TeMA
SP.09
Researches

TeMA*Lab* journal of
Mobility, Land Use and Environment

Journal website: www.tema.unina.it
ISSN 1970-9870
Vol 3 - SP - March 2010
SELECTED PAPERS 2009

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Envisioning Parking Strategies for the Post-Automobile City

The Role of Parking in a Framework for Sustainable Urban Transport

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ARTICLE INFO

TeMA*Lab* journal

www.tema.unina.it
ISSN 1970-9870
Vol 3 - SP - March 2010 (29 - 38)

Department of Urban and Regional Planning
University of Naples Federico II

Keywords:

Parking
Sustainable transportation
Urban Planning

ABSTRACT

Parking policies and regulations are important tools in planning for the governance of urban mobility. The proper design and location of parking facilities, in fact, contributes to an efficient use of the transportation system (or it may reduce its efficiency, when these infrastructures are not properly planned). This paper discusses the role of parking as part of the policy packages for strategic planning aimed at increasing the sustainability of urban and metropolitan areas. In particular, the integration of parking strategies in a comprehensive vision for the future of a city may significantly improve the allocation of resources and the reduction of the overall environmental externalities.
The role of parking in the strategic planning of cities is discussed through the analysis of several recent projects in the city of Bari (Italy). The paper discusses the way these projects are linked (or eventually not linked) to broader strategies for urban mobility, and how they might be coordinated into policy packages that promote more sustainable transportation. The use of an integrated land use transportation modeling approach to simulate the long-term evolution of the urban area may significantly contribute to estimate the long-term effects of the proposed policies. This approach may successfully support the process of policy evaluation and the selection of the optimal strategies to implement.

Parking facilities in a car-dependant society

Parking is an important element of the transportation system of any urban area, and its organization is an important task for transportation engineers and planners. If properly planned and managed, parking facilities may considerably increase the accessibility of urban settlements and contribute to reduce congestion in most central areas. However, defining efficient parking strategies is not a simple task. Parking strategies and regulations deeply affect the use of cars and more generally of transportation: when correctly located, parking facilities may efficiently support the use of the road network, and reduce the number of vehicle miles travelled by private vehicles. Besides, parking strategies may be often useful to promote public transportation, when designed in coordination with the development of mass transit. However, if not properly designed and built, or if not provided in the right amount, parking can easily become a critical element of the transportation system.

At the beginning of the 21st century, there is sufficient evidence that parking facilities cannot be designed separately from the remaining components of transportation. The development of parking facilities entails important issues related to their interactions with the other elements of the transportation system. Besides, their construction requires huge investments, both in terms of financial instruments and in terms of consumption of natural capital (developable land), which is often a very scarce resource in higher density areas. For these reasons, in a time of increasing environmental concerns, it becomes extremely important to link the design of parking facilities to the development of sustainable transportation solutions for urban and suburban areas.

Parking facilities are land intensive infrastructures that stimulate in the medium run the demand for trips by private vehicles. Thus, an increase in parking capacity usually leads to additional vehicles traveling on the road network, and to a stronger car dependence of transportation. This phenomenon makes the increase in parking capacity desirable only for rather limited quantities. Once the *optimal* amount of parking is available, the provision of additional parking space makes the environmental quality of the system gradually worsen. It generates demand for additional trips by private car, and stimulates the demand for additional road capacity and even more parking. This may not always be satisfied due to land availability constraints, and is unacceptable from the perspective of the conservation of natural resources.

Moreover, there is cause for additional concerns regarding the adoption of common land use patterns associated with huge parking facilities. These facilities contribute to shape new developments

oriented to a more car-dependent mobility, in particular in low-density suburban areas. They often make the use of public transportation less convenient, and reduce the physical accessibility by alternative (non-motorized) travel options, as walking and biking. The process determines a pattern of energy-intensive (and *energy wasting*) urban settlements, with lower quality of life and increasing environmental decay. Indeed, parking regulations and strategies are an important tool for governing travel demand. They deeply affect the use of the transportation system, and the selection of the travel mode, as an effect of the transportation costs associated with the use of parking facilities and the time required to access them. Pricing policies significantly affect the mode share and the use of the transportation system: most users are sensitive to parking costs, especially when other valuable transportation options are also available. Moreover, the financial instruments for the regulation of parking are a powerful tool for local administrations to collect additional revenues, and raise flows of capital to cover the management costs of parking facilities or finance other investments in transportation. The policies for the regulation of parking play a significant role in the governance of the urban mobility. As elements of a comprehensive strategy to address more sustainable mobility, they may contribute to meet the goals of a more balanced mode share, and of reduced environmental externalities from transportation. In this paper, the issue of the coordination of parking strategies with the development of transportation is discussed vis-à-vis their potential to support more environmental-friendly travel solutions. The issue is discussed with several examples from the implementation of recent projects in the city of Bari (Italy). The paper discusses the way these projects are linked (or are not linked) to broader strategies for urban mobility, and how they might be coordinated into policy packages to pursue more sustainable transportation. The way in which the effects of parking strategies can be forecasted in the long-term strategic modeling of the development of the city is then presented with reference to the use of an integrated land use transportation modeling approach. Some conclusions on the role of parking as part of long-term strategies for transportation in urban and metropolitan areas can be accordingly drawn.

Parking facilities and the strategies for sustainable cities

Parking facilities are an important element of the transportation system of a city. Nevertheless, the complexity of their design and organization is often under-evaluated, and most of the attention usually focuses on the construction of other elements of the transportation system and of the road network. Somehow, the existence of sufficient space dedicated to the parking of motor vehicles is assumed in the design of cities and neighborhoods. As a result, the importance of the role of parking, either along public roads or on private areas, is usually underestimated (with a few limited exceptions), and not thoroughly studied.

According to the dictionary definition, a parking lot is simply “an area used for the parking of motor vehicles”. The definition itself is vague, and many different ways for organizing parking facilities actually exist. The choice of the best solution should be carefully made in each context in conjunction with the overall objectives leading to the definition of parking policies in a municipality and/or other local administrations. Many times, however, and especially in those cities and regions that do not have strong planning authorities and agencies, parking facilities are located arbitrarily, providing additional capacity to the existing on-street parking where possible, and gradually occupying the remaining developable areas that have not been used for other purposes yet. This inevitably leads to a lack in the efficiency of the parking solutions, and in their ability to solve transportation needs.

Nowadays, there is the need to integrate the development of parking facilities into a wider perspective, and within the framework of more comprehensive planning strategies for urban mobility. This need is even more urgent due to the necessity of reducing the environmental externalities of transportation, and of making transportation systems more sustainable. The environmental impact of transportation is in fact mainly associated with the use (or often misuse) of cars and other private vehicles. As already mentioned, the design of parking facilities greatly affects the use of cars in urban and suburban areas. Hence, the development of more thoughtful and carefully designed strategies for planning may actively contribute to rebalance the use of transportation in most congested areas, and contribute to an overall improvement of the performances of the transportation system.

Since the first definition of sustainable development by the Brundtland Commission (World Commission on the Environment and Development, 1987), many have called for urgent measures to reduce the environmental impact of human activities. A huge debate has followed (Daly, 1990), but small efforts have been made so far to design operational and logically consistent plans to “green” the society, and to reduce the impact of mankind on the ecosystem. The issue highly regards transportation projects: transportation is nowadays responsible for about one third of the total energy consumption (U.S. Department of Energy, 2006) and emissions of greenhouse gases in the atmosphere, and its share of energy consumption and pollutant emissions is increasing (U.S. Department of Transportation, 2007). Moreover, at least in most developed countries, transportation of passengers is disproportionately

directed toward the use of automobiles (Chapman, 2007), with an almost total dependence of private mobility on the combustion of fossil fuels (oil and/or natural gas). The dominant use of cars is the cause of the depletion of natural resources and of soil degradation and increasing urbanization, due to the construction of new roads and highways, and the increase in the capacity of other transportation facilities (Crawford, 2000).

From this perspective, the redefinition of policies for transportation in urban and metropolitan areas assumes immediate priority among the objectives for a reduction of the environmental impact of transportation. This relates to the definition of global strategies to green our cities, which must include interventions on both the land use and the transportation system. Their objectives must match an equilibrated and smart growth of new developments with the adoption of mass transit solutions, and the construction of roads and other transportation facilities in the already built areas.

Although several studies have investigated the relationships between land use and transportation, to date there is still little evidence concerning what the ideal settlement structure from the point of view of sustainable transportation would be (Greene and Wegener, 1997). The idea of linking the development of land use with an equilibrated development of transportation that is not dominated by the use of cars has inspired several movements in planning that aim e.g. to a *smart growth* (Handy, 2005) of the urban system, or to forms of *New Urbanism* (CNU, 1998). The common background is the awareness that urban areas featuring mixed land use and higher density, if properly designed in coordination with transportation, usually lead to higher efficiency in transportation and they reduce urban sprawl and environmental externalities (Newman and Kenworthy, 1999). The concept is similarly developed in the transit oriented development (TOD) of neighborhoods (Cervero, 1998; Dunphy *et al.*, 2005), in which many efforts are made to promote the use of transit. In the short term, TOD solutions maximize the benefits of the investments in public transportation, and support the increase in density, mixed land use and urban quality along the transportation corridors. In the long run, they cooperate in transferring travelers to public transportation, and they significantly limit the urban sprawl.

In these processes, the overall strategies for establishing less car-dependent settlements involve interventions to promote both public transportation and other environmental-friendly travel options, i.e. the non-motorized "soft mobility". Besides, they require the adoption of dedicated design for road and parking infrastructures. Some projects in many areas of Europe, North American and Asia have already achieved successful strides toward this objective.

An additional contribution to these successful projects may derive from the adoption of travel demand management (TDM) solutions, which reduce the demand for traveling by private vehicles (especially if directed towards "driving alone", i.e. the most energy intensive travel option), and traffic calming measures, which actively contribute to reshape the road network and the overall transportation infrastructures. With these objectives, efforts should be made to integrate major interventions on the transportation system, and coordinate the development of public transportation, i.e. subways, local and urban railways, light rail systems/tramways and bus services, with the development of the road network and of parking facilities. The design of parking facilities is expected to match these overall goals, to support the use of public transportation with an increase in the demand for transit, and to improve the efficiency of transportation (Black, 1981; Meyer and Miller, 2001). In such a multimodal system, the supply of the optimal amount of parking space is important. The right location and design of parking lots allows the proper development of the road network, and supports proper access for private vehicles and door-to-door service. However, oversupply of parking facilities negatively affects the use of transportation, increasing the attractiveness of the use of private vehicles, and increasing the modal share for cars in spite of the use of alternative means of transportation, and in particular of mass transit. Besides, an incorrect design of parking facilities concurs to an excessive consumption of the available land (either from natural undeveloped land, or subtracted from alternative uses), and weakens the geographical cohesion of the urban structure. Urban patterns with broad avenues and large parking facilities facilitate the use of cars, and reduce the accessibility for pedestrians and bicycles (as a result of the larger distances among blocks and facilities). They reduce the density of the settlements depowering the implementation of transit solutions. Moreover, overcapacity is often quickly absorbed by the market, through an increase in the number of cars on the road network, as an effect of the increased accessibility by car caused by the additional parking space, and as a consequence of the reduced accessibility with the other means of transportation.

Parking facilities in congested areas

Parking facilities include various solutions, ranging from the on-street parking (common in low-density residential areas and suburban neighborhoods) to conventional or underground multi-store parking facilities. These facilities can facilitate the access of users to terrestrial infrastructures (railway stations and bus terminals) if properly planned in a framework of multimodal transportation. Public transportation solutions often benefit from the presence of park and ride (P&R) facilities, in which the traditional

"walk-in" access of transit is complemented (if not completely substituted in suburban areas), by a "drive-to" access, increasing the area of influence of transportation terminals and local transit stops.

On-street parking, the easiest and cheapest way to provide parking space, is indeed land intensive. It subtracts important surface area from other uses, reducing the road capacity or narrowing pedestrian sidewalks and bike lanes. It is not well suited to provide sufficient parking space in high-density areas. Surface parking may be a good solution for suburban areas, where land is cheap and available in large amounts, and it allows creating surface parking lots close to the locations that originate the travel demand.

Structured parking is a more expensive solution, often chosen in central areas of the cities, where land is more expensive and scarce (Dunphy *et al.*, 2003). Structured parking facilities, either underground or in multi-store dedicated buildings, are significantly more expensive than surface parking, although their cost is often more than compensated by the reduced amount of land required for their construction, and by the potential revenues derived from the exploitation of the parking facilities. These parking solutions are usually located in the central areas of larger cities, in proximity of the Central Business District (CBD), or of important points of attraction as fairs, important transportation nodes (e.g. railway stations and airports), amusement parks, etc. They require huge financial investments, which are seldom justified by local demand in lower density areas, where cheap undeveloped land is available.

Time and costs associated with parking (generally collapsed into a comprehensive term, i.e. the generalized cost of transportation) relevantly affect users' behavior and the choice of travel options in the short run, and they contribute to the formation of long term preferences of travelers. From this perspective, the use of financial tools to regulate the access to parking may significantly affect the use of cars in urban areas: these tools can be used as part of an overall strategy to organize the transportation system, and their effects must be taken into account in the evaluation of the impact of transportation policies in the urban area.

Parking strategies in the city of Bari

The discussion on the implementation of parking strategies will now focus on some recent projects that were designed, and later developed, in the city of Bari (Italy). The interventions were part of various strategies pursued by the local administrations over a time span of almost 15 years (starting in the 1990s), in order to reorganize transportation in the central area of the city. Different strategies were proposed for this area, according to different visions of the future development of the city and of the surrounding metropolitan region. Such differences are revealed in the way parking facilities have been planned and designed.

Some elements of the organization of transportation and parking, which were mainly designed as traffic calming measures with a short-term horizon, are common to all packages of policies designed in this time span. However, a significant change in the policies to enforce was recorded because of a change in the actions of the local government, and as a consequence of a change of the political coalition leading the city council of the main center of the area, Bari, in 2004. The possibility of merging some of the different projects into a whole strategy that envisions a more integrated development of the transportation system is presented at the end of this section, when the topic of the definition of long-term strategies for the metropolitan area of Bari is discussed.

The use of structured parking at the end of 1990s

According to the 2001 census data, about 320,000 inhabitants live inside the administrative boundaries of the city of Bari. The total population of the metropolitan area of Bari, however, sums up to almost one million residents, with a total population of the province that exceeds 1.5 million. Important changes are registered in the demographics of the area: while the population of the central city of Bari has been mainly stable, if not even decreasing over the last 40 years, the smaller settlements surrounding the city have experienced a sharp increase in their population. Nowadays, many of the residents of the smaller towns in the metropolitan area commute to the central area of the city, with additional relevant traffic flows directed to other destinations, e.g. the industrial areas surrounding the city, and several commercial areas in the immediate proximities. The transportation system serving the area has not grown with the same pace though, and this has determined a significant increase of the congestion on the main roads and freeways of the region. Various local bus companies operate regular scheduled services connecting several destinations in the metropolitan area, while a publicly owned company runs the urban bus services in the city of Bari. National and local railways connect many centers, too, even if they do not serve the whole population of the region. However, the services provided on many secondary railway lines have lower quality of service than those offered in the municipalities served by the main railway parallel to the sea cost.

In order to reduce congestion and provide enough parking space to commuters, at the end of the 1990s the city hall of Bari promoted a huge plan of investments that involved the construction of several structured parking facilities in the city.

The plan was supported by the requests of the population for additional parking in the central area of the city, and supported by the lobbies of storeowners and retailers of the area worried about the declining revenues of their activities associated with the reduced accessibility by car and the difficulties of parking in downtown Bari.

The parking plan was developed as part of a global vision for transportation. This included parking fees for on-street parking in the central business district, the reduction or even elimination of on-street parking on the main branches of the road network, in order to reduce traffic congestion, and to increase the road capacity and commercial speed of vehicles to/from downtown. A sophisticated road pricing system regulating the access to a rather small central area of the city was designed, but never fully enforced. In the proposed solution, the access to a restricted area of downtown should have been regulated by the payment of a toll, similarly to the congestion charge projects developed in other areas (e.g. London and many other Italian cities) in the previous years. This would have generated additional revenues to finance transportation, and would have reduced the number of cars accessing the area.

Apart from the construction of some structured parking facilities in other areas (the most significant one serves the largest hospital of the city), the parking strategy focused on the central area of the city. It included the development of three main underground parking structures located under the main squares of the city. Two of these parking facilities were to be developed in the downtown, while another one should have been located under Giulio Cesare Square, in a semi-central residential and commercial area, which had faced increasing congestion in the previous decades.

The strategy behind the interventions was clear: the planning offices of the city hall aimed at reducing surface traffic congestion through the construction of a relevant number of parking spaces in the center of the city and relocating street parking in underground facilities. Part of the on-street parking on the avenues to access the area was eliminated, increasing the accessibility by car to the central area. The adoption of road pricing would have limited the access to a restricted area (almost one half of historic downtown), further reducing the traffic flows to this area, and making traveling to downtown more expensive (for the combined effects of the road pricing and the parking tolls). It would have reduced the volume of cars accessing the very central area of downtown, but caused additional congestion on the boundaries of the restricted area.

The plan relied on the use of car as the central element of the transportation system, with a calming effect on traffic due to the increased capacity of the road network and of the parking system, and the adoption of road pricing. Long-term interventions on transportation were poor or completely missing, thus undermining the stability of the plan in a long-term perspective. In the authorities' plans, the adoption of parking fees for on-street parking in downtown would have reduced the average duration of stands in downtown, thus further increasing the capacity for short-term parking. This should have stimulated shopping activities and the whole economic vitality of the area.

Indeed, the plan lacked of a comprehensive vision to the problem of transportation, and of sufficient support to the development of transit. Mass transit solutions were encouraged through the enhancement of the railway services on the north-south corridor, and the provision of additional local services on the same shared railway tracks run by the national railway company for intercity services. A new metropolitan railway line was designed for connecting the peripheral neighborhood of San Paolo. However, this would have entered into service only several years later.

Bus services remained almost unmodified. Unfortunately, a few dedicated bus lanes were converted into regular car lanes in the effort to speed up private traffic flows, with consequent reductions in bus speeds on some routes. Alternative non-motorized travel solutions, bikes and pedestrians, did not receive enough support, if not only marginally through the reduction of the on-street traffic volumes in the downtown.

The only exception to this trend was the complete closure of the medieval center of the city to private traffic. Even if more significant on a symbolic level than for its practical effects, due to the small traffic volume in the area, this project was a successful story of urban requalification, and it contributed to reshape the attitude of pedestrians and to revitalize the narrow streets and squares of this historic neighborhood. No other projects for the development of a bike lane network or for the enlargement of pedestrian areas in the other parts of the city were enforced.

The transportation and parking strategy designed during these years failed to meet their goals. In part due to some delays in the implementation of the system, and to the opposition of important groups of stakeholders among the population, the road pricing system never got into operation. However, most facilities for the collection of tolls and for the control of traffic flows in the area had been actually built before the project was abandoned. This caused a large waste of funds in a time of financial constraints for public investments, which further reduced the opportunities to develop alternative projects in the region.

Several technical issues in the construction of the underground parking facilities delayed their completion. This was mainly due to severe design flaws, in particular for the diversion of the underground water. Of the three main underground facilities that were planned, only one entered into service in the following years. The construction of a second one was significantly delayed, and its date of delivery was still uncertain at the time this paper was

published. The construction of the third large underground parking facility was never approved. This means that several years after the design of the facilities, only one third of the originally planned parking spaces were provided. In the meantime, the transportation strategies of city of Bari had been drastically modified.

An unpopular truth stands behind the failure of these plans. As in many other European cities, largely built in a time in which car ownership was quite limited, the road network of Bari was not able to support heavy traffic volumes. It was planned for small amounts of public transportation vehicles and pedestrians flows. No later interventions have significantly modified these conditions. Ironically, projects carried out in the second half of the 20th century even tried to reduce the width of sidewalks in order to increase road capacities. However, the city was never really able to substantially reduce its road congestion from car traffic. The ambition of the transportation and parking strategy developed at the end of the 1990s did not escape this trend. Bari was not supposed to become a totally car-dependent city.

Traffic calming measures at the beginning of the 21st century

A modification in the objectives of transportation planning took place few years later. This became more evident after the political elections of 2004, as a result of the change in the political majority leading the city council of Bari. This significantly modified the political agenda at the local level, and brought new priorities in transportation strategies.

The new course of local planning agencies developed a different strategy to address transportation issues in these years. This mainly related to the combination of private travel solutions with public transportation. The aim was pursued through the introduction of three new bus lines on radial routes to/from the downtown, which today serve “park and ride” facilities for inter-modal trips. Three large parking facilities were integrated in the network. A new surface parking lot was inaugurated near the city park Due Giugno in the southwestern part of the city. The plan included the use of two already existing parking lots on the North and on the South side of the city. The new lines were operated with modern buses (with a level of service above the average standards of the local bus company), and on a regular schedule with high frequencies on all three routes. A competitive fare allowed combined access to parking facilities and the bus service, with a resulting transportation cost far below the average of the other solutions to access downtown.

At the same time, the local government promoted the integration of alternative travel option solutions. They promoted the construction of new bike lanes, which were the first branches of a future bike network, and that connected the neighborhood of Carrassi, a semi-central high-density neighborhood, with the downtown area. Moreover, an ambitious plan of bike sharing (inspired by similar projects in cities like Vienna and Paris) started with a limited number of bikes available for local commuting trips at several locations.

Some of the solutions designed in the previous period were also confirmed. This is the case of the parking fee policies, which were extended to additional areas and now cover the entire city center. The fees make long term parking particularly expensive, in order to discourage the use of car for regular commuters.

Additional efforts were made to reduce congestion and deal with the scarcity of parking spaces in the central area of the city, with an increase in parking capacity. This goal was achieved through the completion of one of the underground structured parking facilities designed in the previous years. It included the design of another big surface parking lot not far from the main railway station of the city. This additional parking lot was quickly turned into operation to face the increased demand for parking in the central area of the city. The parking lot was built as a temporary facility on the land made available by the dismissal of a large military area (Rossani), located in a very central location. After the Army had dismissed the area, many projects for its redevelopment were proposed. Proposals included a large bus terminal, which would have increased the strategic role of the adjacent train station as the main multimodal transportation hub of the city. According to another proposal, the area was supposed to be converted to green areas and public space. This proposal received high interest also due to the location of the military area in a neighborhood with very limited amount of green areas.

Therefore, the construction of the parking lot on this portion of land determined a change in the plans for the future destination of use for the area. It was a (supposedly) temporary disruption to its redevelopment. This was only one of the issues arising in the transportation policies of recent years. An endemic bug appeared again: the focus on mid-term oriented actions in planning, with a dramatic lack of long term objectives for the future development of the city. This was evident in the transportation planning during the years 2004-2009: the case of the ex-military base was only an example of an area available for green areas and city parks (or, at least, for the construction of an important bus terminal) that was quickly converted, under contingent conditions, into a surface parking area.

The same lack of coherent choices occurred in the definition of mass transit priorities, particularly for one of the park and ride lines. The parking lot at the end of this line was located in the immediate proximity of a city park, on a portion of land that should have been

designated to an expansion of the existing park, in the semi-central neighborhood of Carrassi. This demonstrates a lack of forethought from the point of view of the efficiency of the system. It attracts additional private vehicles in a semi-central area, and causes more congestion in this neighborhood. Also in this case, the long-term impact of the new line was not carefully explored. A future extension of the line with the relocation of the park and ride facility far from the central areas was not envisioned. Similarly, the substitution of this congested bus line with a high capacity transit solution - a light rail system (*tramway* in Europe) to connect the neighborhoods of Carrassi and Carbonara with the downtown - has not been planned yet.

Although the planning offices have addressed the issue of the coordination with alternative mobility networks (in particular, the construction of bike lanes), these interventions to date remain very limited. In particular, the safety and the quality of the design of the bike network and of the bike intersections are still not enhanced enough. Technological and operational difficulties severely limited the success of the local bike sharing program: the lack of an efficient system to manage the access to the bike rental (e.g. a credit-card based system, as implemented in other European cities), has so far deprived this experiment from any success, failing to provide a steady source of revenues from the service, and limiting the access to the service to a very restricted group of registered users. All these elements of criticality reduced the quality of the adopted solutions. This was even more unexpected if taking into account the contemporary institution of the metropolitan planning organization (MPO) of the Metropoli Terra di Bari, with the duty of envisioning the future development of the metropolitan area, and of inspiring the planning process with strategic visions inspired by the principles of sustainability and of reduced environmental impacts of human activities. The non-linearity of planning actions is somehow also mirrored by the apparent confusion in the definition of the projects for the improvement of the road network. Behind the approval of several road construction projects, the overlap between primary and secondary links of the road network is often confusing. Some recent projects that duplicate not very useful road links, without eliminating the existing bottlenecks on the network, were witness to this. In summary, the planning process of these years resulted in a rather contradictory process. On one side, it worked on taking cars out of the central areas, and on reducing the travel dependence from private vehicles. On the other hand, it did not provide long-term solutions for urban mobility, in particular for commuters who do not want to commute by car, and who are not conveniently served by the new park and ride lines. The construction of the new surface parking facilities close to the central area has contributed to provide additional parking capacity in the immediate surroundings of the downtown. Thus, it encouraged traveling by car, and an even more car-dependent travel behavior.

Overall, still limited efforts to promote alternative mobility and to support mass transit have been produced. The proposed interventions, even if entailing a new era in the direction of the integration of private and public transportation policies, lacked of long term willingness to create lasting solutions, as part of an integrated strategy for steady sustainable transportation.

Long-term strategies for Bari

The experience of the last fifteen years of transportation and parking policies has demonstrated a general failure in dealing with the problem of reducing traffic congestion systematically. One feature is indeed missing in both approaches to transportation planning that have been described: the lack of a strategic vision for the development of transportation.

Many interventions have been proposed, and some of them have been developed, with contradictory orientations on the way to reshape the local transportation system. Even in the most recent years, in which a number of apparently connected projects have inspired the process of transportation planning, elements of contradiction still exist. The establishment of a metropolitan planning organization that should inspire strategic solutions for the growth of the city has not completely solved the problem. The first interventions proposed by the new strategic MPO have in fact not always gone in the same direction of the objectives that officially inspired them. The new authority for strategic planning has highlighted several interventions to implement in the future years. The need for further development of light rail projects and subway lines has been voiced. However, there is still an urgent need for consistent strategies aimed at a more sustainable mobility in the urban and metropolitan area, including several packages of policies as part of a unique vision for a modern, efficient and sustainable city. Among the priorities of such a plan is the upgrade of public transportation, with the investment in new mass transit solutions, e.g. subways and light rail systems. This could attract an increasing share of travelers, with frequent and reliable services that reach most destinations in the metropolitan area. However, the improvement of transportation also means a coordinated effort to support alternative mobility, with the extension and upgrade of pedestrian areas and bicycle paths, and their protection in designated intersection, and the eventual use of barriers to separate them from motorized flows. Additional efforts to make urban mobility more sustainable can be reached through the adoption of specific regulatory and financial policies, to support more

environmental friendly solutions, and make the "drive alone" travel solution less attractive. Parking policies play an important role as part of all these integrated strategies. Apart from providing the access to transit solutions, through the construction of dedicated parking facilities in the proximity of transit terminals, they can be used as a flexible tool to reduce the access of cars to specific areas. The choice of the location and the size of parking facilities, together with the policies with which parking lots are managed, become therefore extremely relevant for the success of the whole transportation strategy.

The simulation of parking policies through the use of integrated land use transportation modeling

The availability of advanced tools for modeling the evolution of the transportation system, and the interactions with the other activities in the urban area, provides important advancements in the evaluation of the outcomes from parking policies and strategies. Integrated approaches for land use and transportation modeling help to support the development of the planning strategies, through the estimation of the long-term results that derive from their implementation. The use of strategic models is particularly useful to simulate the joint development of land use and transportation in the metropolitan area. Land use transportation interaction models can conveniently simulate the interactions among the different subsystems of the territorial system, and their use has been successfully applied to test the long-term impacts of interventions on transportation infrastructure and services. In particular, the use of these models may be an important support for planning, in the definition of the strategies for the future governance of the city.

The development of the transportation and parking strategies for the city of Bari, presented in the previous paragraphs, for example, could be successfully assisted by the use of an integrated model, as the model MARS-Bari. MARS-Bari is a fast land use transportation interaction (LUTI) model that has been developed on the assumptions of the Metropolitan Activity Relocation Simulator (MARS) modeling system (Pfaffenbichler, 2003). The model was developed for applications on the metropolitan area of Bari, and it was applied to test several scenarios of development in the area (Circella, 2008). It is designed as a support tool for applications in strategic planning, and its simulations allow forecasting the future development of the city and of its metropolitan area with a time horizon of 30 years (in the current version of the model). The model is based on the assumptions of systems dynamics, and it works at a high level of spatial aggregation. It includes a transportation model and a land use model. The latter simulates the relocation of economic activities and of residences in the area of study. Feedback loops among the sub-models allow taking into account the interactions among the changes in land use and the modifications in the transportation system and in travel behavior (and vice versa). The transportation sub-model of MARS-Bari was designed in order to allow various tests of interventions on the transportation system. It simulates the travel behavior of the users and their mode share among all relevant means of transportation in the region (cars, motorcycles, public transport-railway, bus services, and "soft mobility" represented by pedestrians and bicyclists). Different scenarios involving the development of transportation can be tested in MARS-Bari. In particular, the long-term effects of transportation projects can be estimated in terms of their impacts on travel behavior, and the other modifications they induce in the system of the economic activities and residences.

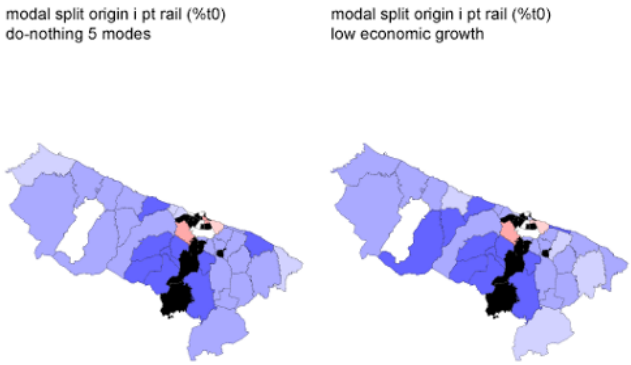
The transportation model of MARS-Bari is particularly suited to study the development of integrated strategies for transportation, designed according to a global vision of the future development of the city. The application of the model may assist planners in the fine tuning of such strategies: it would allow testing the results of their implementation, and checking the consistency of the proposed solutions with the aim of reducing pollutant emissions and the overall impact of transportation on the environment.

The transportation model of MARS-Bari allows evaluating the impact of such strategies on the travel behavior of users: it estimates the mode choice of travelers depending on the availability of private vehicles in each household. It identifies four main travelers' groups, depending on their access to private vehicles, which is defined in terms of possession of a valid driving license, and respectively of a car and/or of a motorcycle.

The effects of parking policies can be tested in the system through their impact on the friction factor for the use of car in the transportation and mode share sub-models. Specific projects of development in this field can be tested. Parking fee policies can be studied through the modification they determine on the attractiveness for the use of car for a specific trip from an origin *i* to a destination *j* in the metropolitan area.

The availability of parking in each zone of the system of analysis affects the use of car through the total parking capacity in the area, and the time needed to access a parking spot in the specific time of the day. The model allows testing specific parking policies, as the adoption of differentiated parking fee schemes for different parts of the day (e.g. for peak/off-peak), and differentiated fares for long term/short term parking. A subjective valuation factor is used in the model to correct the different amounts of time associated with the use of cars for the subjective perception e.g. of the walking time to access the car, the time spent in the vehicle, and the time spent to

find a parking lot. This allows a more realistic simulation of the choice behavior of travelers, and of the perception of the actual features of the choice alternatives. A similar factor measures the perception of costs for the use of car.



MARS-Bari forecasts of mode share under specific policies on the development of the transportation system

Similar functions are adopted for the use of motorcycles, with the important difference that parking is usually free for motorcycles (at least in the region of Bari), and that parking time is usually shorter.
The flexible cost structure adopted in the model allows testing several policies affecting the use of cars, as road pricing or the development of additional transit links in the region. Therefore the application of a similar model may considerably contribute to the development of transportation strategies in the area, as a way to test the outcomes from their implementation and from their future interactions with the other elements of the system.

Difference in the use of public transport in two future scenarios according the forecasts of the model

The model MARS-Bari was applied to several scenarios involving the adoption of specific interventions on transportation. The GIS interface of the model (shown in the figures) allows the users to represent the outcomes from the simulation graphically, e.g. in terms of numbers of trips originated from each zone, mode share, etc. Additional modules of MARS-Bari allow estimating traffic congestion in the different areas, and the levels of pollutant emissions due to transportation activities, in order to support the analysis of the environmental impacts and the level of (un)sustainability of the system.
The application of the model to specific scenarios that test transportation strategies with relevant modifications on the parking system is currently under development. The availability of the results of these simulations will contribute to the formulation of comprehensive transportation strategies, in order to integrate the local interventions on parking with the development of mass transit and the other interventions on the system, in a framework of improved and more environmental-friendly future transportation.

The role of parking in the future development of cities

This paper discusses the role of parking facilities in urban and metropolitan areas with the aim of analyzing how parking facilities can nowadays play an important role in the definition of packages of policies for sustainable transportation.
Parking infrastructure is an important element of the transportation system: they are a necessary support for private mobility, and a major element of more complex multimodal systems of transportation. In this paper, the organization of parking facilities is discussed from the viewpoint of the enhancement of sustainable transportation solutions. The contribution is based on the awareness that the determination of the optimal amount of parking space for an urban settlement is not a trivial task. The supply of insufficient parking space has negative effects on the environment, especially in presence of poor services offered by mass transportation, due to the increase in congestion on the road network, and the consequent increase in pollutant emissions.
An overcapacity of parking facilities contributes to increase congestion, since it induces additional travel demand and increase the attractiveness of the use of private vehicles. Moreover, in the long run, low density settlements with large parking space produce less pedestrian- and transit-friendly environments, with an overall decrease of environmental quality.
In the paper, the topic of the definition of parking policies in high-density urban areas is outlined with reference to some recent projects implemented in the city of Bari (Italy). From the analysis of the outcomes of such projects, the discussion moves to the

potential integration of parking policies into more comprehensive strategies for urban transportation.
The possibility of estimating the results of the implementation of such integrated strategies in long-term scenarios is then presented with regard to the use of a land use integrated model, MARS-Bari. This offers the possibility to estimate the long-term outcomes of the implementation of such policies, and to support the definition of the best suited interventions to include in such strategy.

Note

An earlier version of this paper was published with the title "Envisioning Parking Strategies in the Framework of Sustainable Urban Transport" on TeMA - Territorio Mobilità Ambiente, Vol. 2, Issue 1, in March 2009.

Acknowledgement

The strategic land use transportation model MARS-Bari described in the last section of this paper was developed at the Technische Universität Wien (Austria) with the important support of Paul Pfaffenbichler.

References

Black, J. (1981). "Urban Transportation Planning". London, Croom Helm.

Cervero, R. (1998). "The Transit Metropolis. A Global Inquiry". Washington DC, Island Press.

Chapman, L. (2007). "Transport and climate change: a review". Journal of Transport Geography 15(5): 354-367.

Circella, G. (2008). "Integrated Land Use and Transportation Modeling for Sustainable Transport Solutions". Doctoral dissertation, Bari, Italy. Politecnico di Bari.

CNU (1998). "Charter of New Urbanism". from http://www.cnu.org/.

Crawford, J. H. (2000). "Carfree Cities". Utrecht, International Books.

Daly, H. (1990), "Toward Some Operational Principles of Sustainable Development", Ecological Economics, 2,1-7.

Dunphy, R., D. Myerson, M. Pawlukiewicz (2003). "Ten Principles for Successful Development Around Transit". Washington D.C., Urban Land Institute.

Dunphy, R., R. Cervero, F. Dock, et al. (2005). "Developing around Transit: Strategies and Solutions That Work". Washington, D.C., Urban Land Institute.

Greene, D. L. and M. Wegener (1997). "Sustainable transport". Journal of Transport Geography 5(3): 177-190.

Handy, S. (2005). "Smart Growth and the Transportation - Land Use Connection: What Does the Research Tell Us?" International Regional Science Review 28(2): 146-167.

Meyer, M. D. and E. J. Miller (2001). "Urban Transportation Planning". New York, McGraw-Hill.

Newman, P. and J. Kenworthy (1999). "Sustainability and Cities: Overcoming Automobile Dependence". Washington, DC., Island Press.

Pfaffenbichler, P. (2003). "The Strategic, Dynamic and Integrated Urban Land Use and Transport Model Mars (Metropolitan Activity Relocation Simulator). Development, Testing and Application". Doctoral Dissertation. Vienna, Austria, Technische Universität Wien.

U.S. Department of Transportation (2006). "Transportation Air Quality". Selected Facts and Figures.

World Commission on Environment and Development (1987). "Our Common Future. Bruntland Report". Oxford University Press.