

Effectiveness of Parking Guidance and Information Systems: Recent Evidence from Nottingham and Frankfurt am Main

K W Axhausen¹, J W Polak² and M Boltze³

1 INTRODUCTION

In recent years excessive amounts of parking search time has been identified as a significant contributor to urban congestion and as an important influence in destination choice, in particular for shopping. Recent studies of parking behaviour have found that parking search time can constitute up to 25% of the average total travel time (Polak and Axhausen, 1990). Anecdotal evidence indicates even higher shares. The same studies also indicated that car drivers value parking search time at about 1.5 to 2 times of the value of driving time (Axhausen and Polak, 1991). This substantial increase in the generalized cost of travel diminishes the competitive position of city centres giving rise to concern for European policy makers.

Parking search and congestion arises because of a mismatch between parking intentions of the travellers and supply. In some cases, this mismatch may be clearly due to an overall shortfall of parking supply relative to parking demand and can only be effectively dealt with by expanding capacity or limiting demand. In other cases however, the mismatch is more spatially and temporally specific and may be due to local inefficiencies in road layout, poor car park design or to drivers being unaware of prevailing levels of occupancy in key car parks or alternative parking and travel opportunities. In the latter case, systems designed to provide travellers with improved information on the parking system have the potential to reduce parking congestion by enabling more efficient use to be made of existing capacity. In Europe there is currently considerable interest in the scope for advanced parking management systems based on in-vehicle, roadside and broadcast information (Polak, Hilton, Axhausen and Young, 1990).

The oldest and most widely used form of information system is the *Parking Guidance and Information* (PGI) system based on variable message signs (VMS) installed at fixed points in the road network. Since the first implementation of the idea in Aachen (West Germany) in the early 1970's PGI systems have proliferated in Europe and beyond (Polak *et al.*, 1990).

The provision of broadcast information on parking is a logical addition to general traffic announcements. Its use is not as well documented as the installation of PGI systems, as the initiative for its provision rests very often with local radio stations and/or local parking facility operators and may not involve local authorities. In addition, the information is often provided only for the short periods of seasonal peak demand for parking, in particular in the run up to Christmas. The authors

know of three such services: one in London, initiated by the car park operator NCP, the service in Nottingham discussed below, and a service in Frankfurt, who uses the information collected by the PGI to generate RDS-TMC messages.

The provision of parking information via in-vehicle route guidance systems is currently under development. A number of DRIVE II projects have included this task into their work programmes (see for example Keller, 1993, for an overview of the German initiatives). These systems might reduce the vehicle miles driven both to reach the final destination, as well as to find the necessary parking space. Still, the possible encouragement given by reduced parking search to overall demand levels should not be overlooked.

It is clear that all three forms of parking information have the potential to contribute to a better utilisation of the existing parking stock and to help reduce search traffic by improving the decision making of the drivers at different stages of their journey. Unfortunately, the literature on the actual effects of the systems implemented is sparse, and many studies do not allow firm conclusions as their designs were not comprehensive enough for the task.

The purpose of this paper is to contribute to this literature by reporting results from two recent studies, with which the authors have been associated. The structure of the paper is as follows. The next section briefly reviews the results of past evaluations of PGI systems. This is followed by the results from the evaluation studies of the broadcasting based PGI system in Nottingham and of the VMS based PGI in Frankfurt am Main. Directions for future development of PGI systems are discussed in the conclusions.

2 PAST STUDIES

An evaluation of a PGI system must take into account a wide range of indicators reflecting the different nature and objectives of the system. For example, in the case of an in-vehicle or roadside based system, the evaluation would have to establish whether the system:

- reduced search time by directing drivers to the appropriate parking facilities
- improved usage of off-street facilities by diverting drivers away from an attempt to park on-street

¹ Lecturer, University of London Centre for Transport Studies, Imperial College, UK - London SW7 2BU, AM ITE; ² Senior Research Officer, Transport Studies Unit, University of Oxford, 11 Bevington Rd, UK - Oxford OX2 6NB; ³ Albert Speer & Partner GmbH, Hedderichstr. 108-110, D-6000 Frankfurt am Main 70.

- reduced queuing by motivating drivers to drive to facilities without queues, including motivating people to leave queues they have already joined
- induced drivers to switch to Park+Ride (P+R), or to walking from a more distant area or to change parking location

while controlling for the total demand, including vehicular through traffic and traffic using other modes, such as public transport or cycling.

In the assessment of systems which reach a potential driver at home, such as broadcast information systems or full pre-trip information systems, it would be necessary, in addition, to investigate effect on:

- the timing of travel
- the choice of destination
- change trip participation

These requirements cannot be met by observation of flows and usage alone, as these do not allow to attribute the changes unambiguously to the PGI system. They have to be supplemented by interview work, preferably panel based work, which would involve the same users in a number of interviews before and after the introduction of the system. See Polak and Axhausen (1990) for a discussion of different survey and observation methods.

Past and current studies have not been comprehensive, but have focused on particular aspects. It has to be pointed out, that the narrower the focus the more difficult it becomes to draw conclusions about the effectiveness of the PGI system.

The study of the PGI system in Aachen by Heusch and Koppe (1973) consisted of a before and after survey of car drivers parking in the city centre. There was no control for the total demand. The results showed that the reliance on the system increased with distance between home location and Aachen. The vast majority of users (81%) parked in the facility they had planned to use. Of those about half had used the PGI to reassure themselves about the availability of places. Of those who did not park in the facility of their first choice, 56% said that they had used the PGI to find their final alternative location.

Similar surveys were carried out in Torbay and Truro (Andrews and Hillen, 1980, Gould and Kinsey, 1981) which again indicated that non-local users relied more on the system than local users and that only a small share of the drivers actually followed the advice given without question. A comparable pattern was detected in a study in Manchester (Hilton, Swindley and Thurwell, 1989) where four years after the installation of the system about 14% of a sample of parkers stated that they had followed the system with out-of-town visitors relying more heavily on the system. Similar results were obtained from a number of surveys conducted in Germany (ADAC, 1989).

A study in Cologne using before and after one-day counts at the entries of the parking facilities (KOCKS Consult, 1988) found that the use of the facilities showed less variation over the day, but without the missing control of the total demand final conclusions are not possible.

The effectiveness of the VMS messages to direct drivers was shown by Wright and Withill (1992) in Leicester, where they compared the flow to a particular car park before and after the appropriate VMS sign had switched from the message 'Spaces available' to the message 'Almost full'. They found that the flow had dropped by substantial percentages. Unfortunately they did not repeat the exercise for the same facilities or controlled for the total inflow into the city centre studied. See also Allen (1992) for a discussion of the effectiveness of different VMS messages.

The results reported so far indicate, that the PGI systems are able to influence the behaviour of a subset of the drivers, particularly of those drivers who visit an area less frequently but the local drivers tend to use them mostly to back up their prior decisions. No results indicating a reduction of search times are available yet.

3 EVIDENCE FROM NOTTINGHAM

The PGI system in Nottingham is based on information broadcast on the two local radio stations during the pre-Christmas period, when Nottingham experiences a substantial increase in the total demand for parking, which leads to long queues at the most popular car parks. These queues reduce the overall capacity of the network and are a safety risk. This situation led Nottingham County Council, the highway authority for Nottingham, to search for a solution. The PGI system is part of that solution intended to redirect drivers away to other under utilized car parks in or in the vicinity of the city centre and to promote the use of P+R (Chatfield, 1989, Polak, Vythoulkas and Chatfield, 1991).

The broadcast information system provides the listeners of the radio stations with short messages (up to 2 minutes) three times an hour during the day in the period from the beginning of October to the middle of January. The message covers:

- a list of car parks with queues including estimated queuing times
- a list of car parks with spaces available
- the current status of the P+R facilities
- plus some further advice at the discretion of the presenter

The evaluation study was to investigate the awareness and the use of the systems by the visitors to Nottingham city centre and to assess the impact of the information on individual behaviour. Macroscopic observations of queues, usages or total demand were not possible within the available budget.

The study was based on a two-stage survey procedure. The first stage consisted of a short personal interview conducted at

a number of different locations in the city centre plus the P+R facilities at the fringe of Nottingham. The interview covered the basic journey and personal details and established the awareness and use of the PGI system. The second stage consisted of a mail-back instrument, which the respondents received during the personal interview. This covered the same ground in more detail, but also added questions about the amount of knowledge of the parking situation and questions on the parking search strategies employed by the drivers. A quota sampling procedure was used to cover all important population segments. Such a sample is not necessarily representative for the total population of visitors. No attempt was undertaken to weight the sample, as the appropriate data on the characteristics of total population was not available.

A total of 1584 car drivers responded to the personal interview, of whom nearly 40% returned a complete second stage questionnaire. Over 70% of sample were shoppers staying for less than four hours in the centre. Nearly half the sample visited Nottingham at least once a week by car. Parking in off-street facilities and in the P+R facilities was the preferred by nearly 90% of the sample. The users of on-street spaces stayed for shorted periods and were not normally engaged in shopping.

Table 1 summarizes the awareness and use of the system by the sample. The awareness of the system increased with the frequency of parking in Nottingham and with the frequency of listening to the local radio stations. Among the personal characteristics only being aged between 24 and 45 had a significant effect on awareness. Most of those aware had learned about the service either by listening to the radio or by seeing the road side advertisements of the service. The users tended to be selective with a small group only listening to it during the Christmas period. Most users of those listening only did so in the vehicle (74%), while a minority switched to the service at home. This choice seems to interact with the choice of type of parking, with those listening pre-trip having a significantly higher propensity to use P+R. The large majority users of the system were satisfied with it and found it reliable and felt that they profited personally from it.

Nearly half of the non-users (45%) felt they were able to find a space without assistance. Most of the remaining non-users did not want to switch their radio station for the parking news. Only a very small proportion of the non-users stated that they had tried the service and found it wanting.

The effect of the PGI system on parking search time was established with the help of a regression equation relating the time spent searching to the relevant socio-economic and situational characteristics (Table 2). The dominant factors are the time of arrival, as a proxy for the total demand and the overall level of parking congestion, and the use of P+R. Those, who had listened to the service pre-trip, had on average a 2.5 min shorter search time, whereas those who started listen en-route had no gain. The parking search time budget (Lorenz, 1990), i.e. the total time of driver was willing to search, had a small effect on the duration of the parking search time.

Table 1 Nottingham: Awareness and use of the PGI system

Aware	Listening	Survey day	First listened	Share [%]
No				37%
Yes	Never			25%
	Sometimes	No		27%
		Yes		11%
			Pre-Trip	4%
			P+R	72%
			Centre	28%
			En-route	7%
			P+R	41%
			Centre	59%

Table 2 Nottingham: Effect of PGI use on parking search time

Variable	Coefficient (t-statistic)	
Search and queuing budget	0.079	(7.90)
Use of broadcast service on day of interview		
Listened first at home	-2.462	(-2.11)
Listened first en-route	0.396	(0.56)
Time of arrival		
09:00-10:00	-0.609	(-1.20)
10:00-11:00	1.789	(3.15)
11:00-12:00	5.097	(7.67)
12:00-13:00	1.106	(1.00)
13:00-14:00	0.448	(0.69)
Frequency of parking		
>= once per month	-1.257	(-3.11)
Type of parking chosen		
City Centre	4.039	(10.30)
Constant	-0.098	(-0.22)
Diagnostics		
F with df	28.21	(1573,10)
R ²	0.152	

4 EVIDENCE FROM FRANKFURT AM MAIN

The centre of Frankfurt is the location of the financial capital of Germany in addition to being a major regional shopping and administrative centre. The City of Frankfurt decided to improve the parking situation in the Centre through the implementation of a large scale PGI system. The system covers the whole CBD plus additional VMS signs at the periphery pointing to P+R facilities (Boltze *et al.* 1992). The system is descriptive. The information is provided in a hierarchial fashion advising first about the parking areas inside the centre and then advising

about specific facilities. The first of three phases of the system was installed in November 1992.

An evaluation study of this first phase was required under the terms of the state of Hessen financial grant. This study is currently being carried out by the authors. The study consists of three waves of observations, counts and interviews, which were or are to be carried out in September 1992, February and July 1993 on both a Tuesday and a Saturday:

- Parking search surveys off-street and on-street
- Automated traffic counts at selected off-street facilities
- Licence plate surveys at selected off-street facilities
- Automated traffic counts on selected downtown links
- Observations of queue lengths and waiting times at selected off-street facilities

This design makes the Frankfurt study the most comprehensive evaluation reported so far. The first two waves of the study have been analyzed so far, but this analysis is not complete yet. In particular the necessary weighting of the survey results has not yet taken place. The results reported below should therefore be treated with care.

The interview procedure involved a short on-street interview covering questions relating to the trip and parking search just undertaken, to the basic socio-demographic details and in the after period to the awareness and use of the PGI system. The interviews were conducted by the market research firm *Infratest Burke*, München. A total of 2332 car drivers have been interviewed in the first two waves.

The survey asked, if the driver is aware of the system, and if the driver had used the system since its installation. The awareness of the system is already high ten weeks after the installation of the system (78.0% on the Tuesday and 86.2% on the Saturday), whereas the use is lagging behind with 29.9% or 44.8% of the visitors respectively. The third wave will allow to judge the speed with which the system is adopted. The Table 3 details the characteristics of those being aware of the system and of those who have used the system. The awareness of the system is larger among those using on-street facilities, living closer to Frankfurt and visiting the centre more frequently. Age and gender have no visible influence. The use of the PGI is higher among those parking off-street, but the origin and frequency of use show no clear pattern of impact, but background information of parking strategy makes the pattern understandable. The Saturday and/or shopping visitors, in particular, are on average less knowledgeable about the City and rely more frequently on the PGI, whereas the Tuesday and/or business visitors rely more on their own knowledge and use the PGI to crosscheck their expectations. The share of users stating that they rely exclusively on the PGI was only 2.6% on Tuesday and 7.4% on Saturday. Still, users gave the system good grades for overall quality, ease of comprehension and reliability. Hardly any of the users felt distracted by the signs themselves.

Table 3 Frankfurt: User characteristics (Second wave February 1993)

Characteristic	Aware		Prior use	
	Tues day	Satur day	Tues day	Satur day
Shares [%]				
Parking location				
On-street	76.1	84.9	39.5	56.2
Off-street	95.4	100.0	30.2	20.3
Gender				
Male	80.8	88.0	33.8	51.4
Female	73.7	83.1	47.7	52.2
Car registered in				
Frankfurt	83.9	91.9	28.1	45.0
Vicinity	76.7	86.2	47.6	53.9
Elsewhere	68.8	73.9	30.4	61.2
Frequency of visit				
Daily	86.9	93.9	41.4	54.0
Weekly	82.6	88.0	36.5	45.3
Monthly	77.3	91.6	34.7	58.3
Less than monthly	50.7	69.5	39.5	48.2
Sample size	541	578	425	502

It is very difficult to assess the effect of the PGI on parking search times, because of the complexity of parking behaviour - parking search strategy, parking search budget, background knowledge - and because of different levels of demand during the waves. Table 4 gives a first indication of those impacts. The numbers are subject to change due to necessary weightings and corrections.

The data seems to indicate a decrease in parking search times for users of off-street facilities on both Tuesday and Saturday in spite of an increase in demand for off-street facilities on the Saturday. The breakdown of search times by awareness and use of the PGI does not support the overall impression in a straightforward way, as the users of the system have in most cases a longer parking search time than the non-users. The confounding effects of parking search strategy and of searching for a different type of parking first have to be kept in mind. The detailed analysis of the effects of these confounding factors has not yet taken place, but will be reported later.

5 CONCLUSIONS

The evidence from Nottingham and Frankfurt underline the results of the earlier studies, that parking information has to be seen against the background of the overall parking behaviour which reflects factors such as background knowledge, parking search strategies and parking search budgets which are all chosen to account for the trip purpose and perceived demand. In Nottingham the PGI has a clear benefit in terms of reduced parking search time for those who adjust their behaviour before

Table 4 Frankfurt: Uncorrected parking search times before and after the installation of the PGI

Day (Mean, std [min]) (Off-street demand)	Location	Before		After PGI	
		All	Aware	Used	All
Tuesday (15863/13687)	Off-street	2.24, 4.47			1.96, 4.32
			Yes	Yes	1.27, 2.55
			No	No	1.81, 4.89
		No	No	2.79, 4.56	
	On-street	8.12, 9.13			6.65, 3.12
			Yes	Yes	7.89, 3.03
			No	5.89, 3.02	
	No	No	8.33, 2.89		
Saturday (17267/19309)	Off-street	8.35, 11.76			5.68, 7.81
			Yes	Yes	6.65, 7.97
			No	No	3.76, 6.89
		No	No	7.69, 8.56	
	On-street	7.52, 5.37			9.69, 6.19
			Yes	Yes	14.62, 5.19
			No	8.43, 5.89	

The off-street demand was measured as the total number of users at 16 off-street facilities in the centre

they begin their journey. For Frankfurt it is not yet possible to judge this on an individual level, but at the global level the PGI system might have led to a reduction in average parking search time.

The Nottingham result strengthens the case for giving parking information as early as possible in the decision process of the driver. The P+R advisory signs of the Frankfurt system are clearly a step in the right direction, but the systems designers might want to develop this idea further. In particular, the development of integration of parking guidance and pre-trip and in-vehicle travel information should be pursued. In the case of route guidance systems, for example, the parking information could be displayed at the start of the trip to allow the driver to adjust his or her expectations early. Otherwise, there is potential for a conflict between the original plan of the driver and the current advice (See also Boltze, 1993).

6 ACKNOWLEDGEMENTS

The authors wish to acknowledge the support of the Nottingham County Council and of the City of Frankfurt for the empirical work reported here. Additional funding was also provided by the European Commission through the DRIVE programme. The views expressed are those of the authors

alone and do not represent the views of either Nottingham County Council, the City of Frankfurt or the European Commission.

7 REFERENCES

- ADAC (1989) Schneller Parken mit Parkleitsystemen - Erfahrungen aus der Praxis - Empfehlungen für die Praxis, *Reihe Ruhender Verkehr*, 1, München.
- Allen, P (1992) Driver response to parking guidance and information systems, paper presented at the 25th UTSG Annual Conference, Southampton.
- Andrews, D. and S.M. Hillen (1980) Compact UTC Car Park Information System, Paper presented at the PTRC Summer Annual Meeting, Warwick.
- Axhausen, K.W. and J.W. Polak (1990) The role of parking search strategies in understanding parking behaviour, Paper presented to the 22nd Universities Transport Studies Group Conference, Hatfield.
- Axhausen, K.W. and J.W. Polak (1991) Choice of parking: Stated preference experiments, *Transportation*, 18 (1) 59-81.
- Boltze, M. (1993) FRUIT: Der Managementansatz für Frankfurt am Main und Umland, paper presented at the 9th Deidesheimer Seminar.
- Boltze, M., M. Dinter, E. Dörr and U. Vietor (1992) *Parkleitsystem Frankfurt am Main - Verkehrstechnische Ausführungsplanung - Teil 1: Grundlagen, Verkehrsführung und Gestaltung der dynamischen Hinweischilder*, report to the City of Frankfurt am Main, Albrecht Speer und Partner, Frankfurt.
- Chatfield, I. (1989) Signalling the spaces, *Surveyor*, 7th December, 14-15.
- Gould, P. and Kinsey, P.J. (1981) Variable direction signs to car parks - Truro experiment, *Traffic Advisory Unit*, Department of Transport, London.
- Gould, P. and P.J. Kinsey (1981) *Variable direction signs to car parks - Truro Experiment*, Traffic Advisory Unit, Department of Transport, London.
- Heusch, H. and Koppe, M. (1973) Parkleitsystem Aachen, Parkverhalten vor und nach Einführung eines Parkleitsystems, Büro für Verkehrstechnik und Datenverarbeitung Heusch - Boesefeldt, Aachen, Report to the Stadt Aachen.
- Hilton, I.C., Swindley, G.A., and Thurlwell, P. (1989) Parking search traffic in central Manchester, UMIST, Manchester.
- Keller, H. (1993) Europäische Feldversuche für Verkehrsleitsysteme in Deutschland, *Straßenverkehrstechnik*, 37 (1) 24-32.
- KOCKS Consult (1988) Parkraumuntersuchung: Auswirkungen des Parkleitsystems, Report to the Stadt Köln, Koblenz.
- Lorenz, K. (1990) Interim report on localised parking behaviour, Report to DRIVE, Project *Changes in Driver Behaviour due to the Introduction of RTI Systems*, Technische Universität Berlin, Berlin.
- Polak, J.W. and K.W. Axhausen (1990) Parking search behaviour: A review of current research and future prospects, *Working paper*, 540, Transport Studies Unit, Oxford University.
- Polak, J.W., I.C. Hilton, K.W. Axhausen and W. Young (1990) Parking guidance systems: Current Practice and Future Prospects, *Traffic Engineering and Control*, 31 (10) 519-524.
- Polak, J.W., P. Vythoulkas and I. Chatfield (1993) Broadcast parking information: Behavioural impacts and design requirements, *Transportation Research Record* 1376.
- Wright, D.A. and R.A. Withill (1992) Variable message signing: measurement of effect, paper presented at the 6th International IEE Conference on Road Traffic Monitoring and Control, London.