"PARK AND RIDE AS A MEAN FOR REDUCTION OF THE TRAFFIC CONGESTION"

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Abstract

General outlook of the operating Park and Ride systems in few European cities will be given. In this paper an attempt of characterizing the economical and functional efficiency of Park and Ride is taken into consideration. Special interest will be given for calibration of discomfort trip index (DI).Formula for the generalized cost of the trip poses one of the means on how to describe Park and Ride economical efficiency. The formula consists of three elements: trip cost by car, trip cost by public transport and discomfort trip index. The DI take into consideration of access time, travel time by car, travel time by public transport, interchange time, and egress time. Each component of the journey has its own weight, calibrated on the basis of travel questionnaire. Assessment of final effect of introduction Park and Ride is possible by using Visum programme - there is possibility to compare the traffic volume in the street network with and without P&R system.

1. Introduction

Major cities all over the world suffer congestion, on ring roads penetrating the urban centre (especially in a peak hours). Increasing of road network available for private vehicles cannot be the only solution. Each new road helps drivers drive easily, but it is a matter of time, that new link generate more traffic. The trend in the last few years has been towards improving and promoting public transport. It is rather impossible to provide a public-transport network of sufficient quality when origin and destination of trips are scattered like on the outskirts of major cities and rural areas enclosing the cities. Park and Ride is one of the way how to solve traffic problems and mitigate the process of urban sprawl (1). That system tries to combine the advantages of public transport in high-density areas and the advantages of the private car in less densely populated areas. Park and Ride facilities thereby act as an interface between private vehicles and public transport. The first Park- and- Ride facilities in Europe appeared towards the end of the fifties (London, 1958) and at the beginning of the sixties (Hamburg, 1963). Since then growth has been spectacular (tabl.1):

Year	Cities	No. of P&R	Spaces	Average size
1970	24	1166	194,213	168
1990	76	3722	849,226	228
Increase (%)	**216**	**219**	**337**	**36**

Table 1. Development of Park and Ride in Europe

Park and Ride facilities usually were situated near railway-stations aimed at long distance commuters. Later-on P&R facilities appear at the outskirts of towns, linked to the local public transport system. In the run of time the quality of Park & Ride improves. At first they just consist a simple parking lot, conveniently situated at a bus of train stop (10). But later there were an introduction of additional facilities (even having their own public transport line, as for example is the case of Oxford). The objectives of Park and Ride are in the first place to decrease the traffic pressure on the inner city. Other objectives may be to increase the use of the public transport system, improving environmental conditions and improving accessibility of the city.

There is no possibility to implement P&R system in every city. There are some preconditions (11) which have to be fulfilled to get proper working Park and Ride system. The most important are:

- High car ownership.
- Suburban zones with low population density.
- Street network with traffic congestion problems on approach roads.
- The availability of a metropolitan ring road leading to the city centre.
- Parking prizing (especially high rates)
- Shortage of parking places.
- The existence of a good public transport system (high frequency, share rates, easy transfer). That system should channels large flows towards the centre, and not penalise the user in terms of journey time and comfort.
- Employment primarily located in city centres.
- Clearly defined morning and afternoon peak hours.

2. Operating Park and Ride systems in chosen European cities.

P&R in Prague (2), (3), (4)	**P&R in Vienna (2), (5), (6)**
• 11 Park and Ride lots with 1 300 spaces Diverse capacities of P&R: 37 – 300 places • Localization in the city outskirts, close to highway intersection • Each P&R have connection with underground • Tram and bus lines have a little importance • One P&R (Radotin) is situated close to railway station • No multi-storeyed parking lots • Different share of usage: 15 – 40 cars/place/month • All P&R are guarded car – parks • Share rates for P&R and public transport	• 70 P&R lots situated in metropolitan area of Vienna • 11 P&R inside city border • Over 18 000 parking spaces • Easy connection with fast rail (S-Bahn) and underground (U-Bahn) • Bus and tram lines – slight participation • Easy access to street network • Different capacity (50 to 1 800 parking spaces) • Bike and Ride • Only P&R situated inside city are payable and attended
P&R in Helsinki (2), (7), (8)	**P&R in Krakow (2), (9)**
• 43 Park and Ride facilities • 3 800 parking places for cars • Diverse capacity (14 – 450 spaces) • Bike and Ride (B&R) with 5 000 parking places • Share of usage in B&R is close to 100% - during summer and 20% during winter • Easy connection to minor ring road • 7 P&R have connection with bus and tram lines • 36 P&R are served by rail • P&R lots are situated close to railway station • Average share of usage in a peak hour does not exceed 50%	• In the year 1991 – 1999 there were existing Park and Ride system. • 5 Park and Ride lots , situated close to congested streets leading to the city centre • 490 parking spaces • Easy connection with tram and bus lines • Share ticketing; free parking for P&R users • Resignation from the system in 2000, due to lack of funds, advertising and too little interests of users • In Pre Master Land Use Plan for Krakow, there is a proposition of new Park and Ride system • 20 P&R lots would be situated near III and IV ring road • Capacities of each P&R is close to 150 parking spaces • Park and Ride facilities would be served by rapid tram and fast urban rail (alternatively by bus)

3. Modelling of modal split concerning Park and Ride.

Estimation of functional and economical effectiveness of Park and Ride system is a very complicated problem. In western countries (where P&R exists from the early 50') transportation survey takes into consideration P&R in modal split (11). This is very convenience in a process of P&R efficiency. In Poland, where P&R doesn't operate, estimation of its effectiveness will be very difficult.
Generalize cost of the P&R trip is one of the parameters which can help to estimate the effectiveness of the system (12). That parameter characterizes user's cost of the trip from origin to destination taking into consideration not only operating costs (e.g. fuel or insurance) and public transport fees, but also cost of the time spend for individual stages of the trip. To describe generalized cost, additive model was established:

$$K_{P\&R}=K_{p.c.}+K_{p.t.}+U$$

where: $K_{P\&R}$ – generalized cost of P&R trip, $K_{p.c.}$ – cost of private car riding, $K_{p.t.}$ – cost of public transport riding, U – cost equivalent of trip time inconvenience.
Cost of private car and public transport riding is not complicated to find. The problem is how to estimate cost equivalent of trip inconvenience. Access time, riding time waiting time and egress time (fig.1) has the same unit, but there is no possibility to directly add all those values.

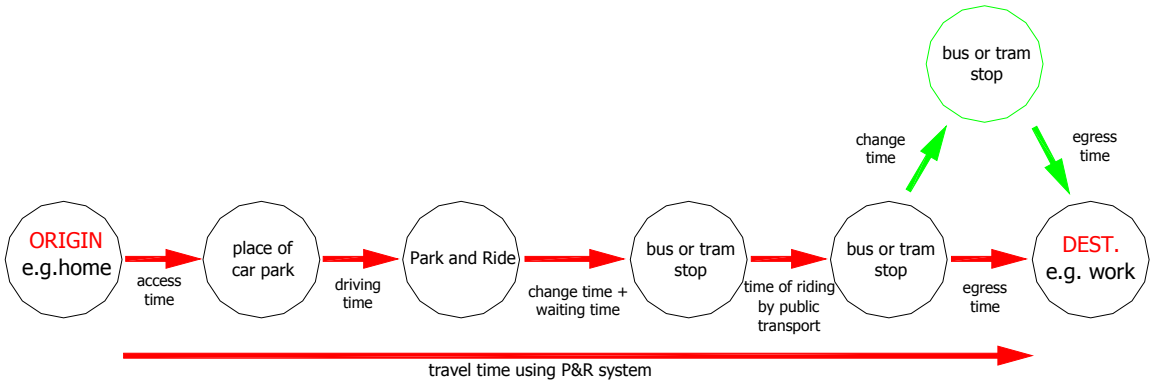

Fig. 1 Trip chain for Park and Ride system.

The reason is simply – each user has different feeling of travel time. Weights of each time component were introduced to diverse influence of time on each travel stage. To make all elements additive it is necessary to multiply U by unitary cost of time. In the result, the equation describing (U) can be presented as follow:

$$U = [\ \mu_{apc} * t_{apc} + \mu_{dpc}t_{dpc} + \mu_{wpt} * t_{wpt} + \mu_{rpt} * t_{rpt} + \mu_{cpt} * t_{cpt} + \mu_{ept} * t_{ept}\ ] * k$$

where: U – cost equivalent of trip time inconvenience, t_{apc} – access time of private car, t_{dpc} – private car driving time, t_{wpt} – waiting time for public transport vehicle, t_{rpt} – public transport vehicle riding time, t_{pkz} – tome of mode of transport change, t_{ept} – egress time, $\mu_{[.][.]}$ – weights of each components of travel time, k – unitary cost of time.

4. Methodology of scientific research.

Main assumption for presented methodology (12):
- The weight of time of driving a car is equal to 1,0 (It means that all travel time components are related to this).
- The assumed travel time was diversified but average duration of the trip time was fixed (25-30 min).
- Traffic conditions in the street network were assumed as a medium congestion.
- High level of public transport reliability

The aim of investigations was to obtain:
- How many times access time to a private car is more onerous than driving time

- How many times , waiting time for a public transport vehicle is more onerous than driving time
- How much minutes more, the user is capable of driving a car, so as not to change into public transport with P&R system
- How many times driving a car in a traffic jams is more onerous than driving a car in medium congestion.
- How many times the public transport riding time is more onerous than driving a car.

5. Results:

Due to lack of operating Park and Ride system in Poland, the inquiry ("SP" – stated preference) was taken among public transport experts and students in Cracow University of Technology. In the result the formula for generalised cost of P&R trip was obtained:

$$K_{P\&R}=K_{p.c.}+K_{p.t.}+[\ 1{,}20 * t_{apc}+ 1{,}00*t_{dpc}+ 2{,}16 * t_{wpt} +1{,}61 * t_{rpt}+ 7{,}28 * t_{cpt} + + 1{,}40 * t_{ept}\ ] * k$$

6. Park and Ride modelling using Visum software.

The aim of researches was to check the result of implementation of P&R system in Krakow. City of Krakow was divided into 15 macro-zones. For existing public transport network and land usage, 7 P&R lots were assumed (see fig.2).

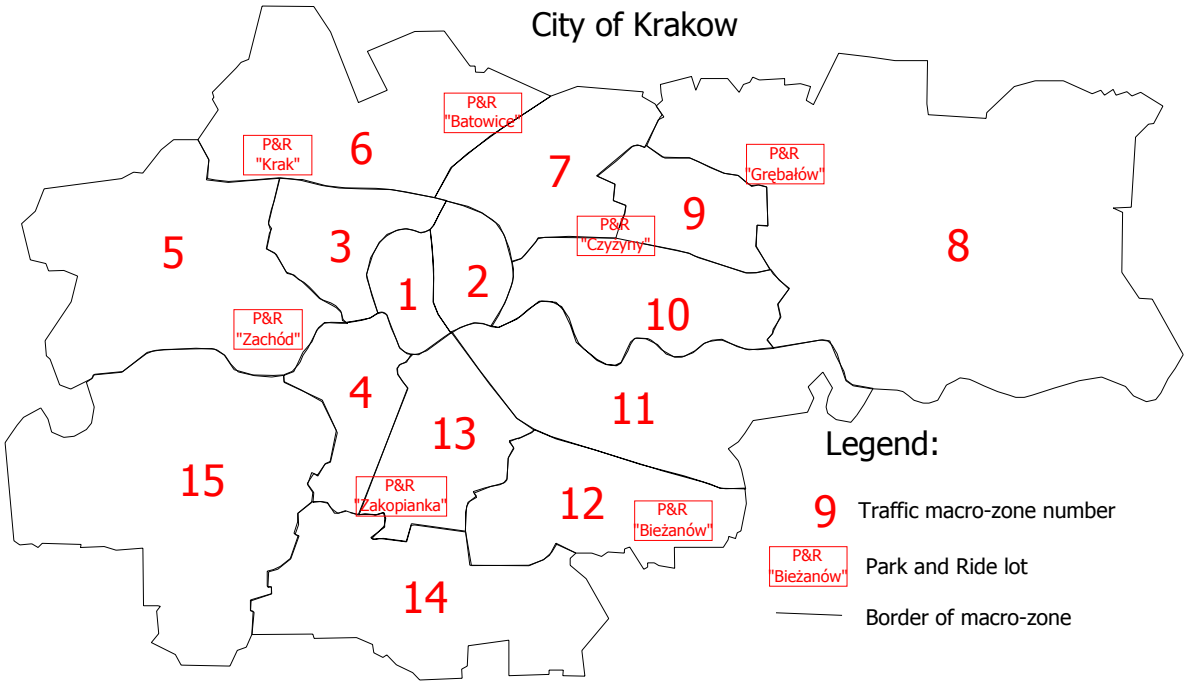

Fig.2 Macro zones for Krakow.

Trip distribution table was prepared according to the results of transportation survey for Krakow conducted in the year 2001. Number of P&R users was assumed as 5% of traffic flow leading to the city centre (11). In the result of assignment, in the network with P&R, traffic volume on main streets in city centre was 2-5% less than in the street network without P&R system. The simulation shows, that P&R has strong influence on travel time. In some cases travel time with P&R is shorter than driving a car (for the same distance). On the other hand, there were some cases, in which travelling with P&R lasts longer. It was also possible to notice, that high parking fees in city centre (generalized cost of the trip takes it into consideration) cause decreasing of traffic volume and higher rate of public transport users.

7. Conclusions:

- During last 20 years Park and Ride reached spectacular growth
- The main objectives of Park and Ride is to decrease the traffic pressure on the inner city
- There are a lot of possibilities, how to organize Park and Ride facilities (different localization, capacities, charges)
- P&R lots should have easy connection with street network and urban transport
- Park and Ride system require high level of public transport quality
- There are some preconditions which should be fulfilled for successful implementation of P&R system
- Generalized cost of the trip takes into consideration operating cost, public transport fees and cost of the time spend for individual stages of the trip
- Main problem is to estimate cost equivalent of trip inconvenience
- Due to lack of operating P&R system, questions in public inquiry could be incomprehensible for potential P&R user. That is the reason, that the answers had hypothetical nature.
- Significantly value of standard deviation for each weight
- Main aim of next stage of researches is to decrease value of standard deviation and implementation of calibrated function to P&R modelling.

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