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Research paper

Investment challenges pertaining to the achievement of the goals of the Mobility Policy based on the analysis of the results of traffic surveys in Wroclaw

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Abstract: The paper presents an introduction to the method enabling the estimation of the range of investments necessary for the realisation of the mobility policy understood as the correction of the modal split into the sustainable proportion between car and non-car journeys. The models allow the calculation of the number of travellers required to shift into the public transport mode and the scale of selected investments including the development of the transport network, interchanges, rolling stock, and technical infrastructure. The basis of such calculations is the results of traffic surveys. The worldwide context of the study and similar actions are also presented. The paper consists of five sections. The first section contains a review of current problems connected with the sustainable mobility policy and the role of modal split. The second section focuses on the case study with the presentation of the local mobility policy and selected results of complex traffic surveys. The models used to estimate the investment challenges with exemplary calculations and presentation of similar effects of the intervention are described in the next section (3). Section four contains a discussion on the described methodology. The conclusions in section five end the main part of the paper..

Keywords: Mobility policy, Sustainability, Modal Split, traffic survey, Investments

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1. Mobility OR transport policies and their goals

Mobility policies (previously known as transport policies) are the key documents necessary to create the rules for shaping transportation systems in specific area (e.g. cities, communities). They formulate selected goals of which one of the most common is achieving a sustainable modal split (participation in the choice of mode of transport). In order to obtain the required values (meaning the concrete numbers of travellers using a specific mode of transport) selected tools are formulated. Some of the tools need investment, especially the creation of transportation networks, additional aspects like interchanges, rolling stock and technical infrastructure. It is important to estimate the appropriate level of investments, the costs and time needed to realize it. Knowing the current situation (shares in modal split) and comparing with the planned level could be helpful to implement these actions. This paper presents the proposal of methodology to estimate the scale of investments necessary to achieve the goals of the mobility policy.

Several questions will be considered here as the review of current problems important to the topic of the paper. What is acceptable sustainable mobility? What is a sustainable modal split according to today's values? What is the role of public transport, pedestrian and bike movements in shaping a sustainable modal split? Why and when do people choose a specific mode of transport? What tools can most effectively correct the modal split? Is there a correlation between modal split and the tools of the mobility policy? What is the role of "mode availability" (infrastructure condition and offered standards) to achieve desirable modal split?

Achieving sustainable mobility requires not only changes in the use of certain modes of transport, but also the reduction of travel needs. To successfully implement sustainable mobility, it is important to increase the efficiency of the public transport system and to promote walking and cycling. Attention should be paid to the importance of slowing down traffic, reducing parking, priorities for public transport [2] and the need to understand the thought process that is the basis for choosing the means of transport [19]. Thus, sustainable mobility is not just the result in the form of groups of people moving in a certain way. It is also a set of comprehensive actions regarding both investment and impact on users.

Numerous studies show the differences in contemporary modal split around the world. For example, in Sao Paulo, Brazil (2008), approximately 31% of journeys were in private vehicles, 37% in public transport, and 32% in non-motorized vehicles [11]. In Hong Kong, the use of private cars accounted for about 10% of the total number of daily trips, which represents a value of about 50 private cars per 1000 people [21]. On the other hand, Rome in Italy has a very high level of this indicator: over 700 per 1000 people [10]. In the agglomeration of Porto in Portugal, in the period of 10 years, from 1991 to 2001, the number of trips by car to work or school increased from 23% to almost 50% [3].

The percentage of people travelling by bicycle can vary greatly. In an example from British cities, shares between 1.9% in Sheffield and 29.1% in Cambridge were identified [5]. In selected cities, the share of cycling mode is expected to increase, for example from 6% to 25% in Portland or from 1.6% to 5% in Philadelphia [19]. Attention is drawn to the specific means of transport or groups of travellers: for example, the use of motorcycle taxis (paratransit) in Bangkok with an average range of 15.8% [18] or the use of alternative modes of transport, such as cycling, walking, or public transport by 56% Los Angeles off-campus students [28].

The question about the desired proper modal split is intriguing. Exemplary study [22] presents three alternative visions of the role of walking and cycling in urban areas for 2030. In all visions, car use is limited to 30% ("best European practice") or even 5% ("public transport-oriented future without cars" or "local energy-efficient future"). The share of public transport varies: 15% in the third vision, 25% in the first vision and 35% in the second vision. The role of walking and cycling is dominant, especially for the third option (up to 80%).

The choice of a particular means of transport is influenced by various factors: travel time [15], [24], the quality of public transport [3], [20] population density, availability of stops, configuration of the transport network [10], availability of parking spaces [23], personal characteristics such as age, gender, wealth and employment, as well as norms, values, lifestyle, relationships and social responsibilities [17]. From the above review, both universal and local specificities can be noted.

The reasons for choosing cycling or walking and differences in indicator values are not clearly identified [1], [5]. The role of social practice theory in the understanding of the transport mode selection is indicated [4]. For example, grouping friends and colleagues increases the chances of them using public transport [29].

Comprehensive, coordinated and consistent actions are needed to change the modal split [8], [10]. There are important factors: the availability of alternatives to travel by car [4], discounts or free travel on public transport [9], [14], [28]), parking regulations, including Park and Ride (P+R) system [25], [27], the role of autonomous vehicles [26]. The impact of infrastructure development and the level of its quality on changes in modal division was noticed [12]. Consideration of dependence between demographic changes and traffic intensity is important [7], [13].

The availability of the mode (understood here as infrastructure condition and offered standards) is important at the beginning of the mode selection process [19]. It is possible to formulate the transport system in which most people do not use or own a car [22]. The priority given, among others, to public transport and controlling the growth of private cars has laid the foundation for success in Hong Kong in the last quarter century. The total size of the rail network increased to 200 km, which corresponds to the achievement of the goal of increasing the percentage of rail transport from 33% in 1997 to 50% in 2016 [21]. Isolated actions, such as exclusive price cuts in public transport, are not effective. It is necessary to improve the quality of alternative transport to the car [14], expand the P+R system and integrate bus and rail systems [27], and develop paratransit systems [18]. The reviews mentioned above show the importance of complex actions (including investments) to achieve the goals of mobility policy, especially sustainable modal split. Although, the sustainable value (ratio) is not clear as it differs around the world. The role of the car and the participation of alternate modes varies in different selected locations.

The review made above shows i.a. the differences in terminology used by Authors and in countries. In fact, the same quantity or measure can be named differ and with use (or no use) differ units. In the review part of the paper the original terminology was used, and in the next analyses – the Author's individual way.

It is possible to study different ways in the grouping of transport means. Several publications (include presented above) specify more or fewer numbers of groups. In this paper, three ways of grouping are used. By the description of Wrocław's comprehensive traffic surveys the three groups are considered: V – travelling in cars, P – travelling by public transport, O – others (including travellers on foot and on bicycles). To describe the modal split only two groups are considered: V – those exclusively using cars and P – those using public transport at least for part of the journey. By formulation of the model and in exemplary calculations (section 3), only the numbers of public transport passengers will be considered. This differentiation will be commented on in the discussion part of the paper.

The three temporal stages are defined as (figure 1): "nowadays" with the domination of cars, "balance" as a temporary point with the same ratio of cars and public transport, "sustainability" as a target point with the domination of public transport. It is assumed, that other forms of transportation could play a role, but are not considered in the evaluation of the transport system and realisation of mobility policy. The way to realize the mobility policy shown in figure 1 requires increasing the ratio (numbers) of public transport journeys along with a proportionate decrease in the car movement sector. This would necessitate the shifting of a specific group of travellers from cars to public transport.

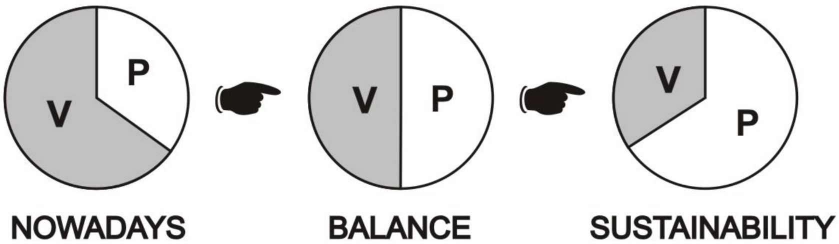

Fig. 1. The scheme of realization of mobility policy goal

This paper presents a method enabling the estimation of the range of investments necessary for the realisation of the mobility policy understood as the correction of the modal split into the sustainable proportion between car and non-car journeys. The models allow the calculation of the number of travellers required to shift into the public transport mode and the scale of selected investments including the development of the transport network, interchanges, rolling stock, and technical infrastructure. The basis of such calculations is the results of traffic surveys. The proposed method is not a finished tool for complex analyses, rather is it an introduction to wider studies with the need for the development of selected elements of the method. Presented examples show the possible use of the method, but should be detailed and convert to the specific tool (existed or to prepare). These remarks will be described in the penultimate part of this paper (discussion).

2. The case study description

2.1. Wroclaw's Mobility Policy

Wrocław (the core of agglomeration) is the fourth largest city in Poland and has about 675 thousand citizens, including about 636 thousand people aged more than 6 years. From the year 2013 the city has possessed the Mobility Policy, WMP [16], as a continuation and development of the previous Transport Policy. The general goal of the WMP is: "*the creation of optimal conditions for the efficient and safe movement of people and goods in the city and the metropolitan area, while complying with the requirement to limit the burden of transport on the environment*". In the long term, the share of non-car transport (understood as public and bicycle transportation as well as pedestrian traffic) should not be less than 65%. By 2020 the share of non-car transport shall not be less than 60%, while the most important goal for the upcoming years is to overcome the current negative upward trend in the share of car traffic in urban travels.

Measures for the realisation of the WMP should be introduced while observing the many principles. They consider, among others, specific rules for shaping the transport system, taking into account the preferred availability of different parts of the city. They formulate preferences regarding the development of public and bicycle transport and pedestrian traffic infrastructure, as well as the priority of using existing infrastructure. In the mobility policy, an influence on traffic demand is foreseen. To control the effects of WMP implementation, a number of analyses are planned. The document contains 32 elements of such analysis. The most important of these relate to the study of the share of non-car travel in the total number of journeys and the level of satisfaction of residents regarding the functioning of the public transport system. Investments that will positively affect the functioning of transport in the city and the workplaces for which a mobility plan has been developed and implemented will be inventoried and monitored. The technical condition of tram tracks, average speed on bus and tram lines and the parking spaces of the P+R system are to be tested.

The "Metropolitan area" mentioned in WMP is not precisely defined (has no legal definition). Access of selected communities to this area is variable according to different studies. It could be "broader" as in the traffic survey (see next section and figure 2) or smaller as in the exemplary calculations (see section 3 and figure 5). Extension of the mobility policy to the surroundings of Wrocław would be desirable. But, so far, neighbouring communities (surroundings) do not possess similar documents. There is agreement between official and general groups, but there are no tools (including the common law) to coordinate development, transport system and standards in whole agglomeration. The agglomeration contain of core (main city) and surroundings (other communities around the core) – see on the figure 2 (Wrocław is the core and makes with other 21 communities the agglomeration).

2.2. Traffic survey in Wroclaw (year 2018) and analysis of the results

The current complex traffic survey (Comprehensive Traffic Analysis) was made in 2018 for the city and for 21 neighbouring communities making up the "surroundings" (figure 2). The surroundings contain about 364 thousand people including about 336 thousand people aged more than 6 years. Data was collected from various sources: surveys performed in households; an online survey; surveys of public transport passengers; complementary surveys at bus stations, railway stations, shopping centres, municipal entities, universities and companies; surveys of vehicles of public transport enterprises; car, bike and pedestrian traffic volume measurements; measurements of the number of public transport passengers. Figure 2 presents the main elements of the studied area. The borders of considered units and the location (with name) of the core city (Wrocław) are shown. A complete description of the survey (include characteristics of all units) and access to the database of results are available on the internet [6].

The journeys take place using a wide range of real transport means. Such a "travel chain" could include for example firstly a journey on foot, next by public transport mode (train, bus or both), next by rental of a city bike and so on. The basis for grouping here is the main mode of selected journey (longest part of the journey). Thus, three basic groups will be considered: car (including carpooling but not including journeys like: car – bus, car – train), public transportation (any cases with travels including the use of other transport modes in travel chain too), other (including: bike exclusively with this transport mode, on foot only during full journey, much more seldom means of transport like mopeds, rollerskates etc.).

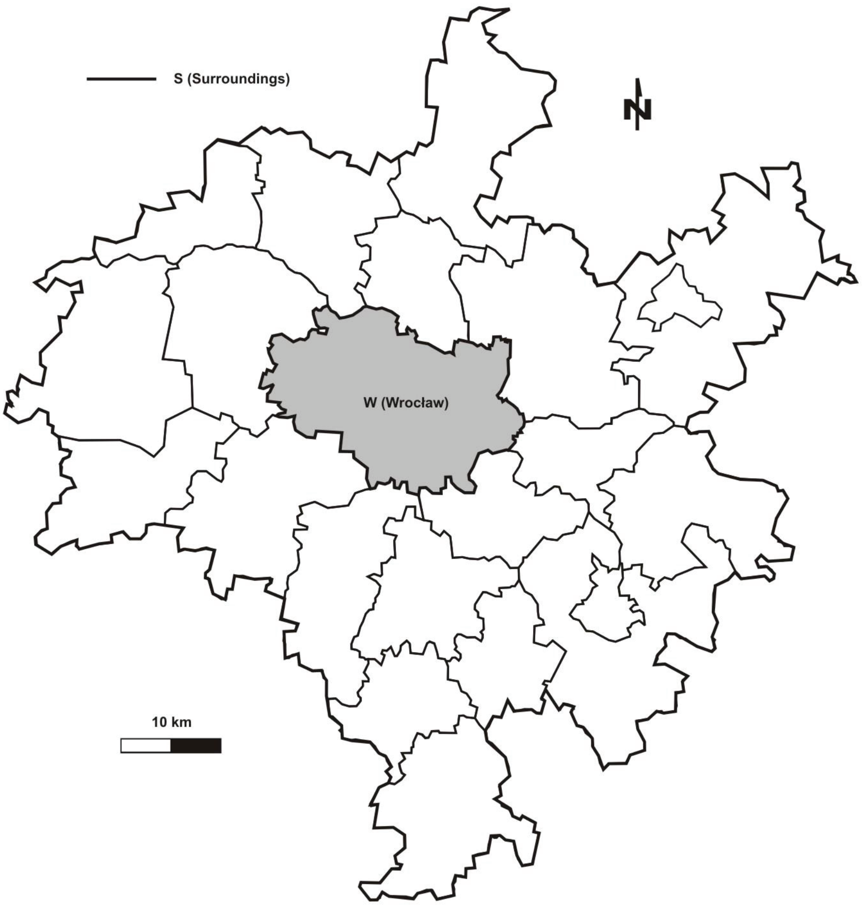

Fig. 2. Area of traffic survey

The number of journeys made by Wrocław residents (inside the city) is about 1 million a day. The number of journeys comprising the crossing of the city limits is about 240,000 per day, which means about 1.24 million travels in the city in total. Over 580,000 car journeys are undertaken in the city every day compared to 320,000 journeys by public transport. An earlier survey (2010/2011) has shown about 570,000 car journeys and about 424,000 by means of public transport. So, during eight years the number of journeys by car increased by 11,000 and the number of journeys by public transport decreased by 104,000. The total number of observed journeys by all possible modes stays at a similar level, which means that the number of journeys by other modes (including: bikes, on foot) was increased. Differences in numbers between both surveys may be the result of slightly changed methodologies too. Worth noting are the data considering the location of travel. Journeys in the core only are often realised by the use of non-motorised modes of transport. Today the number is about 590,000 (including 285,000 by public transport means) versus about 422,000 journeys in cars. Since the year 2010 car journeys have decreased by about 69,000 and journeys by public transport have decreased by about 121,000. Journeys between surroundings and the core are realised more often with the use of cars, about 160,000. In such locations, this number has increased during the last 8 years by 80,000 when the number of journeys by public transport increased by 17,000 in the same period.

A significantly increased amount of travel now takes place within the agglomeration's core. Demographic structure is also important. Wrocław is getting older, there are more and more people in post-productive age group, and these people are less likely to travel by car. About 15,000 people of working age arrived during the last decade in the surroundings, with a total population increase of 28%.

2.3. Changes in Modal Split

Modal Split (MS) will be divided here into three groups: V – travelling in cars, P – travelling by public transport, O – others (including travellers on foot and on bicycles). The MS was designated for journeys in Wrocław for 2018 in the ratios of 46/25/29%. In 2010, it was: 44/33/23%. Archival data for 1996 give the following proportions: 25/45/30%. Throughout all these years, the share in group O remains at a similar level, while the change in proportions between journeys in group V and P is clearly visible, to the detriment of the use of public transport.

The figure 3 shows the current values and outlines the potential directions of changes in MS. These three directions form "classic" scenarios: optimistic, pessimistic and intermediate. Each of them seems to be equally probable and their existence is conditioned by the options of activities carried out and external factors.

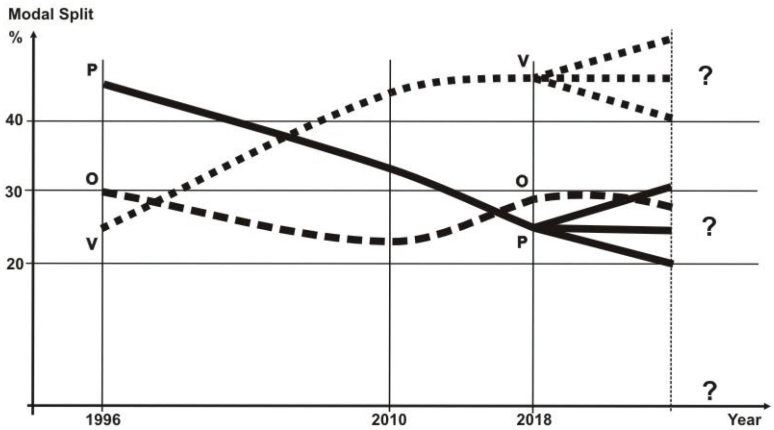

Fig. 3. Scenario of changes in Modal Split

The optimistic scenario assumes reversing the trend of reducing the share of travel by public transport while limiting the number of journeys made with private cars. This requires comprehensive, coordinated and consistent actions ("3C" rule). The pessimistic scenario assumes further reduction of the number (and share) of journeys by public transport and an increasing number of private car trips. Changes in the demography in Wrocław and its surroundings combined with ineffective activities for the development of integrated public transport may make this scenario real.

The last question mark concerning figure 3 involves doubt in forecasting the speed of changes in MS. Each scenario could be realised more slowly or more rapidly. More ambitious goals need more intensive works and lead to more uncertainty in prognoses. The numbers of journeys and travellers identified in the agglomeration traffic after the analysis of results of the Complex Traffic Survey compared with the current and desired MS allow the estimatation of the scale of actions necessary to achieve the desired change in MS. It is necessary to modify approximately 120,000 journeys a day in the context of changing the mode of transport from V-group (car) to P-group (public transport), including change in the Park and Ride system.

3. Models to estimate the investment challenges

3.1. Formulation of models

According to earlier assumptions the next measures and values (and whole description) are dedicated to journeys by means of public transport. Two models are formulated here:

- M1, to estimate the number of travellers as a subject of intervention: calculation of "Number of Commuters Shift", *NCS*,

- M2, to estimate the scale of interventions: calculation of “Investments”, *I*.

The way (scheme) to calculate the necessary values of *NCS* and *I* were shown in figure 4. It contains 11 basic steps.

Steps: 1 and 2 collect the “Entrance Number of Commuters”, *ENC*, accordingly in the core exclusively (*C*) and between surroundings and the core (*SaC*). In the presented method this number should contain commuters travelling to work and to school in the “rush period” of a typical working day. But in the broader use of the method, *ENC* could contain other reasons for travelling, other groups of travellers or other periods in a day.

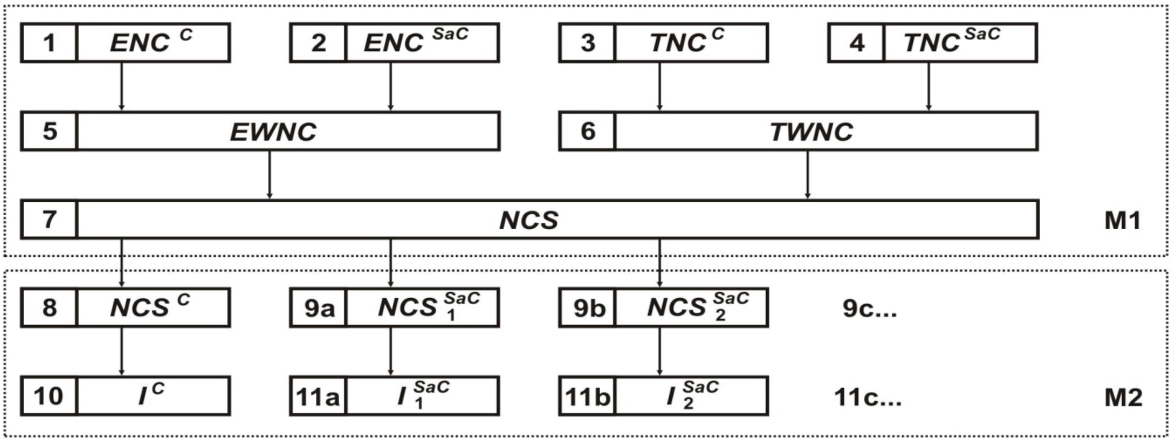

Fig. 4. The scheme of the approach used in the proposed method to calculate the values of *NCS* and *I*

Steps: 3 and 4 present the “Target Number of Commuters”, *TNC*, accordingly in the core exclusively (*C*) and between surroundings and the core (*SaC*). *TNC* should be calculated according to goals of MP and forecasts of changes in the number of travellers. A specific target number of commuters could be correlated with specific year, for example imported from MP or could be assumed for made analysis (as in hypothetical horizon “Sustainability” on figure 1).

Knowing the values of *ENC* and *TNC* in the core and between surroundings and the core it is possible to identify the values of total journeys in the agglomeration (steps: 5 and 6) and finally find “Number of Commuters Shift”, *NCS*, and thus to estimate the number of travellers shifted by the intervention (step 7). It is described by the formula (1) by the assumption that $TWNC > EWNC$:

$$NCS = TWNC - EWNC, \tag{1}$$

where:

NCS – Number of Commuters Shift,

TWNC – Target Number of Commuters,

EWNC – Entrance Number of Commuters.

This ends the work of model M1.

The value of *NCS* should be divided into specific locations. According to details of MP and local political conditions the scale of changes in modal split in specific communities could be different. But it is possible to formulate the factors to divide the *NCS* into groups: in the core and in surroundings. The model M2 considers the more detailed division into the parts of the core (zones) and parts of surroundings (corridors or communities). The algorithm shown in figure 4 considers no division of the core (step 8) only the several connectors between the core and surroundings (see "corridors" on figure 5) in surroundings (steps: 9a, 9b, …) although similar division of the core is possible too. Interactions between parts of surroundings, core, and the whole area are possible but are not draw in figure 4 (to make a scheme more clear). Specifically, the analyses may be conducted only in selected parts of agglomeration (for example in selected corridors). This aspect will be presented in the next part of the paper. Such method of division is formalised by the formula (2):

$$NSC = \sum_i NCS_i^C + \sum_j NCS_j^{SaC} , \tag{2}$$

where:

NCS^C – Number of Commuters Shift in the core,

NCS^{SaC} – Number of Commuters Shift between surroundings and the core,

i – number of zones in the core,

j – number of corridors in surroundings.

Having the values of *NCS* it is possible to formulate the "Investments", *I* (steps: 10, 11) in specific locations. In general, the range of investments depends on *NCS*.

The investments could contain different interventions, but according to earlier assumptions here were concentrated on the following groups: improving the availability of public transport means, development of more interchange points, providing the appropriate rolling stock (and technical facilities like depots). Such a set could be described as follows:

$$I = I_{OP} + I_{PI} + I_{RS}, \tag{3}$$

where:

I – investments,

I_{OP} – investments which improve the standard of the public transport system in the sense of providing an adequate number of lines, frequency and volume of rolling stock,

I_{PI} – investments which develop the number of interchanges,

I_{RS} – investments which increase the rolling stock.

The real and effective set of interventions should of course be broader (details later).

The detailed calculation of investments will be the topic of other author's studies. Here, the estimation of the scale of interventions ends the model M2.

3.2. Exemplary calculations - Investment challenges

With reference to the optimistic scenario of potential changes in the Modal Split (figure 3) the reversal of the trend of decreasing the share of journeys by public transport while limiting the number of journeys made by private cars for Wrocław and its surroundings is assumed. This is consistent with the objectives of WMP, but requires comprehensive, coordinated and consistent actions. As "close surroundings" of Wrocław, nine communities are presented here in relation to the studies of transport integration (it is a working proposal that does not mean the final delimitation of the area). The considered area (surroundings and the core) is presented figure 5. Later on, an area smaller than in traffic survey will be considered as "surroundings".

The current value of *EWNC* is 107,000 and equates to the ratio between journeys by vehicles (individual cars) and public transport (V/P) of 64/36% and full MS as 46/25/28% (V/P/O). This includes the total number of journeys in the rush period of about 420,000 and in the "not on foot" sector of about 300,000. The "desirable" proportion formulated in WMP means "not more" than 35% travels by a motorised mode of transport. Assuming an unchanged number of all journeys (but corrected proportion between *C* and *SaC*) and similar number of journeys in group O, it is necessary to shift a significant portion of travellers from cars to public transport means. In this example the number of 43,000 people gives the value of *TWNC* as 150,000 (using the formula 1 and 7. step of the algorithm). This will create a 50/50% proportion between journeys in individual vehicles and by public transport (V/P) and full MS as 36/36/28% (V/P/O). The proportion of "non car" journeys will achieve the level of 64%, almost as much as in the goal of the mobility policy.

There is a need to focus on infrastructure activities as a important first step to start influencing users of the transport system in order to change their behaviour. Infrastructure can be understood here as: the agglomeration railway network, new tram and bus routes, park and ride car parks and interchange junctions which should form the basis for enlarging the public transport system of the city and surroundings. Investments must be made on a scale appropriate to the stipulated shift of a particular number of travellers currently travelling in private cars.

It is proposed to consider 10 corridors in the surrounding areas (represented by the digits from 0 to 9 on the figure 5 and in the next calculations). This division is derived from geographical conditions, especially the shape of the transport network, barriers such as the bigger rivers, administration and tradition in the numbering of bus lines. Each corridor serves a similar number of residents and travellers and is connected predominantly with a rail line (or lines) as a main public transport means to connect the surroundings and the core. The core is not divided in this example into zones, thus the steps in algorithm: 8 and 9 create the following division (using formula 2):

$$NSC = NCS^{C} + \sum_{j=0}^{j=9} NCS_{j}^{SaC} \ .$$

The proportions in the above division should consider local conditions (including political ones) and the likelihood of attracting specific investments. Here, it is assumed that in the core the shift covers about 23,000 travellers (about 16% of today's car drives) and the rest i.e. about 20,000 travellers equally divided between all corridors in the surrounding areas (about 40% of today's car drives). This creates the values: NCS^{C} = 23,000 and $NCS^{SaC}{}_{j}$ = 2000 as the basis for calculation of I.

Starting from the surrounding areas, each corridor should create: enough places, courses and lines in the local public transport system, an adequate number of interchanges and sufficient rolling stock. The number of 2000 additional travellers would require in this case: at least one new railway connection (during 3 hours in rush period) and an adequate number of places in the "delivery system". Such a delivery system will contain specific bus lines (arriving to at rail stations) and P+R places close to rail stations. These stations are shown in figure 5 including new/planned/postulated ones.

The proportion of commuters travelling on buses or in their own cars (with specific consideration of bike and foot journeys) will change. But, considering the dispersed nature of village buildings, it is possible to assume that most commuters will use cars. Thus, the number of places in P+R should be distinct. For example, in corridor 5 (Czernica) it is important to create about 1500 parking places by all of the 5 stations (an average of 300 in each location but with possible differences according to each vicinity). Additionally, the remainder of commuters will use: local buses (with a need of about 200 - 300 places) and bikes. The above formulates the need for dedicated courses of buses (6 times in rush period with at last 50 places in buses), parking places for bikes, safe, comfortable bikeways. It is also necessary to buy new rolling stock: trains and buses.

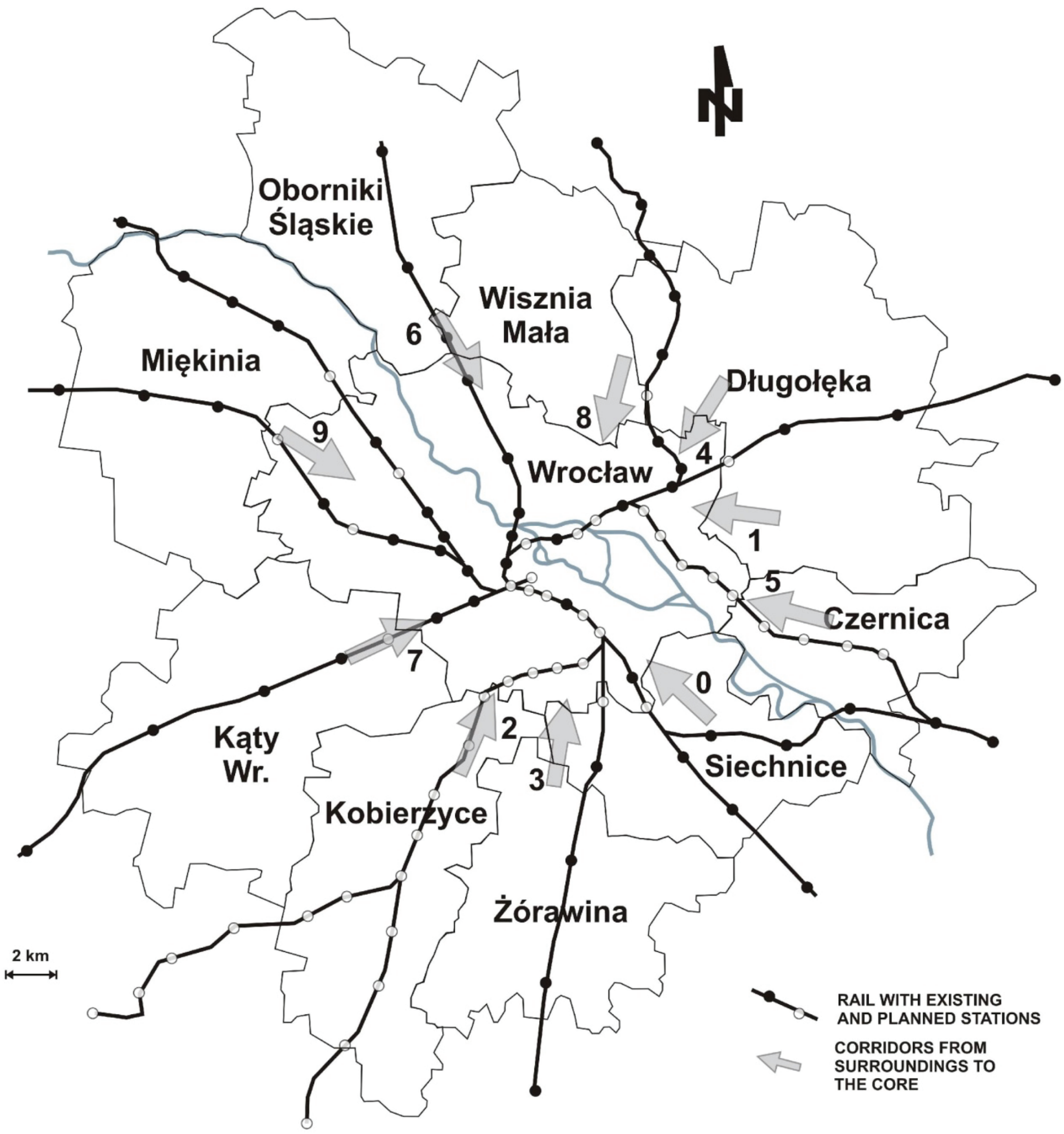

Fig. 5. The map of the "close surroundings" of Wrocław

The public transport system in the core should be operated for the new shifted "local" passengers and some of the new travellers from the surrounding areas arriving by rail or suburban buses wishing to continue their travel by use of the city's public transport means. These arriving passengers can continue their journeys on foot, rental bikes or mopeds, but for the majority of destinations the use of trams or buses seems to be most popular. Here, it is assumed that 60% of new travellers from surrounding areas, that is about 12,000 people, will need additional means of public transport in the core. Considering these 23,000 new "local" travellers, the public transport system in the core should be enhanced to be effective and comfortable for a total of 35,000 new passengers. That is about 30%

more than today. So the number of places in trams and buses, the number of courses on traffic lines and the amount of rolling stock should be enlarged to a similar level.

The program of investments should of course be more detailed and requires identification of the priority places for intervention (the parts of the city most visibly lacking in public transport and with distinct numbers of travellers). For example, it is desirable to develop the tram network, as a fundamental, reliable form of city transportation, from today's roughly 90 km to a potential of 120 km. The use of trams in the primary transport corridors releases the majority of today's bus fleet to cover other parts of the city, but thus creates the need to buy about 60 new trams to add to the 200 operating today. Enlargement of the tram fleet requires the construction of at least one new depot. In fact, Wrocław needs more new technical facilities. The existing tracks and power stations require maintenance and renovations. Some present depots will not be appropriate for the new rolling stock, therefore it is necessary to plan construction of two new depots.

Under different assumptions, different requirements could be necessary regarding the number of parking spaces, trains or trams, but the overall level (investment challenges) will remain similar. In reference to the adopted assumptions, one can indicate the scale of activities with slightly differently formulated objectives (e.g. with the desire to shift more than 50% of those travelling by car across the city border). The implementation of the above action plan requires specific investments and adequate financial resources. Therefore, the level of MS assumed in WPM (see question mark on figure 3) is forecast to be reached not earlier than after 16 years.

In addition to the above formulated actions, the tools of integration, information or popularization are needed. These should be: organization of a unit coordinating public transport in the agglomeration (at least Wrocław + its close surroundings), introduction of an integrated and functional tariff and ticket distribution system throughout the entire area, public consultations of planned and implemented solutions, information distribution about the implemented solutions, other actions.

3.3. Similar results of intervention

The effect of the impact of specific actions on changes in the modal split can be traced in the examples from Rome [10] and from São Paulo [11]. In Rome, three scenarios were formulated regarding the time horizon of 2020 each differing in the degree of development of the public transport system and changes in population density. Scenario 1 corresponded to the local administration's plans to increase supply in the local rail (extension of the network from 36 to 76 km and introduction of 11 new high-speed feeder corridors). Scenario 2 consisted of grouping the residences in the so-called 12 "transit villages" increasing the population density to 300 people/ha. In scenario 3, five "transit villages" were created increasing the employment density to 250 people/ha.

Calculations made for the first scenario have shown that the share of travel by public transport increases by only 5%, although the service could potentially service over two million people. The conclusion was made that the exclusive expansion of the local rail network does not cause significant changes in mobility. It is both expensive and would take a long time to implement. In scenarios 2 and 3, similar increases in the share of public transport travel were obtained (4–5%). The results are slightly better where the creation of 5 "transit villages" are proposed. The results of the activities were therefore also unsatisfactory in view of the mobility requirements. Admittedly, these actions would be cheaper than in scenario 1. The final conclusion indicates the need to combine actions from different scenarios. Only in this case will it be possible to achieve significant changes in the modal split.

The impact of different types of investment on mobility in the São Paulo metropolitan region in Brazil was simulated by taking into account ten scenarios divided into two groups. The first group includes infrastructure investments in the development of metro corridors, trains and buses (increasing supply). The second group of interventions concerns policies that limit car access to the city (decreasing demand). A specific scenario that includes a combination of these two groups of activities was devised. The development of transport infrastructure reduces the average travel time spent in public transport, which reduces the overall cost of public transport for individuals and can lead to significant economic benefits for the metropolitan area.

4. Discussion

Presented calculations contain no units because of the initially (and general) stage of analyses. From this point of view, an exemplary number of commuters is no focused on a specific period like day or hour. According to more detailed calculations, forecasted to future, the period and units may be more precise. Similarly, the investments (measure I) are understood as a general with a focus on "scale of investment", which means a complex of cost, influence on the transport system, and agglomeration or mobility. The more precise formulation of measure I in the proposed method need wider studies, planned by the Author in the future. So, the presented analysis estimates only the scale of necessary investments, with no precise costs or influence on modal split. These need the use of specific tools – existing ones or potential to create, but not considered in this paper.

The disaggregation and aggregation of the considered area is the next element of the proposed method to develop and study in other publications. Here, the possibility of dividing the core and surroundings is pointed only. Important, and intriguing is the possibility of study the specific corridors with no need to analyse the whole area. Remembering the interactions between all parts of the transportation system it is probably possible, for selected investments, a study of chosen corridors only, especially for a part of surrounding with independent transportation infrastructure, separated from other parts of surrounding (for example an individual rail line). Such “independence” is to observe on an exemplary map (figure 5) or is present in cited publication [10].

The use of only two groups in modal split (those exclusively using cars and those using public transport at least for part of the journey) has two reasons: (1) simplify the analyses, (2) show the basic conflict between two groups of travel means. According to new possibilities of a journey, like a car-sharing, rental bikes, mopeds and connection of them with more conventional ones like rail, tram, bus, we should promote all these modes and limit the use of private cars exclusive. This could simplify the way to the achievement of mobility policy goals.

5. Conclusions

Worldwide examples show that the use of complex tools can change the modal split and reach the goals of the mobility policy. It is important not to concentrate on selected investments, but to implement plans in a broader spatial context (the core and surroundings). The role of public transport should be increased, however bike and pedestrian movements could play a significant role in the transport system. Sustainability in modal split is hard to define, but it is possible to interpret it as minimisation of private car movements in favour of domination of alternative transport means. An improved service offer in this group of transport means is important to encourage travellers. The basis for a persuasive offer is the improvement of infrastructure understood as networks, interchanges etc.

It is possible to estimate the scale of necessary investments by the use of results of traffic survey and mobility policy initiatives. The proposed models allow the calculation of the number of travellers to be shifted and in order to influence the modal split and to calculate the necessary scope of investments. The potential use of the proposed algorithm, its steps and formulas have been shown in the specific example. Identified investments in the area of public transport system extension (including: interchange points, rolling stock and technical facilities) will not lead to complete success in modal split changes, but will be a concrete basis to introduce other methods to encourage travellers to leave their cars and choose other transport means in everyday journeys to work or school.

The potential efficiency of such actions was shown in examples from Rome and São Paulo. Probably, the presented method will be useful in Wrocław as well as in other agglomerations worldwide. Formulated investment creates a chance to achieve the assumed goals of the mobility policy (desirable and sustainable MS) in an identified (realistic) time frame. The currently conducted actions in Wrocław's agglomeration will contribute to the improvement of MS too, but with a scale much smaller than desired (flow between V-group and P-group of 1–2 percentage points instead of 10). In the case of further unfavourable demographic changes, the reduction of car traffic in the city may then be unnoticeable.

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Wyzwania inwestycyjne dotyczące realizacji celów polityki mobilności w oparciu o analizę wyników badań ruchu we Wrocławiu

Słowa kluczowe: Polityka mobilności, zrównoważony rozwój, podział modalny, badanie ruchu, inwestycje

Streszczenie:

W artykule przedstawiono wprowadzenie do metody pozwalającej na oszacowanie zakresu inwestycji niezbędnych do realizacji polityki mobilności rozumianej jako korekta podziału modalnego na zrównoważoną proporcję między podróżami samochodowymi i innymi. Modele pozwalają na wyliczenie liczby podróżnych koniecznych do przeniesienia się na środki transportu publicznego oraz skali wybranych inwestycji, w tym rozbudowę sieci transportowej, węzłów przesiadkowych, taboru i infrastruktury technicznej. Podstawą takich obliczeń są wyniki badań ruchu. Przedstawiono również światowy kontekst badania i podobnych działań. Artykuł składa się z pięciu części. Pierwsza część zawiera przegląd aktualnych problemów związanych z polityką zrównoważonej mobilności i rolą podziału modalnego. Druga część skupia się na studium przypadku z prezentacją lokalnej polityki mobilności i wybranych wyników kompleksowych badań ruchu. W kolejnym rozdziale (3) opisano modele użyte do oszacowania wyzwań inwestycyjnych wraz z przykładowymi obliczeniami i prezentacją podobnych efektów interwencji. Czwarta część obejmuje dyskusję nad prezentowaną metodą. Artykuł kończą wnioski zamieszczone w części piątej.

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