

PARK-AND-RIDE SYSTEM: URBAN PARKING MANAGEMENT POLICY

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Abstract: Urban parking is typical for almost all types of populated and developed areas. Various solutions for urban parking problems have been offered since the motorization became more intensive thus increasingly making available street space an extremely valuable resource. Consequently, the introduction of off-street parking facilities became an adequate approach for city planners due to the possibilities for achieving some effective community goals in accordance with new transport (parking) demand management paradigm. Therefore, the park-and-ride terminal concept could be seen as a technological solution that aims to relocate the process of mass parking from the most valuable and economically most desirable urban parts to the peripheral areas, while at the same time offering carefully planned alternatives for passengers to save their time and money. This type of multimodal and intermodal transport has been presented by city authorities as a solution for some common parking issues in urban areas. It has also been politically promoted as sustainable over the last two decades. However, park-and-ride can be observed as a part of parking subsystem and as an adopted parking policy, with its basic role having been to provide a potential reaction to parking problems of city centres half a century ago.

Keywords: parking management, parking policy, park-and-ride, peripheral parking, city center.

1. Introduction

Not only is parking a phase of stopping and leaving a vehicle in the journey process but also a complex and multidisciplinary field which intensively thus shaping the city and affecting the entire community. The most important factor that contributes to the common parking problems in cities is urbanization. Consequently, the population in cities has steadily increased since the Industrial Revolution in 1760. Due to this process and rapid economic and technological development, the urgency for achieving desired lifestyle and consumption

have led to the increased motorization, individual mobility, and car dependence. Nowadays, according to the recent data (Statista, 2017), nearly one billion and a half motor vehicles are used on the planet, with predictions that the number will have been increased to two and a half billion by the end of 2035. The percentage of those people who will have been living in urban areas in the same year climbs up to 60% of the total world population (UN, 2016).

In the last decades, parking has become more important in urban planning mainly due to the fact that while car ownership and

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car use keep growing, urban space becomes smaller (Mingardo *et al.*, 2015). Car parking is defined by the needs of car users (parking demand), and by limited spatial possibilities, or a final number of parking places (parking supply) (Milosavljević and Simićević, 2018). In many urban areas parking is becoming a key transport policy issue, having adopted the attribute of a *problem* in situations when parking demand overcomes the parking supply. Furthermore, Willson (2015) states that parking problem can also result from the poor management (oversupplied parking and inefficient land use; increase in vehicle-kilometres of travel and traffic demand on the network due to the inadequate price policy or *underpriced parking*; negative impact on using alternative transport modes such as public transport, cycling, walking and shared rides; lower potential for economic development and impact on greater social differentiation).

Parking is an interdisciplinary field that is often treated from urban, transport-technological, and economic point of view, thus implying the need for more structural and systematic behaviour in the problem-solving process. This kind of approach can result in the development of a wide parking policy and possibility to handle complexity of parking process to a certain level. In the modern concept of understanding transport process and its impacts (redesigning urban transport and adaptation to livable communities and cities), parking policy is increasingly becoming a part of the *transport demand management* (TDM) paradigm, or in other words, *mobility management* framework. Using a strategic approach in solving parking related issues contributes to achieving the general social, environmental and economic goals. Accordingly, it is possible to define one management strategy (see Fig. 1) as the

highest decision level in one city with the objective of regulating widespread parking conditions. Its primary goal is to improve the transport in the city including its urban, socio-economic, and ecological situation. The actual parking policy including a set of measures, standards or actions that form one management system results from the above mentioned strategy. One type of the policy that is presented by this paper refers to the situation where car parking is not necessary at the desired journey destination in the urban area. Rather, the mass parking needs to be removed from the most valuable city space and the congested streets and it should be connected with an alternative mode of transport to a car – *the park-and-ride concept*, so as to achieve the desired positive outcome in one community. Park-and-ride is a special element of the off-street parking aiming to support the city's *engine*, or its central area, while representing the result (tool) of the modern management process in the parking subsystem.

As an intermodal location designed to shift users between multiple means of transport, the park-and-ride option has traditionally been viewed as a part of larger and more comprehensive systems such as public transport or a city highway network (Spillar, 1997). According to the same author, for the highly automotive-oriented environments in the United States (US) park-and-ride sites have been designed primarily to serve the commuters, while park-and-ride policy in Europe has been implemented as a way of *protecting* historical town centres from additional traffic and parking demand. Today, from the point of view of many politicians and decision makers, the park-and-ride concept is observed from the aspect of *integrated transport* (refers to the term of *New Realism* in transport (Goodwin, 1991.),

which aims to make transport policy and practice more economic, social and ecological sustainability oriented), whereas the efficient transfer of passengers from private cars to other modes of transport can bring some positive outcomes.

The purpose of this paper is to emphasize the park-and-ride connection with parking subsystem in particular and to define the position of this concept in parking policy of a city's central area. Further, this paper also presents a review of the basic park-and-ride impact on the urban parking subsystem. Based on the current literature, one could argue that the approach that includes analysis and observation of park-and-ride technology as a tool for parking management in the central city area has been used the least. The researchers mostly focus on its connection with other subsystems.

Frequent park-and-ride research approaches recognize this system as a strategic tool that has an impact on the transport modal share diversification and the environmental and traffic parameters of the target area at the same time, thus representing also the overall goal of parking management strategies. The authorities and researchers mostly consider park-and-ride to be a part of the city's public transport system that provides increased opportunities for shifting from cars to vehicles with greater transport efficiency and capacity. Location analysis is a method that is also popular, likewise the research on traffic level impact at the city access corridors. Although these topics prevail in the literature, park-and-ride facilities would certainly not be able to operate with the desired performance, or as a part of a balanced package of integrated policy measures, without observing and explaining their connection with the parking subsystem

of the city. In this case, park-and-ride system is observed as a transport and technological component with the main purpose to have an impact on the parking in central areas.

This paper will attempt to define the position and importance of parking within the city's transport structure in the next chapter. The third chapter consists of observations about parking management and policies in urban areas. The fourth chapter provides a short history, definition, and park-and-ride policy overview, while the fifth chapter offers an answer about its place and position in urban parking policy. The sixth chapter offers general premises about possible impacts that park-and-ride could have on a parking subsystem.

2. Importance of Parking in Transport System

This paper mostly relates to the urban core, or more precisely, to its central area (central business district - CBD). CBD is the biggest technical and technological challenge for transport engineers and planners because of its high attraction to variety of users. One could argue that car use requires a lot of resources and huge costs in general. Apart from materials and the use of energy, each car needs a suitable space where it could be located (parked) at both ends of a journey. Such parking place is usually public. Thus, hundreds of hectares of valuable city area have been used as a generator of stochastic user demand by private cars. For example, one analysis (Melosi, 2005) estimates that almost half of the land of the US cities is under transport infrastructure, while a half of that is covered with parking areas. Despite the claims of many authors and engineers of today that a car is parked about 95% of the time, the implications of its massive impact

on the environment are certainly global. This claim is best reflected in the greenhouse effect of the car, with around 44% of its share in total road transport emissions in the EU (EEA, 2017). However, a personal car offers certain positive attributes (specific power, freedom and intimacy in traveling, movement dispersion or *door-to-door* journey, comfort) which still make it a preferred means of transport. These facts place car parking in the field of economies of scale and large numbers, thus giving this socio-economic presence a significant place in urban engineering.

Every mode of transport, apart from vehicles and right-of-way, requires a terminal. In order to use certain features at a city location by any form of transport, at the beginning and the end of the transporting process, appropriate areas, stations or parking places are mandatory (Milosavljević, 2007). With this respect, an individual parking space can be defined as a simple terminal that has the function of accommodating vehicles between two uses, or as a place where user's requirements for vehicle parking are fulfilled. When a journey ends, the inability to find the appropriate parking place affects the efficiency and effectiveness of car use significantly.

Parking is a part of the transport system due to the fact that in most cases the user travel demand requires a certain amount of urban space which is necessary for parking, often accompanied by the user's wish to park as close to the destination as possible. Further, one could argue that transport service is essential for functioning of any city, while each city location requires adequate traffic connections, or a certain level of accessibility. According to Litman (2010), not only does level of accessibility depend on

availability, price, and convenient parking location, but also on the quality of terminal operations and its location. Consequently, the park-and-ride concept also represents a tool by which it is possible to manage the accessibility of the central city area, thus significantly supporting its function.

Finally, it may be concluded that car parking is a subsystem of a larger and more comprehensive city transport system since it is necessary for a vehicle to stop in any transport process, and it is related to the initial and terminal movements that the user makes in order to accomplish the motive of his or her travel. Therefore, the parking management strategy is an integral part of a wider mechanism that includes management of the entire transport system. In this case, park-and-ride may be observed as one of the parking subsystem elements, and it will be defined in the following chapters.

3. Parking Management in Central Areas

Three decades ago, Ligocki and Zonn (1984) said that for a long period of time authorities and city planners had had a very serious problem with car parking with no fundamental solutions. They also pointed out that total parking area occupied a large part of the populated city area. Parking problems belong to a group of issues that are related to the city growth, with such consequences as the irrational use of urban areas and other urban resources, the decrease in the transport service quality, and negative impact on the environment (Milosavljević and Simićević, 2018).

During the period from the sixties to the eighties, European cities and cities of the rest of the world used parking policies mainly to encourage the building of new parking

capacities (Kodransky and Hermann, 2011). The cities had the strong tendency to satisfy the increasing demand for free parking space by those people who wanted to travel by car, or in other words policy was – available, accessible and cheap parking at almost every desired location. Negative impacts of this policy had not become an issue until the beginning of the nineties when it became clear that it was impossible and unsustainable to meet the growing user demand with endless building of new parking areas. This period brought a significant change in transport (and hence – parking) awareness. The new paradigm introduced a general shift towards the optimization of supply and demand, or the tendency towards the more efficient use of the existing resources. No more was the so-called *predict-and-provide* trend used and it was replaced by new principles that put street congestion and environmental pollution issues that used to be only secondary topics in the first place. The existence of an adequate parking policy became fundamental at the time of significant increase in motorization and living standards in cities.

Cities, as places of the biggest consolidation and concentration of socio-economic activities, are very complex spatial structures in a relatively small area supported by a transport system. The most apparent traffic and parking problems are often related to the built-up areas and they occur when the current system is unable to satisfy the growing transport demand. Car parking is an almost inevitable social phenomenon that is related to all communities and it is activated by their spatial expansion, increase in population and private car use in modal share. Transport technologies, policies and economy trends that shape user mobility behaviour have largely created the

city form, while the central area itself has emerged as a product of their application and effects. Not only do CBDs tend to be in the geographic centre of the metropolitan area, but due to the historical and cultural patterns of development, they also tend to be key points for regional transport systems that simultaneously rely on both cars and public transport (Voith, 1998). Central city areas are technologically important and they are developed on the principle that it is crucial to have very high content density and the vicinity, or direct availability, of broad-spectrum activities that are offered to users as opposed to the other parts of the city (Shoup and Manville, 2004). However, the issue of adequate and reliable access to all the contents of this area by a significant number of users during the day is of basic social and economic importance. For example, due to its transport and technical characteristics, public transport is an efficient mode in densely populated areas that saves space significantly. On the other hand, a single trip by car requires the use of much bigger urban areas, especially when it comes to the issue of car parking. Further, the relevant data, or city modal shares and motorization levels, show that the car is still a key mode of transport for the socio-economic success of the central area. The main reason for this is the potential passenger market extent that car opens to CBD, and due to mainly concentrated nature and inflexibility of public transport, or its inability to serve most of the potential demand in all areas. At the same time, urban zones can also be locked in the situation where their functionality and environmental state is being threatened by traffic conditions on a transport network, resulting in a low level of service and a high level of pollution. One of the factors that can also contribute to this situation is a time-consuming search for a free parking

place as close to the destination as possible (housing, commercial, administrative, recreational and educational centres, or transport terminals). Shoup (2006) provides an overview of relevant urban studies showing that a 7-84% of traffic consists of users who are searching for a vacant parking place for 3.5 to 14 minutes. Apart from the above mentioned transport problems, the reports of experts often highlight that prevailing parking spaces, which meet large car demand, have a negative effect on the design and functionality of the streetscape itself i.e. free and undisturbed walking, user safety, total travel time and environment conditions, also impacting the surrounding microeconomic development i.e. opportunity costs of parking lots, the lack of shared parking concept and the inefficient use of existing capacities in commercial areas. One could also argue that the promotion

of mass parking can affect social inequality in cities where low parking costs favour car owners with a special type of subvention – cross subsidy, whereas additional costs are introduced so as to provide parking supply in economically relevant parts of the city, while the burden of such behaviour falls on all the central area visitors by paying taxes. Having in mind people’s tendency towards efficient and comfortable journey and the fact that the car has deep roots in everyday life and habits, it is clear that unregulated (unmanaged), unrestricted and *free parking for everyone*, can lead to a chronically low level of service on the network among other consequences. Administrative, systematic, technological and economic regulation of parking subsystem should be contained in its strategy and policy documents. It is one of the essential requirements for determination of processes in one transport system.

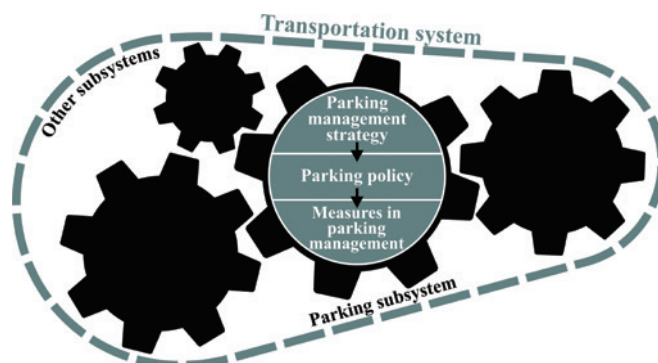


Fig. 1. Parking Policy Place in an Urban Transport System (Relative Importance Scale not Applied)

Therefore, it is of high importance for city authorities to regulate and manage parking process, as well as all the uncertain and large systems. Parking management requires broader context, or a parking management strategy, which serves as the foundation for further decisions. Additionally, parking

management includes the application of various policies and measures that can lead to more efficient use of parking resources, while this type of mobility management supports solving different categories of problems that have been mentioned above. Parking management is also of crucial importance

for the developing cities where the space is very limited and still unregulated resource. Finally, parking policy is a set of measures that are used for parking management, which support the defined parking strategy (Milosavljević and Simićević, 2018). Implementation of a parking policy comes into effect when transport problems caused by the user demand for even more free parking areas impose limitations on the development. Parking management measures result from the selected policy, and they are in accordance with the objectives of the adopted parking management strategy (Fig. 1). Such measures relate directly and in a real-life situation to the limited and precise technical, technological, administrative and economic interventions and decisions that reflect and achieve the goals of the adopted strategies and policies. Local authorities, or cities and towns, are responsible for establishing parking policies which represent a higher and more comprehensive level of decision-making process that may include the management of the total parking demand, the selection of the location of parking facilities, the prices formation and tariff policy, including the access for certain categories of users. Old-fashioned strategy of providing supply for general demand is abandoned and have only historical and theoretical value.

For parking policy development it is an important attribute that European cities follow a similar pattern in its implementation (TCT, 2005). Mingardo et al. (2015) define the framework for parking policy formation, highlighting three clear phases (Fig. 2); basic parking regulation and control (for example, the introduction of parking time limits in central areas in order to provide an appropriate offer to as many visitors as possible free of charge. The main goal is to regulate parking demand and the

efficiency and ease of the personal car use), the introduction of parking fees in particular parts of the city with possible extension of the zones depending on the needs, and recognizing parking policy as an integral part of the overall TDM strategy. Planning and implementation of any of the above policies, however, depend solely and directly on the current situation in the parking subsystem, or more precisely, on the number of the users' requests for the general parking offer. The logical conclusion is that parking regulations do not have to exist as a necessity as long as the parking problem is not visible and does not cause any problems for the urban area. Today, this could only happen in remote towns with small population and low density where vehicles are allowed to be parked on the curb freely. However, the situation in the cities and their commercial and administrative centres is completely different, with the strong need for plans and regulations regarding available parking capacity throughout the whole day. The increase in population density, activities, motorization, and quality of life cause the increase in differences between parking demands and what some parts of the city may offer users as parking space. These problems are mostly present in the CBDs, where such measures are introduced initially. In these situations, the second phase of parking regulations is usually formed, relying on the so-called *command-and-control* concept. Building off-street parking facilities in the form of (mainly) underground multi-story garages is characteristic for this period. Although these facilities may provide additional supply in order to meet the ever-increasing demand, at the same time, they tend to control the demand by introducing the appropriate tariff policy. Garages of this type were mostly common in central areas where they aimed to use the available

urban space effectively. However, following modern policy trends, or non-expansion of transport infrastructure in the attractive city zones, locations of such objects of high parking capacity were moved to the outskirts of the city and positioned next to the frequent public transport stations, which was in accordance with the TDM policy that is typical for the third phase of the development

of parking policy. Unlike the first two stages, the third one is a response to the principles of sustainability in the transport system and a reflection of the new systematic behaviour towards the improvement of the quality of life and environmental protection on one hand, and reaction to the significant increase in the cost of parking infrastructure as a new offer for users on the other.

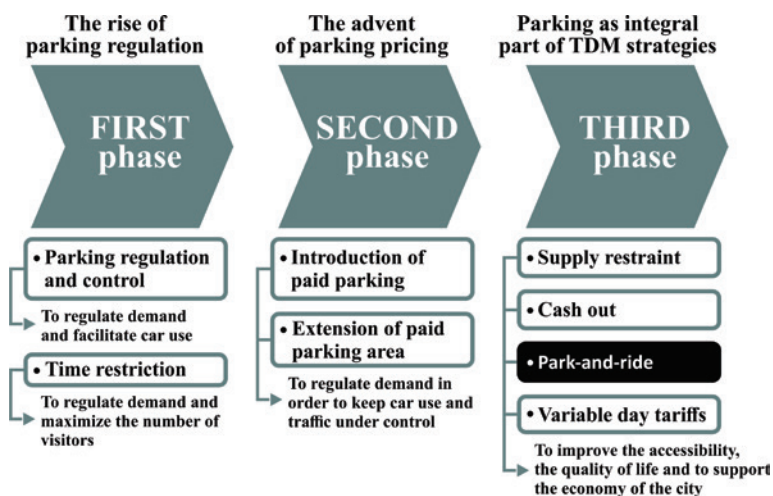


Fig. 2.
Evolution of Parking Policy Implementation and Park-and-Ride Designation
Source: (adapted from Mingardo et al., 2015)

Not only are general parking supply and adequate sustainable policy present topics in professional and academic researches, but these are even more important for the public. Practically, urban parking policy should offer a compromise between the economic aspect (the value of parking places and its real costs, the revenue from parking, the economic potential of a particular zone, etc.) and the fact that it is one of a few effective engineering instruments that may influence the number of cars in the modal share (the offer of parking through spatial and administrative regulations, prices, location,

access and capacities). Such compromise may be reached by the application of carefully designed regulation mechanisms that will define a *qualified demand* (In the situation when parking demand overcomes available supply it is important to ask the following question: which users should have access to the limited capacities, the initial condition being not to build new ones? Qualified demand refers to users who *must* and *should* park in the target zone and these categories consist of people who live in that zone, clients and short-term parking visitors who are essential to its functionality) and

by an imposed price list that will favour different (preferably short-term) parking duration and different categories of users (tariff policy). According to Shoup and Manville (2004), a conventional parking place may have a negative impact on the central city area due to its high and obvious opportunity costs. This assertion is further supported by a situation in which the defined tariff policy does not reflect the sufficient economic value of the established parking place and its function, while economists of liberal orientation think that the parking fee could be the ultimate solution. However, the chosen parking policy usually does not favour the free market economy in practice, but it is rather a result of the carefully gathered needs and effects from various aspects.

The concept of off-street parking that involves facilities outside the most expensive urban areas represents a technological-transport choice that considers the high cost of parking in the city centre, balancing the parking policies, and satisfying the users who are highly unlikely to stop using their personal car. For example, no matter how positive results the construction of a multi-storey parking garage or large private business car park in the city centre may bring with regard to the very demanding on-street parking when it comes to space usage, it prevents the use of the location in question for purposes that are more necessary in this highly-attractive area, and that are in accordance with the adopted urban management policy. The park-and-ride facility becomes a viable off-street parking capacity solution, or an alternative parking option that is usually located outside the most attractive areas of the city, or in areas of smaller value.

The park-and-ride concept has existed for more than fifty years; however, the

understanding of its importance and its application became widespread in the nineties as the consequence of changing the approach to solving the problems that are caused by transport, in accordance with the principles of sustainable development in transport. Today, the park-and-ride program as a part of one comprehensive parking policy, could be observed as a possible parking management instrument with the double effect: off-road parking capacity supply and parking demand management. The programme involves a technology that urges drivers to park their cars outside the CBD and to continue journey using the public transport options, or to share ride, walk, or cycle. Dijk and Parkhurst (2014) conclude that the objectives presented in this case are in fact twofold and in some way inconsistent – on one hand, there is a tendency to encourage car travelling from remote areas to the city by offering new capacities in park-and-ride facilities, and the possible reduction of the car use in urban areas due to this concept on the other. It is also important to note that the park-and-ride system has often been used as a means of political promotion that presented it as a possible fundamental solution for congestion in cities. However, considering the limited range of transport policy measures that are available to administrations and planners and their efficiency, most of the professionals and academics understand and accept this concept as a part of the balanced strategy, or integrated package of transport measures that are related to both supply and demand management. Park-and-ride is certainly justified in the European Commission's Roadmap to a single European transport area - towards a competitive and resource efficient transport system, through paragraph 19 (last kilometre problem), and paragraphs 22 and 23 (intermodal choices) with the goal to

integrate long-distance public transport with local bus and train lines using the appropriate terminal exchange points.

4. Park-and-Ride Transport Policy

4.1. Historical Aspect and Development through the Peripheral Parking Context

Park-and-ride facilities have existed in urban transport market in one technological form or other for decades (Spillar, 1997). One of the first solutions that required the user to change a personal car for a means of transport with more capacity when traveling to the central city area, referred to the so-called *peripheral* (or *fringe*) city parking. This concept requires the user to leave the car in a suitable parking facility i.e. parking garage or an appropriate off-street terminal, just next to the border of the most attractive city area, and to continue the journey on foot or by short bus ride. It is believed that one of the first serious off-street parking projects on the outskirts of the city was initiated by Baltimore Transit Company (now called Maryland Transit Administration) in 1946. (MTA, 2015). However, Lovejoy (1949) says that some local authorities tried to establish such facilities in the early thirties of the last century in the United States. This type of peripheral city parking was in fact first introduced as a response to the problem of access to the CBD contents due to the increased motorization and traffic congestion on the streets that was common for this period, while the development of parking facilities was coordinated with public transport operations (Lovejoy, 1947). Hughes (1948) specifically dealt with the idea that such means of transport could help to solve the city's parking problem, based on the general view that off-street parking terminals were

an important way of dealing with parking demand for users heading towards the city centre as the core of administrative, business and commercial activities. According to the same author, ubiquitous street parking is considered to be a waste of valuable and expensive space, whereas its main purpose should be the possibility of unrestricted mobility for all users.

The peripheral parking was a very unstable concept that proved to be unsuccessful in many US cities. The main reason for this was the fact that parking a few kilometres away from the final destination combined with bus transport was not substantially more attractive than driving to the city centre, and the costs of organizing public transport and the operational costs of the parking facility could not be covered by the users only (Lovejoy, 1949). Some of the possible reasons for abandoning this technology in some US cities were inadequate locations, the cost of parking in the central parts that was lower than paying the bus ticket, and the fact that the towns were spatially very centralized and concentrated, and the trips were not long enough for intermodality to become attractive for users (Lovejoy, 1949). However, some cities continued to develop and grow in size and population, and due to the increasing level of motorization, they continued with the fringe parking plans until the institutionalization and further improvement (Morrow, 2005). Peripheral parking as a concept still exists in parking management plans, although it is becoming more accepted as one of the park-and-ride technological forms because it involves the change in the way the users move while offering a cheaper parking option and an alternative to creating new parking areas in the city centre.

Due to the decentralization of the wider city area and the creation of integrated urban units that included satellite towns, the peripheral parking required broadening of the idea through the way of connecting very distant places that relied on the city itself socially and economically. Conceptualization of the park-and-ride idea certainly includes the technology of fringe parking as its possible integral part that is also an older concept that was first considered by city planners of the period. The basic technological difference is reflected in the length of travel by car that is required to get to the parking lot, or according to its location, with regard to the place of residence of the potential users, whereas peripheral parking involves driving to the very edge of the city centre, almost to the journey destination, while the park-and-ride system includes shorter car trips as opposed to the part that requires public transport. Today, park-and-ride is accepted as a wider and more comprehensive idea that

developed from the historical tendency to relieve traffic congestion in the central city area. Transport decision-makers find park-and-ride concept to be more technologically complex, more applicable in terms of passenger market size and geography, and more visible as approach with regard to the policy of passenger intermodality in cities.

4.2. Definition

According to ITE (2009), park-and-ride facilities are the primary form of terminals that involve intermodal parking sites and garages that allow the users to switch from private vehicles to other modes of transport. Similarly, Spillar (1997) defines park-and-ride as a technological form of intermodal and multimodal transport that includes a change of the type of movement from private to the means of transport with more capacity so as to complete the journey, by offering a convenient parking lot with direct access to the public transport terminal.

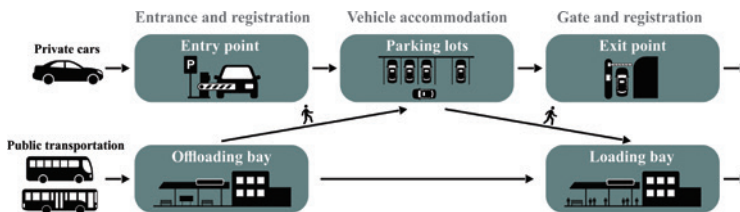


Fig. 3.

General Case for Technological Process, Structure and Functions of a Bus-based Park-and-Ride Terminal

Apart from the conceptual approach, the system-technological aspect defines park-and-ride as an element of the observed transport network, or a node in which different transport modes are met and confronted. In a wider sense, this concept can be observed as a place for traffic determination and the formation of planned and concentrated groups of users who will

continue their journey to the city in an organized and pre-defined technological, financial, and timely manner. Therefore, this transport network object can be defined as an appropriate intermodal terminal with the central function as follows: providing smooth entrance and registration for passengers using personal car, arranging adequate accommodation for their vehicles, keeping

and securing the comfort of passengers during the time they arrive at the terminal until their departure time, and their efficient loading and dispatch by means of public transport or performing a reliable transfer from one type of vehicle to another.

At the same time, park-and-ride has its own structure with elements of a certain function. Fig. 3 gives a basic overview of a technological process in a bus terminal of

this type that is most common. However, some examples show that the arrival at the terminal itself does not necessarily involve a private car. The way of arrival is a result of the tariff system planning and parking management policy, which defines the type of future user category, while others are discouraged by appropriate technology or prices. Parking places are usually organized as outdoor off-street lots or, rarely, as parking garages.



Fig 4.
Organizational Structure of a Bus-based Park-and-Ride Terminal

The organizational structure of the park-and-ride terminal is shown in Fig. 4 by connecting three basic interconnected technological units, whereas the passenger building is rarely constructed unless it is the case of more complex centres (for example, named as *Transit Centers* in United States) with considerable demand, which is characterized by a greater number of operators and means of transport. The terminal front space serves as a parking lot with a certain parking area capacity. Depending on the established operational objectives within this technological unit, it is also possible to find a taxi station, kiss-and-ride area, or (rarely) the public transport zone for feeder lines with regard to the large transfer centres. The public transport terminal space is a technological part of the entire structure that provides the reception and dispatch of passengers and buses.

4.3. Policy Overview

The park-and-ride concept has proven to be an effective way of combining the automobile

and public transport by using each mode in geographic area to which it is best suited – because the automobile is used for the initial collection part of the journey, park-and-ride is able to draw trips from a relatively large market area to a point where there is enough concentrated demand to support public transport (Bullard and Christiansen, 1983). The basic thought behind this concept is the possibility of combining flexibility and dispersion regarding the journey by private car in rural and suburban areas, with the efficiency of public transport that involves larger number of people in complex urban environment with greater population density. According to Turnbull (2004), the key objectives and wider aspects of park-and-ride technology derive from the stance that this concept is designed with carefully planned location and appropriate technology so as to support the following:

- Increasing availability of alternative means of transport, by giving travellers the opportunity to transfer from low

to high-occupancy travel modes and vice versa, thus offering an effective combination of passengers travelling by car or bicycle, with trunk route requiring transit by train and bus, or van poolers and car poolers;

- Concentrating the demand for public transport in the place that could not be provided otherwise. In many low-density areas, without park-and-ride facilities and services, no attractive public transit can operate effectively;
- Broadening the transit options so as to include low-density areas, thus offering the users in the suburbs, who are traditionally used to having their own car, a premium transit services like trains and express buses. For such services, park-and-ride users could be a considerable part of all passengers and they could provide sufficient demand in order to secure the higher quality of transit service;
- Offering a convenient, safe meeting point and parking location for carpoolers and vanpoolers in order to facilitate pool formation, and to support ridesharing in locations where sufficient demand might not otherwise provide a destination for ridesharing;
- Reducing vehicle-kilometres of travel (VKT) and potentially pollutant emissions. Encouraging a high-occupancy means of transport and reducing distances that passengers drive alone, as long as severe indirect results of travel do not occur, may help reduce the VKT system. With proper system design, in most cases, the VKT reductions may lead to the air quality improvement;
- Shifting parking from the CBD to other dense centres. Thousands of parking spaces for a region's central area may be

provided through park-and-ride facilities. This transfer of parking can have a significant effect on the reduction of the CBD parking supply and downtown street congestion;

- Releasing neighbourhoods from uncontrolled informal parking that is caused by the park-and-ride activity that occurs in the absence of formal facilities or their insufficient capacity.

Park-and-ride facilities can be divided into many categories. For example, when observing some aspects, location, function (exclusivity of use) and design can be emphasized. Based upon their location (distance from CBDs), three categories of park-and-ride can be distinguished (Spillar, 1997; Meek *et al.*, 2008a; TCT, 2005):

- *Remote (long distance)* – in this case, terminals are located far from the city centre, between 60 km and 120 km in the United States, and around 30 km in Europe, and they are closer to the place of residence (residential trip generators) often offering a means of public transport in the wider region or within a specific satellite town;
- *Local* – tends to be located on the traditional public transport networks, planning to contribute to the passenger market space between suburban areas and CBD, mostly 2 to 7 km from the city centre;
- *Peripheral* – (already mentioned) includes those park-and-ride terminals that are built on the very edge of the central area. This category often tends to provide additional parking capacity just next to the very edge of the city centre or it is likely to intercept the traffic in the last phase of the journey.

According to the way park-and-ride sites are used, they may be *exclusive* in the way that they are meant only for those car users whose destination is the city centre and they change for the public transport. In most cases they are designed on purpose and publicly or privately owned (or joint). Further, multifunctional facilities such as large shopping malls, commercial buildings, stadiums, and factories, may provide parking places required for park-and-ride in certain parts of the day, or under special conditions. These *shared parking* sites may be an interesting mechanism for supporting park-and-ride programs in cities as they can reduce costs of building a new terminal significantly, which is in accordance with the principles of transport sustainability and more efficient use of existing parking resources. At the same time, local, commercial and sports centres, factories or churches may be interested in participation in the mutual park-and-ride project, or the decision-making process regarding sharing of their own parking capacity or even investment in their expansion. This concept of sharing the existing off-street capacities is a well-known measure in parking management that may easily be complementary to the park-and-ride options.

With regard to the project and design elements, these terminals may be determined by a number of criteria used in planning and implementation, such as mode of access for different types (exclusively for car owners, or for all potential users who would use public transport services from a given location), design of technological processes within the terminal, terminal construction, parking technology, tariff policy and payment method, user guidance information system, connection with other means of transport, pedestrian communications, site security,

design of technological units within the terminal, etc.

5. Defining Park-and-Ride Position within the City Parking Policy

So far it has become clear that parking management, along with the currently available parking policies (or many of them at the same time), is a powerful way for meeting the growing transport demands. However, the establishment of individual policies, in either parking or in some other transport sector, is not the only available way for dealing with current urban issues. Nowadays, the integration and interconnection with higher levels of management are essential for the modern way of understanding technical and technological problems. In accordance with the particular multidisciplinary character of a city and the mutual inseparability of transport subsystems, parking policies are specifically designed for the application in the integration with important documents from other areas; for example, the policy of management and development of the public transport system (where the park-and-ride concept is particularly present), the policy of reduction of car traffic and policy of environmental protection, or the policy of the preservation of cultural and historical heritage of the central area. According to the current urban trends, parking policies are specially tailored for each individual transport-technological, urban or social-economic situation, where current traffic or environmental effects depend on many factors. In conclusion, the objectives and elements of the parking management strategy must be closely related and complementary to the elements of other subsystems, and within the framework of the general transportation demand management

so as to maximize the impact of this process. Thus defined conceptual approach to the city development structurally includes park-and-ride technology as a part of the general parking management policy, that is consistent with its basic principles to a certain extent i.e. the tendency to protect the central city core from parking demand and additional VKT, providing additional peripheral parking facilities as an alternative to the construction of new parking areas in the city centre, organizing informal parking outside the regulated zones, or to save time and money for the users who decide to use this type of travel.

Finally, in order to define the position of park-and-ride within the urban parking policy, it is important to examine its evolution and development over the time (explained in Chapter 3). The park-and-ride policy is a part of the third development stage which offers a new perspective of the utility of transport demand management as a general strategy that may make cities better places to live. Consequently, the subject policy is one of the tools that could be used for managing transport (and parking) demand. The construction, development, and promotion of this system discourage users (mostly long-term parkers) from the city areas with the highest location value and the highest concentration of activities that may be the most sensitive regarding transport supply and demand. Cities may practice integrated park-and-ride programs with different measures e.g. tariffs that discourage drivers from entering the city centre by car. Rather, the access to the city centre is (economically and environmentally) desirable by using all other means of transport that are more sustainable, and also available through implementation of movement priority, integrated tickets, cash-out and other

measures. Apart from the development of the parking management mechanisms, the park-and-ride system can also be defined as a specific policy within the parking subsystem whose implementation may manage parking demand in a conceptually modern way.

The following assumptions may define an example of a hierarchical structure of the complete parking management process (Fig. 1) in a realistic scenario. In the first instance, the parking management strategy tends to support the socio-economic development of the city central area by suggesting an appropriate, urban or regional, parking plan that could provide general guidelines for parking regulations and management. Some of the policies that can be implemented in accordance with the idea of the current strategy relate to the introduction of mechanisms that may establish a policy for parking fees in the areas of relevant city zones, or that may impose limitations on parking supply, introduce the parking maximum, redefine the parking minimum, organize the shared parking facilities, or introduce the park-and-ride policy as an alternative to parking in the central area and as a leverage in managing transport demand. The park-and-ride policy can be complex and comprehensive with regard to the content and connection with other transport subsystems; however, this paper only examines its relation to the parking subsystem. For example, a park-and-ride program can represent an appropriate policy within a mobility management strategy in which it seeks to transform the modal share distribution, with the aim of having more users who will consider public transport. On the other hand, park-and-ride can be a policy that is implemented as feedback at the moment when the parking subsystem makes an additional *call* for a higher (transport)

system to introduce the additional mechanisms that may offer users new and alternative capacities when the existing structure fails to meet users' needs exceeding the level of qualified parking demand.

In the process of locating the park-and-ride policy in the parking management system, the *PUSH* and *PULL* concept is particularly interesting. This strategy involves a well-known principle of *carrots and sticks*, which relies on the combination of rewards and punishment that are used so as to induce certain changes in the travel behaviour. Parking finds its place as an essential transport subsystem within the mentioned concept. For example, restrictive parking measures, such as parking fees, price management, time limitations, reductions or limits in parking supply, may be observed as so-called *PUSH* factors that encourage users to change from individual to more sustainable means of transport, or public transport. *PULL* factors tend to improve the quality of service in public transport and to introduce different incentives for passengers i.e. integrated tariff system, comfortable vehicles, movement priority, adjusted timetables, etc. Of course, *PULL*

effects cannot be achieved to the full extent without the complementary *PUSH* side, so it may be concluded that these two are inseparable. The effects of *PULL* measures are only limited when applied separately, but during the planning process these should be inseparable parts. *PUSH* and *PULL* can be regarded as the final result of the modern concept of transport management, and Fig. 5 shows some usual measures and their effects. In this case, park-and-ride represents a policy that clearly creates the so-called *PULL* effect, because it motivates passengers to use the advantages of the park-and-ride tariff policy that involves money savings, and the benefits of the appropriate transport technology that can bring time savings, while the entire park-and-ride program in one city may involve the public transport priority, the integrated tickets, cash out scheme, etc. Park-and-ride object also represents a specific facility within the transport infrastructure, or terminal, where this concept was introduced and formalized by providing conditions for the transfer of passengers (necessity because of the fact that under the action of *PUSH* measures it is imperative to offer users an adequate location for realization of transfers to more sustainable modes).

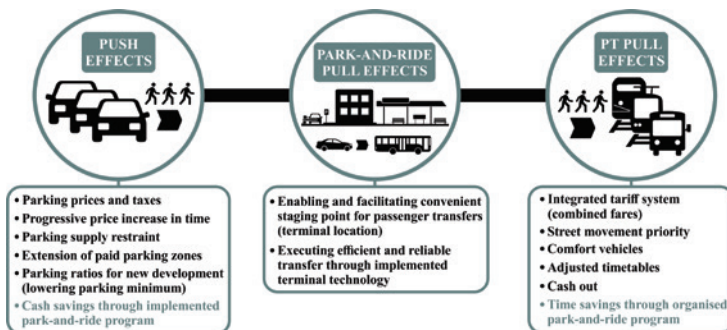


Fig. 5. General Preconditions for Successful Park-and-Ride System and its Role in *PUSH* and *PULL*

6. Park-and-Ride Impact on the Urban Parking Subsystem

At the basic level, the park-and-ride concept is based upon the principle of intercepting car drivers on their journey towards the central area of the city (Meek *et al.*, 2008b), thus protecting urban areas from VKT and excessive parking demand. The distance from the park-and-ride site and the final destination in the city centre, should be travelled by bus, train or other forms of public transport, or by rideshare, bicycle, or on foot. The shift to the alternatives reduces the number of cars in the central areas and relieves urban traffic network, thus improving the quality of the environment. This claim is just nominal, while research and exact measurements of the park-and-ride technology effects are still present as the subject of academic discussions. Since this concept is interdisciplinary and with the transport system being very heterogeneous in technological terms, it is clear that park-and-ride has certain influence on the sectors such as public transport, urban and suburban road and rail networks, and parking. Nevertheless, the purpose of this paper is to understand the park-and-ride concept as a part of the city parking policy and to show its basic impact on the parking subsystem.

Generally, the political support and promotion of these facilities, especially in the US and the UK, offered new, safe and effective solutions to the users and budget decision-makers regarding the quality of life and the quality of transport. However, park-and-ride as a transport solution is still the subject of tests and analyses, especially those regarding environmental issues, size of traffic flows, trip generation, and the positive impact on the public transport system. Certainly, there are various effects produced

by this system and these can be either positive or negative in accordance with defined urban and transport objective functions. It seems that researchers have definitely accepted the fact that park-and-ride has a solid and undoubted position in transport as the element of parking management policy that may be an alternative to the construction of new parking infrastructure in the city, acting like an integrator of various means of transport in the ubiquitous views on the more coherent function of the metropolitan transport system. On the potential passenger market, park-and-ride offers itself as an affordable off-street capacity that moves users away from their final destination in the city centre, but if it is carefully planned, it saves time and money in the form of various administrative or technological incentives and solutions.

The main influence of the park-and-ride concept on the city's parking subsystem is reflected in the possibility of reducing parking demand in the central area that is usually a very attractive part of the city with the biggest demand for a vacant parking place. With regards to the management policy, park-and-ride is introduced as a possible reaction of the decision-makers and as a *call* that is sent to a higher system as a result of the transport demand management actions. Such decisions are made when the existing parking resources in the city centre cannot meet the qualified demand. Consequently, parking is congested, while economic efficiency and area development are threatened. In other words, it is possible to reduce the pressure in both parking facilities and on the street, as well as the need for new parking places. Such approach is in accordance with the modern concept of parking management that is based upon the adaptation of the parking system to

the city, by using the existing resources efficiently and avoiding the construction of new large capacities. Improving access to the CBD by offering different public transport lines and new transport options for certain parts of the city may reduce the widespread phenomenon of long search for a free parking place. However, the full effects of park-and-ride policy can be only achieved after regulating parking situation in central areas (Simićević, 2011).

Formation of the appropriate parking policy is followed by the parking demand segmentation. The implementation of the park-and-ride system could be of particular interest to the following segments: commuters, customers and tourists with long-term stay, peripheral and suburban residents. If a park-and-ride facility mostly attracts long-term stay commuters (for about 8 or 9 hours), parking capacities in the city will be free from the users who should not park in very attractive areas. Consequently, the available places could be used more efficiently (for example, parking turnover is increased along with the parking place value) and they could be open to the users who *should* park here. Trips to work in CBDs during peak hours increase the time of search for the free parking space. Weekend shoppers, visitors in the afternoon leisure hours on business days, or tourists who spend most of their time in the city centre, should also be considered for the park-and-ride program due to their long-term parking. Moving their parking location to the outskirts of the city is in accordance with the need for using one parking space in the very attractive area of the city by as many visitors as possible so as to reach the higher value. Such policy is in accordance with the local economy potential where a specific parking measure may make a local

shop more accessible for greater number of short-term visitors. Additionally, these facilities may also reduce the number of undesired situations caused by car drivers who cannot find a vacant parking space in CBD or those who avoid paying for parking fees. Such drivers often park their vehicles on a local street network in suburbs, outside the zones with parking fees, thus creating additional parking problems for the residents who are used to finding a free parking place close to their homes. Users who avoid paying for the parking fees and time limits usually try to find parking places in local commercial lots, making it difficult for the customers to find their own parking places, although in some cases this type of behaviour is used for advertising purposes. The appropriate service may reduce this kind of informal park-and-ride behaviour and it may control the formation of self-initiated parking lots in residential areas.

7. Conclusion

Parking policy has considerably developed over the last few decades, with the park-and-ride concept emerging as one of the last elements of its application in cities, while most urban areas in Europe are faced with the increase in parking demand. Bigger parking capacities, in accordance with the inevitable transport equilibrium and induced demand, may affect new outcomes and issues regarding the overloaded network and negative influence on the environment. Abandoning the outdated policies, it has become typical for the cities that are faced with these problems to respond with an appropriate transport policy framework (e.g. administrative and economic measures), primarily tending to use the existing infrastructure better (e.g. tariff systems or electronic user guidance systems), or

building new infrastructure only when there are clear structural bottlenecks. Strategically, park-and-ride is an instrument that results from the development of the political mechanisms regarding the problems of negative impacts and consequences of traffic, ranging from *predict and provide*, through the *command and control* concept, to the newer paradigm of the demand management. Park-and-ride policy may be accepted as one of the mechanisms that could help with regulation and management of user preferences and demands. Decision-makers' interest in this concept is significantly supported by the fact that in some cases (shared parking) park-and-ride may be a much cheaper alternative to the financially very demanding transport infrastructure (new roads, garages, etc.).

This paper presents the park-and-ride system from the aspect that has not been sufficiently examined in the literature – its place and function within the parking subsystem. The answer to the question of where the park-and-ride position in the parking subsystem may be, lies in the fact that it is a parking policy tool that results from the application of the TDM strategy with the tendency to reduce parking demand, which is *addressed* at the moment when central area parking problems cannot be solved efficiently using the usual parking policies. This paper also emphasizes its ambiguity as one of the basic park-and-ride characteristics, or as a policy that manages the parking supply, while at the same time representing one of the ways to manage parking demand.

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