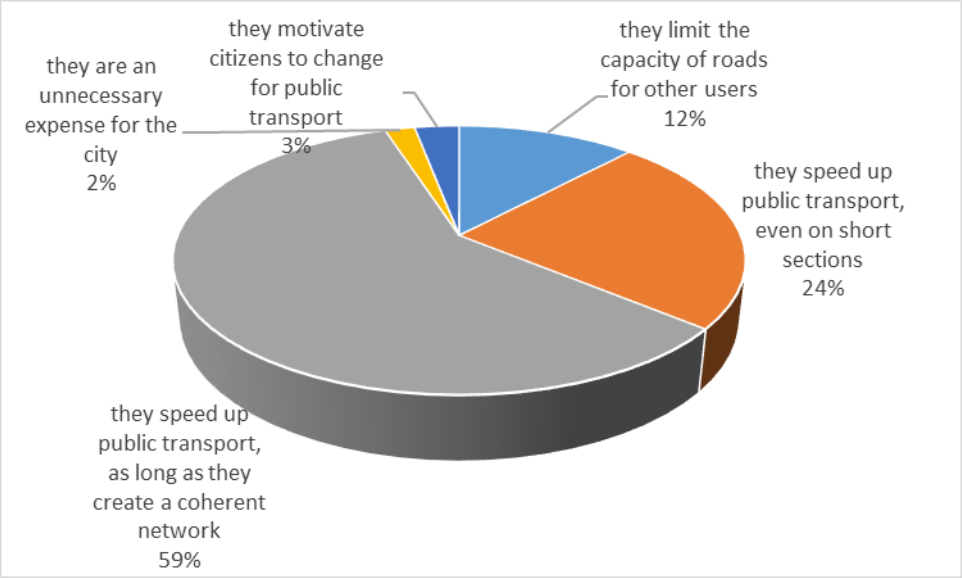

Figure 36. Factors significant in creation of bus lanes [n=505]

Answers on this question could be divided into two groups – expressing positive and negative attitude towards dedicated bus lanes. Answers "They limit the capacity of urban roads for other users" and "They are an unnecessary expense for the city" that expressed negative attitude was chosen by just 14% of respondents (Fig. 36). The majority of respondents (59%) believe that "They speed up public transport, as long as they create a coherent network", which could be regarded as a positive opinion, even though it requires fulfilment of some conditions. 27% believes that dedicated bus lanes "(…) motivate citizens to change for public transport" and "(…) speed up public transport, even on short sections".

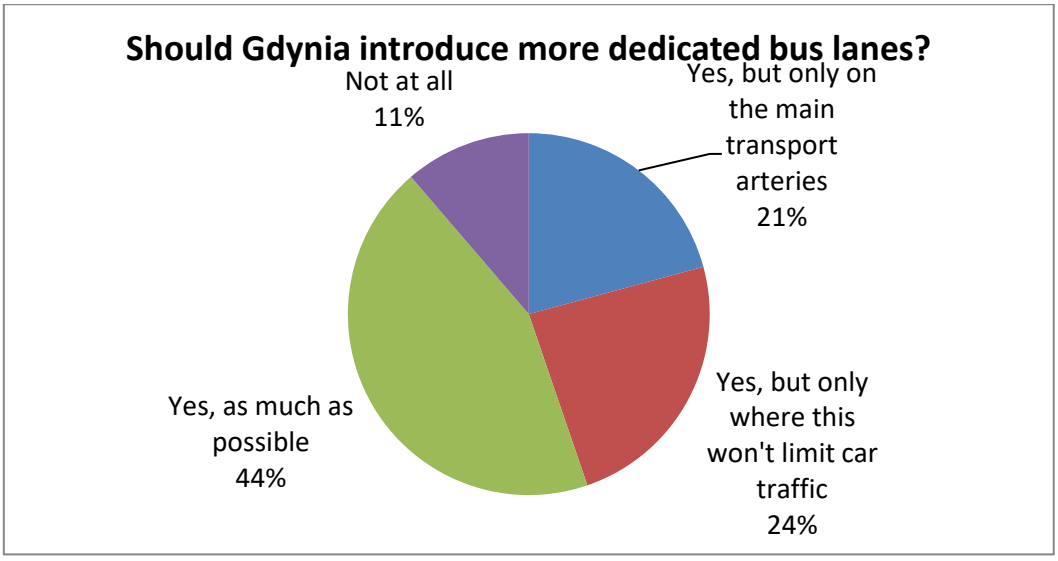

Figure 37. Further implementation of dedicated bus lanes [n=505]

The next question was directly about support for the development of dedicated bus lanes. Only 11% of respondents were against it, while 44% unconditionally supported the implementation of further bus lanes (Fig. 37). 45% support it "(…) on the main transport arteries" (21%) or "(…) where this won't limit car traffic" (24%). Based on the feedback it could be stipulated that even respondents using their car for all or the majority of their trips (31% of respondents) are supporting the development of dedicated bus lanes even if this would limit car traffic.

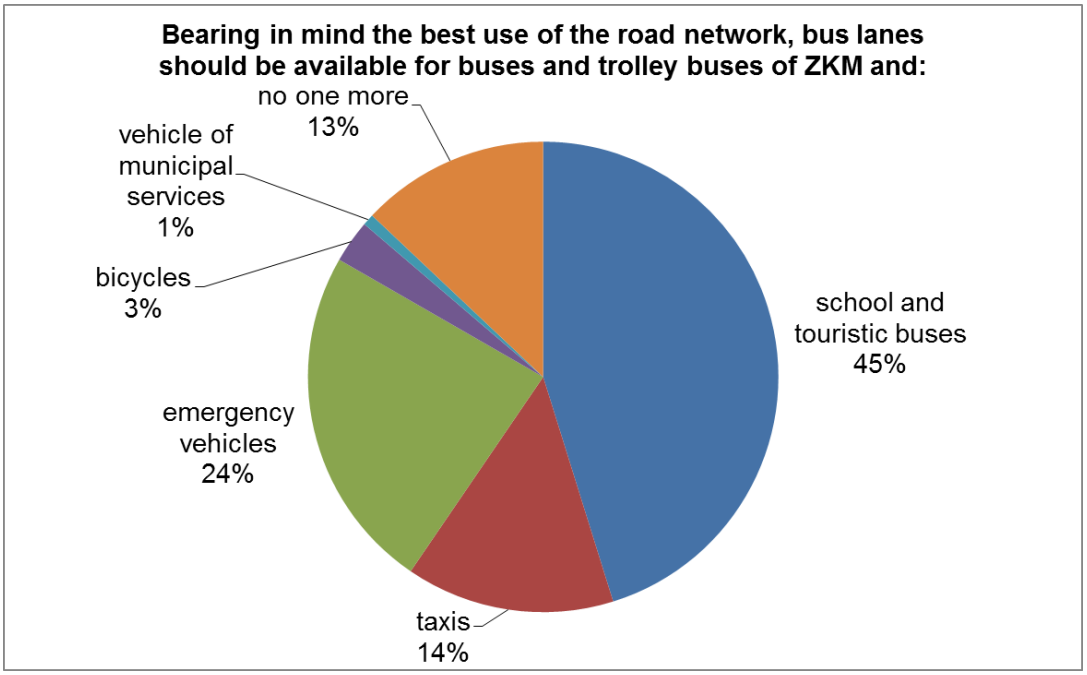

Figure 38. Other vehicles on dedicated bus lanes

When people responded on the presence of other vehicles on dedicated bus lanes they mainly focused on school and touristic buses (45%) and emergency vehicles (24%). These 2 categories cumulated more than 2/3 rd of total number of answers. Taxis also received relatively high support (14%), while bicycles and vehicles of municipal services are definitely less acceptable. Only 13% of respondents said that the dedicated bus lanes should only be used by public transport buses.

For evaluation of particular bus lanes, respondents could give up to four answers, prioritising them according to their order.

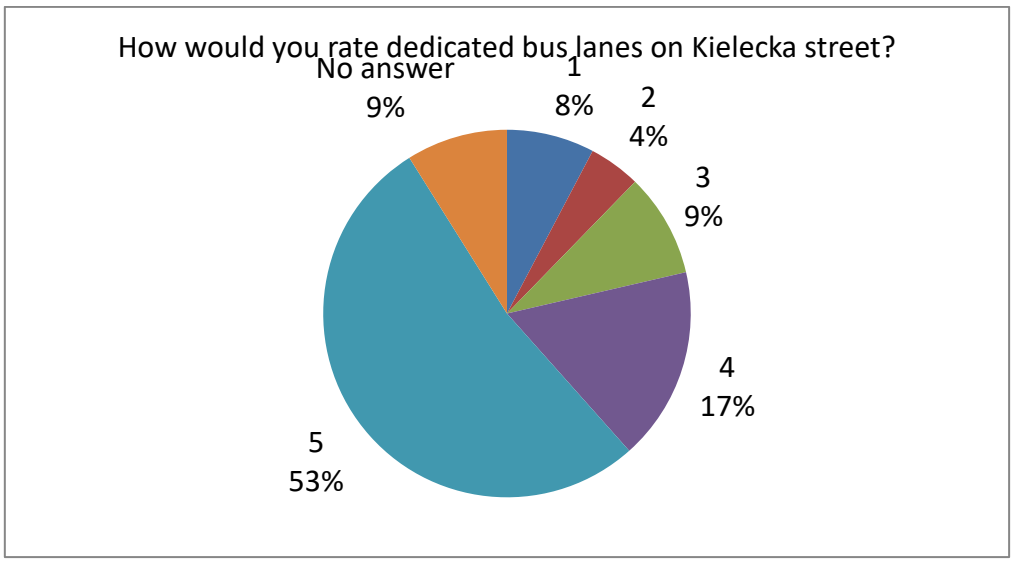

Figure 39. Rates of dedicated bus lane on Kielecka Street

On a scale from 1 to 5 (where 5 is the best, and 1 is the worst) over half of respondents (53%) rated the dedicated bus lane on Kielecka Street at 5. Together with grade 4 it covers 70% or all answers, which gives this lane a quite high average score of 4.12 out of 5. Only 12% of respondents rate it negatively, by choosing grade 1 or 2 (Fig. 39).

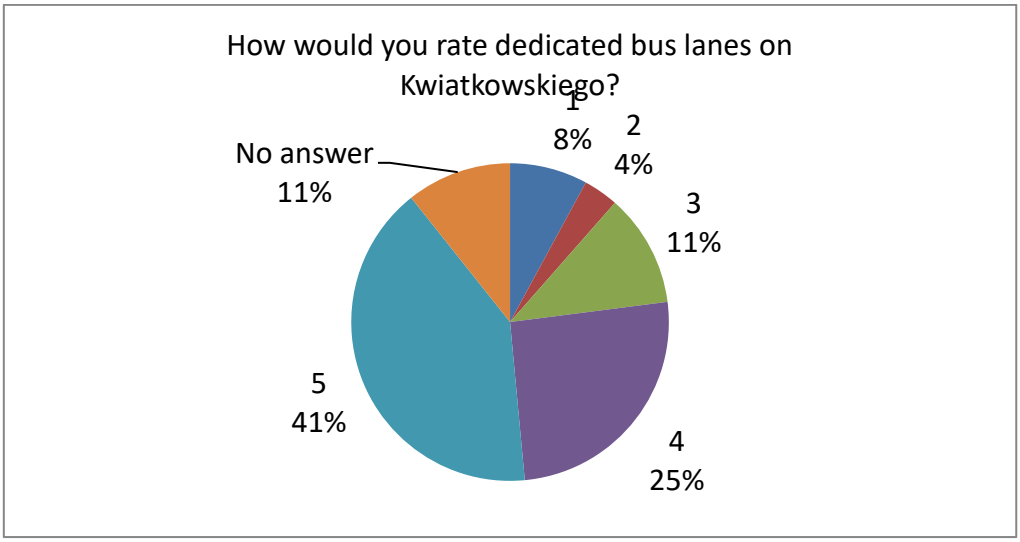

Figure 40. Rates of dedicated bus lane on Kwiatkowskiego

On a scale from 1 to 5 (where 5 is the best, and 1 is the worst) 41% of respondents rated the dedicated bus lane on Kwiatkowskiego Street at 5. Together with grade 4 it covers 66% of all answers, which gives this lane a quite high average score of 3.98 out of 5. Only 12% of respondents rate it negatively, by choosing grade 1 or 2.

6 Analysis of the travel time on determined road lanes for public transport vehicles in Gdynia[8]

The implementation of road lanes for public transport vehicles in Gdynia was executed in stages. The first lane was introduced on Kielecka street, providing a convenient link between the central part of the city with the district of Witomino. Then, selected road sections were transformed into roads with separated bus lanes. However, at this stage they don't yet provide direct, seamless travel for public transport users because they are not yet linked to each other. Therefore, the current status of the bus lanes in Gdynia is only the first stage of their development. To make them a crucial factor for faster public transport, they should be extended and linked together, creating mid to long distance corridors, resulting in time efficiency and higher reliability. The current status of the bus lane network in Gdynia is presented in Fig. 41 (the dotted line presents the planned bus lane on Morska street).

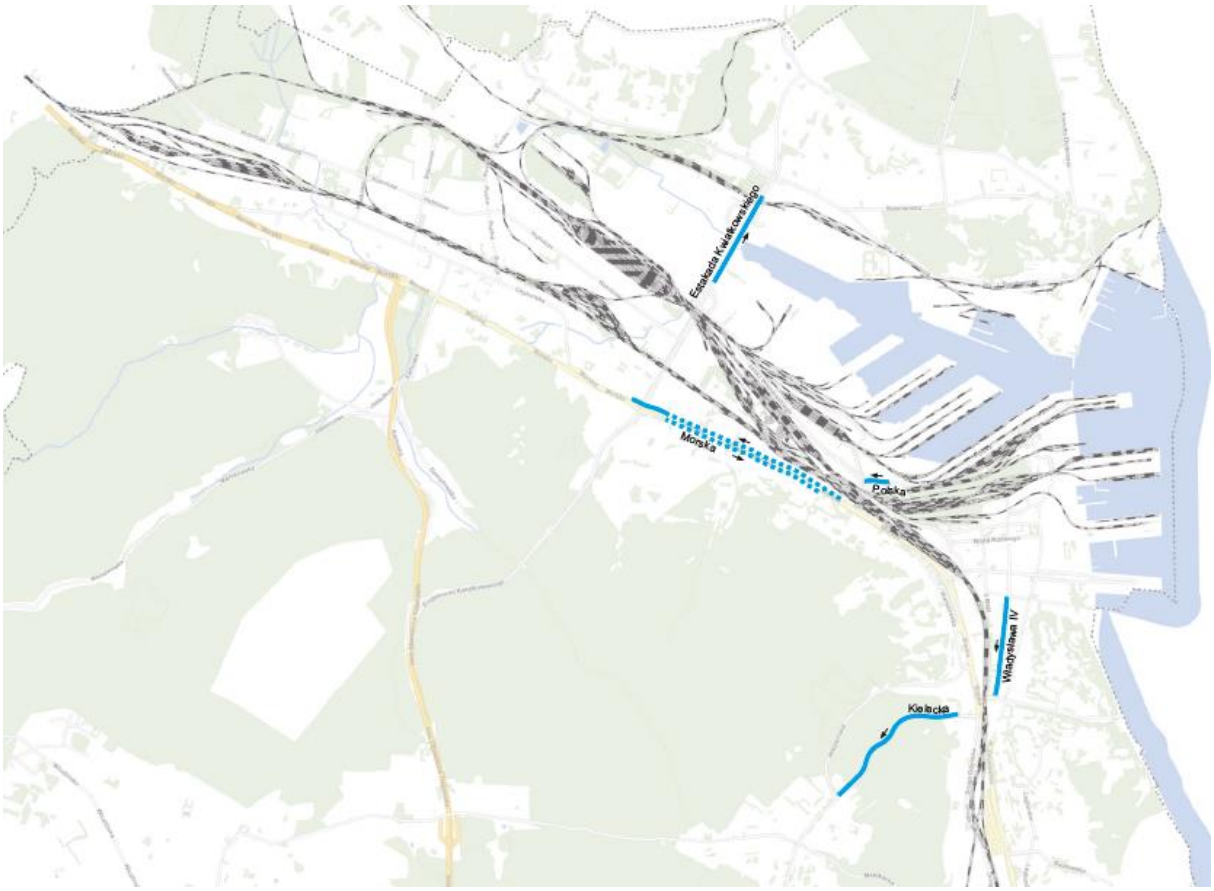

Figure 41. Bus lanes in Gdynia in at the end of 2016

[8] This chapter is based on an internal report of ZKM Gdynia (Public Transport Authority) evaluating chosen bus lanes in Gdynia.

Source: own study

Between 28 May 2015 and 20 May 2016, travel time measurements were carried out along Władysława IV and on Trasa Kwiatkowskiego in Gdynia. The measurements were conducted twice, before and after the introduction of public transport lanes ("bus lanes"). This chapter contains a description of the methodology and scope of the study, as well as a summary of the results in the form of tables with descriptions.

The measurements were conducted using two methods in parallel:

- direct observation, carried out by observers located at bus stops, during one weekday prior to and after the introduction of the bus lanes,
- importing and processing of the data collected in the TRISTAR system database, sent by on-board computers installed in public transport vehicles – for five subsequent weekdays prior to and after the introduction of the bus lanes.

The role of the observers included observing and registering the occupancy rates of the vehicles. They used precise, synchronised watches, noted down the departure or arrival times, including occupancy, on standardised measurement cards.

6.1 Ulica Władysława IV

Table 6 demonstrates, in hourly intervals, a list of the measurements made using the direct observation method – before and after the introduction of the bus lanes on the road in the direction towards Wzgórze Św. Maksymiliana, on the section between the "Armii Krajowej" bus stop to the "Urząd Miasta – Władysława IV" bus stop. In order to ensure representative and comparable results, the measurements included buses that stop at the "Urząd Miasta - Władysława IV" bus stop, i.e. vehicles of lines: W, 109, 137, 140, 147, 150, 160, 172 and 190.

In the columns showing mean travel time, the green colour indicates the shortest mean travel times, whereas red indicates the longest mean travel times. In 2015 as well as in 2016, the shortest mean travel times of 1:38 minutes and 1:25 min., respectively were observed in the final time interval of 18:00-19:00. Travel on the measured section in 2015 took the longest, at 2:04 min. for the 15:00-16:00 interval. In 2016, the longest travel time was observed for the 11:00-12:00 interval, with the greatest extension of travel time of 23 seconds being observed in the same interval. However, the time was reduced in the remaining time intervals – by up to 31 seconds in the 17:00-18:00 interval. Extreme values: the greatest reductions and extensions of travel time are marked in Table 6 in green and red, respectively. For the entire

study period, the travel time remained almost unaltered – the observed travel time reduction amounting to 2 seconds. For four hourly intervals, from 14:00-19:00, with exclusion of the interval 16:00-17:00, travel time was reduced by over 10%. On the other hand, in the intervals 9:00-10:00 and 11:00-12:00 an extension of the travel time was observed by over 10%. These values have been indicated in the table in green and red, respectively. For the entire study period, an average reduction by 1.8% in the travel time was determined.

Table 6. Travel time and occupancy prior to and after the introduction of a bus lane on Władysława IV in Gdynia – on the basis of direct observation

time interval	mean travel time 2015	mean travel time 2016	travel time reduction	travel time reduction %	mean occupation 2015	mean occupation 2016	change (%)
07:00-08:00	01:50	01:40	00:10	9.1%	17.5	17.0	-2.9%
08:00-09:00	01:46	01:47	-00:01	-0.9%	15.0	14.0	-6.7%
09:00-10:00	01:44	02:01	-00:17	-15.8%	15.0	12.0	-20.0%
10:00-11:00	01:48	01:57	-00:09	-8.3%	22.0	13.0	-40.9%
11:00-12:00	01:39	02:02	-00:23	-23.9%	24.5	17.0	-30.6%
12:00-13:00	01:53	02:00	-00:07	-5.8%	25.0	16.5	-34.0%
13:00-14:00	01:43	01:51	-00:08	-7.8%	22.0	23.0	4.5%
14:00-15:00	01:57	01:45	00:12	10.7%	20.0	21.0	5.0%
15:00-16:00	02:04	01:51	00:13	10.1%	22.0	26.0	18.2%
16:00-17:00	01:57	01:56	00:01	0.9%	15.0	16.0	6.7%
17:00-18:00	01:58	01:27	00:31	26.3%	17.0	19.0	11.8%
18:00-19:00	01:38	01:25	00:13	13.3%	16.0	13.0	-18.8%
07:00-19:00	01:50	01:48	00:02	1.8%	18.0	17.0	-5.6%

source: own study

Within the concomitant measurements of occupancy, the greatest use of vehicles, exceeding the mean of 20 people, was observed in 2015 for the hourly intervals between 10:00 and 16:00. In 2016, mean occupancies of over 20 people were observed only for the interval between 13:00 and 16:00. Moreover, in this year of study a low mean use of vehicles was also observed – below 15 people on average. Such values were determined for the intervals 09:00-11:00 and 18:00-19:00. Occupancy rates of over 20 and below 15 people are marked in Table 6 in green and red, respectively. The colour indications in the last column indicate the greatest decreases and increases of vehicle occupancies – by over 10%. Decreases were determined for five hourly intervals – from 9:00 to 13:00 and from 18:00 to 19:00. On the other hand, a relatively high increase in vehicle use was observed in the intervals 15:00-16:00 and 17:00-18:00. For

the entire measurement interval, a slight decrease in vehicle use was observed, by a mean of one person (5.6%).

Table 7 lists (in hourly intervals) the travel times calculated on the basis of data collected in the TRISTAR system database. The analysis included five times more journeys than in the measurements conducted using the direct observation method.

Table 7. Travel time before and after the introduction of a bus lane on Ulica Władysława IV in Gdynia – on the basis of the TRISTAR data

time interval	mean travel time 2015	mean travel time 2016	travel time reduction	travel time reduction %
07:00-08:00	01:35	01:37	-00:02	-1.2%
08:00-09:00	01:35	01:42	-00:07	-7.3%
09:00-10:00	01:40	01:38	00:02	2.8%
10:00-11:00	01:40	01:42	-00:02	-1.6%
11:00-12:00	01:37	01:47	-00:10	-10.9%
12:00-13:00	01:48	01:39	00:09	8.8%
13:00-14:00	01:44	01:36	00:08	7.6%
14:00-15:00	01:53	01:37	00:16	14.1%
15:00-16:00	02:03	01:47	00:16	12.9%
16:00-17:00	01:53	01:39	00:14	12.7%
17:00-18:00	01:46	01:42	00:04	3.2%
18:00-19:00	01:36	01:40	-00:04	-3.6%
07:00-19:00	01:45	01:41	00:04	4.1%

source: own study

The longest mean travel time prior to the introduction of a bus lane on Władysława IV was calculated for the 15:00-16:00 interval, with travel over the measured section taking 2:03 min. for that period. The shortest bus travel time for this section was 1:35 min. between 7:00 and 9:00. In 2016, these values were 1:47 min. (for the 11:00-12:00 and 15:00-16:00 intervals) and 1:36 min. for the 13:00-14:00 interval. This means that the maximum travel time reduction was 16 seconds. The same value was observed for the 14:00-15:00 and 15:00-16:00 intervals. For certain time intervals an extension of the travel time was observed – by up to 10 seconds in the 11:00-12:00 interval. The extreme values have been marked in Table 5 in green and red. For the entire measurement interval, a reduction in travel time by 4 seconds, i.e. by 4.1% was observed. The best result, in excess of 10%, was determined for the afternoon transport peak,

from 14:00 to 17:00. Intervals for which travel time change were determined in excess of 10% are marked in Table 6 in green for reductions and red for extensions in travel time.

6.2 Trasa Kwiatkowskiego

Table 8 demonstrates in one-hour intervals a list of measurement results from the direct observation method – prior to and after the introduction of a bus lane on the road in the direction to Obłuże, between Janka Wiśniewskiego and Unruga. The measurements included buses running between the "Energetyków" and "Obłuże Centrum" bus stops, i.e. buses of lines 103, 128, 146, 152, 170, 173, 194 and 209.

Table 8. Travel time and occupation of vehicles before and after the introduction of a bus lane on Trasa Kwiatkowskiego in Gdynia – on the basis of direct observation

time interval	mean travel time 2015	mean travel time 2016	travel time reduction	travel time reduction %	mean occupation 2015	mean occupation 2016	change (%)
13:00-14:00	02:16	02:31	-00:15	-11.0%	38.0	33.0	-13.2%
14:00-15:00	02:44	02:43	00:01	0.0%	48.5	35.0	-27.8%
15:00-16:00	04:01	03:57	00:04	1.7%	45.0	35.0	-22.2%
16:00-17:00	03:38	04:31	-00:53	-24.3%	38.0	35.0	-7.9%
17:00-18:00	03:22	03:54	-00:32	-15.8%	42.5	37.5	-11.8%
18:00-19:00	02:46	02:52	-00:06	-3.9%	35.0	31.0	-11.4%
13:00-19:00	02:58	03:30	-00:32	-18.0%	40.0	35.0	-12.5%

source: own study

In the columns showing mean travel time, green indicates the shortest mean travel times, whereas red indicates the longest mean travel times. In both 2015 and 2016, the shortest travel times of 2:16 min. and 2:31 min. respectively were observed in the first time interval between 13:00 and 14:00. Travel on the measured section in 2015 was the longest, at 4:01 min. between 15:00 and 16:00. In 2016, the longest travel time was observed in the 16:00-17:00 interval. The greatest extension of travel time of 53 seconds was observed in the same interval. A slight reduction in the travel time was observed by 4 seconds in the interval between 15:00 and 16:00. Extreme values: the greatest reductions and extensions of travel time are marked in Table 8 in green and red, respectively. For the entire study period, travel time increased by 32 seconds. As a percentage, in the intervals 13:00-14:00, 16:00-17:00 and 17:00-18:00, an extension of travel time in excess of 10% was observed. These values in the table have been marked in red. For the entire study period, a percentage extension of travel time by 18.0% was observed.

Within the parallel occupancy measurements, the greatest vehicle use in the excess of the mean of 40 people was observed in 2015 for the hourly intervals: 14:00-15:00, 15:00-16:00 and 17:00-18:00. In 2016, no mean occupancies of over 40 people were observed. At the same time, a relatively low vehicle use was observed, amounting to a mean of below 35 people. Such values were determined for the intervals 13:00-14:00 and 18:00-19:00. Occupancy rates of over 45 and below 35 people are marked in Table 8 in green and red, respectively. The colour indications in the last column indicate the greatest decreases and increases in vehicle occupancies – by over 10%. In this regard, however, only decreases were observed, because in none of the analysed time intervals a sufficient increase in mean occupancy was observed. Occupancies decreased by over 10% over the entire study period – from 13:00 to 19:00, with the exception for the 16:00-17:00 interval. For the entire study period, a decrease in vehicle use was observed by a mean of five people (12.5%).

Table 9 lists in hourly intervals the travel times calculated on the basis of data collected in the TRISTAR system database. The analysis included five times more journeys than in the measurements conducted using the direct observation method.

Table 9. Travel time before and after the introduction of a bus lane on Trasa Kwiatkowskiego in Gdynia – on the basis of the TRISTAR data

time interval	mean travel time 2015	mean travel time 2016	travel time reduction	travel time reduction %
13:00-14:00	02:19	02:17	00:02	1.0%
14:00-15:00	02:41	02:33	00:08	5.0%
15:00-16:00	04:27	04:01	00:26	9.6%
16:00-17:00	07:30	05:52	01:37	21.7%
17:00-18:00	04:01	03:49	00:12	4.9%
18:00-19:00	02:34	02:32	00:02	1.3%
13:00-19:00	04:02	03:36	00:26	10.6%

source: own study

The longest mean travel time before the introduction of a bus lane on Trasa Kwiatkowskiego was calculated for the 16:00-17:00 interval. Travel on the measured section was 7:30 min. at the time. The shortest bus travel time for this section of 2:19 min was observed between 13:00 and 14:00. In 2016, these values amounted to 5:52 min. (again for the 16:00-17:00 interval) and 2:17 min. (again for the 13:00-14:00 interval), respectively. This means that the maximum travel time reduction was 1:37 min. This value was observed for the 16:00-17:00 interval. In the entire study period, travel times were reduced by a minimum of 2 seconds in the intervals

of 13:00-14:00 and 18:00-19:00. The extreme values have been marked in Table 9 in green and red. For the entire measurement interval, a reduction in travel time by 26 seconds, i.e. by 10.6% was observed. The best effect, at the level of over 20%, was determined in the 16:00-17:00 interval, the only one to exceed the travel time reduction of 10%, and it is marked in the last column of Table 7 in green.

7 Next steps

Prioritising PT vehicles is one of the most effective methods to sustain and increase the share of public transport in the general modal split in Gdynia. Dedicated bus lanes proved to be cheap and easy to implement. However, in the current form and quantity they only have a limited impact for the whole transport system. Thanks to the implementation of bus lanes within the CIVITAS DYN@MO project it was able to show that the final layout and quantity of bus lanes should create public transport corridors, linking different districts. Only such a massive shift supported by intelligent signalling (TRISTAR) and modern public transport vehicles could provide the desired and competitive travel time for different segments of urban travellers. Although elderly passengers are mostly focused on directness (lack of interchanges)[9], other users are sensitive to travel time extension and could switch to individual motorisation.

General public acceptance towards bus lanes development is positive. It is stronger among public transport users. Their evaluation after implementation is positive as well.

It should be noted that the findings of measure G3.5 were important for the development of the action plan of Gdynia's Sustainable Urban Mobility Plan, in which further bus lanes are planned. Experience collected from other Polish cities shows that bus lanes are the most efficient tool when they create coherent integrated corridors with highest priority for public transport vehicles. Such a priority should be supported by intelligent transport system and spatial design of urban architecture.

[9] Preferencje i zachowania komunikacyjne mieszkańców Gdyni w 2015 r. Raport z badań marketingowych. ZKM Gdynia, University of Gdansk, Gdynia 2015, s. 29 [Transport preferences and transport behaviour of Gdynia's citizens in 2015. A marketing research report]