



THE ROLE OF PUBLIC TRANSPORT IN THE ACHIEVEMENT OF URBAN SUSTAINABLE MOBILITY IN MID-SIZED CITIES

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ABSTRACT

Mid-sized cities or villages often have important issues associated with the relation between demand and supply of transport, due to its own spatial dimension and also due to the territory sprawl derived from years of deficient land use planning. Traditionally, public transport was mainly designed to cover and serve the entire municipality, giving a rural character to this service. Presently, some of these cities are sufficiently large to support the adoption of an urban public transport. The main question is how to create a public transport service in mid-sized cities integrated with the existing transport and parking system, so that more sustainable patterns of mobility can be achieved. For this purpose, a case study will be presented regarding the creation and planning of an urban public transport service for the city of Barcelos, located in Northern Portugal.

1 INTRODUCTION

Mobility can usually be associated with the circulation of people and goods in a certain area. However, this is a very limited and straightforward vision of this issue, since mobility encompasses not only the circulation function but also other functions that take place in an urban place, such as access, living and place functions, bringing complexity to the transport system. Over time, cities have been developed mainly through a car-orientated planning and as a direct consequence public spaces have been conceived and occupied to accomplish the needs and expectations of drivers.

Thus, current urban transportation planning is a very complex exercise, especially when the goal is the achievement and fulfilment of urban sustainable development principles. As the cities grow to a certain level of urban specialization and segmentation, the role of urban human activities assume an important position on transport planning, especially in what demand is concerned. Mid-sized cities or villages often have important issues associated with the relation between demand and supply of transport, due to its own spatial dimension and, in some cases, also due to the territory sprawl derived from years of poor or deficient land use planning. At the time, public transport was mainly designed to cover and serve the entire municipality, giving a rural character to this service, mainly in terms of frequency and type of buses.

In mid-sized cities, the creation and development of an urban public transport service was, for a long time, considered inappropriate for economical reasons. Presently, some of these cities are sufficiently large to support the adoption of an urban public transport system, especially with the increase of surrounding neighbourhoods and the maintenance of the

main services in the city centres. The main issue refers to the creation of a public transport service in mid-sized cities, integrated with the existing transport and parking system, so that more sustainable patterns of mobility can be achieved.

In this paper, a methodology will be presented on the implementation of a public transport service in a mid-sized city, based on the diagnosis of the existing situation of the transport system, as well as on the structure of the city territory and respective land use. Various scenarios could be feasible to achieve a more sustainable urban mobility, yet this research will focus on the main aspects that must be taken into account on the design of a new public transport service, mainly in terms of time and space scales, as well as in the impact and main benefits for citizens, transport companies and politicians.

For this purpose, a case study will be presented regarding the creation and planning of an urban public transport service for the city of Barcelos, located in Northern Portugal. The predicted impacts on the overall transport system of the city will be discussed, where it will be possible to perceive the central role that an urban public transport service can have on the improvement of the quality of life of the inhabitants of the entire municipality.

The definition and establishment of urban service quality thresholds will be described, which could possibly be adopted by private companies, as a means to offer better conditions even for rural public transport services.

2 PROMOTION OF PUBLIC TRANSPORT IN MID-SIZED CITIES

2.1 The role of urban collective public transport systems to achieve sustainable mobility in mid-sized cities

The application of the main principles of sustainability in mobility should comprise community liveability, environmental protection, and social and economic equity, which are represented in Figure 1, together with the three main pillars of sustainability of environment, equity (society) and economy established by WCDE (1987).

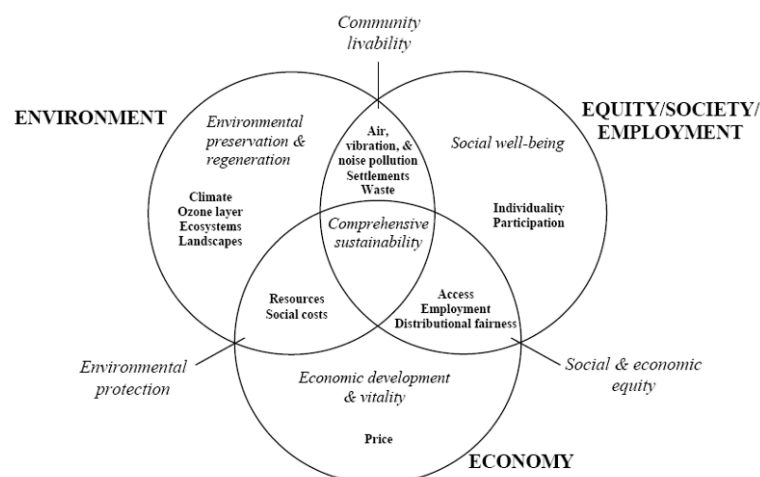


Figure 1 – Visualization of the three E's of sustainable transportation (Hall & Sussman, 2006)

However, sustainable mobility should not be centred in an isolated sector perspective, but

integrated with other systems. According to UITP (2009) there is a virtuous circle between integrating public transport and urban planning that can be referred to the physical integration of different land uses with transport services, to the integration of strategies, policies, administrative entities and disciplines, and to the coordination between public and the private sector.

The benefits of the integration of urban planning and public transport are numerous. Integrating public transport can lead to an improved quality of life, socio-economic development and urban renewal. In many cases, a public transport upgrade is actually the prime impetus for the revitalisation of an urban area. This integration also enables higher density development which has positive benefits for the environment: more efficient land use, higher energy efficiency and related savings, reduced pollution, climate change mitigation and protection of open space through smarter growth patterns. From the urban economic point of view, transport costs for compact development around public transport are generally lower than for car-dependent development. At least, the integration of urban planning and public transport has an effect on mode choice, i.e. well-designed areas where sustainable modes are given priority are characterised by higher public transport use and lower car use. From the social point of view, mobility brings social inclusion and for that public transport can contribute both to social inclusion and economic development by providing access to jobs. A key challenge for public transport to effectively play this role is to connect poor neighbourhoods at the fringes of the cities with areas where job opportunities are. (Ferraz *et al* 2004, UITP, 2007, 2009). On the other hand, it is important to enhance the negative influence that private cars have in the occupancy of the urban public space and in traffic congestion, which can be minimised by the use of buses and soft modes of transports (Vuchic, 2000).

In the Green Book – Urban transports (EC, 2007) in the definition of more accessible public urban transports, it was settled that accessibility is very important to achieve high levels of urban sustainable mobility, but accessibility not only means the access to the infrastructure of the urban public transport, but also to the urban mobility system. On other hand, the expectations of European citizens towards public transport are centred in the service of their necessities in terms of quality, efficiency and availability, in order to have a better urban public service, more competitive with car usage, and consequently a more suitable and sustainable urban mobility.

2.3 The methodology to create and implement an urban bus service

According to the Portuguese Environmental Agency (APA, 2010) there are several aspects that restrict the mobility of population leading to lower patterns of sustainable mobility. One of these factors is the deficient spatial and temporal coverage of the collective transport systems that is directly associated with the main use of private cars to satisfy the basic mobility needs of the populations. This situation becomes even more pronounced in sprawled territories with urban networks characterized by a reduced demographic weight of their centres and a progressive aging of the population, mainly in the countryside. For that reason, in this paper the implementation of an urban bus service will be presented, promoting the use of public transport in cities where the main policies are predominantly orientated for the use of private cars.

Usually, buses are the major collective public transport systems in Portuguese mid-sized cities due to its great service flexibility, in some cases almost door-to-door service, and the

associated lower infrastructure and management costs, especially when compared with railway solutions. According to the methodology developed for low density urban areas presented in the Sustainable Mobility Project (APA, 2010) the introduction of an urban collective transport should be based on four connected and complementary phases, presented in Figure 2.

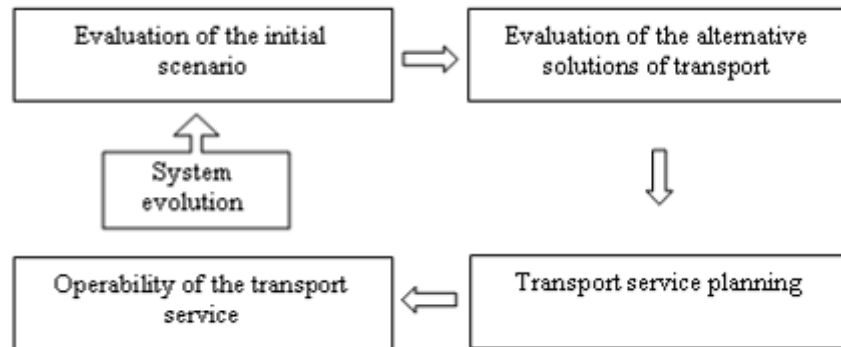


Figure 2 – Methodological approach for the implementation of a collective transport in urban low density areas (APA, 2010)

The first phase is similar to a diagnosis and should include the characterization of the territory, population, socio-economical analysis, urban networks, main trip generators, principal routes for different modes of transport, transport supply, among other issues. The second – evaluation of alternative of transports – should mainly have three vectors: i) the identification of the main issues and restrictions in urban mobility; ii) the definition of the main objectives of the solution to be adopted; iii) the identification of the main action for implementing the solution. The third phase – transport service planning – is the key factor of this methodology, which should be based on the definition of the service characteristics, exploration model, organization framework, fleet and main human resources to be allocated. Finally, the last phase consists in the development and implementation of a monitoring and evaluation system for the collective transport service.

3 CITY CASE STUDY OF BARCELOS

3.1 Mobility management of the city of Barcelos

The mobility system of the city of Barcelos has several issues that can be easily identified, namely the lack of connectivity between the main transport facilities and its central area, as well as parking management issues related with the offer of a high number of parking spaces next to the historic centre, more specifically in *Campo da República*, usually known as *Campo da Feira*, the city’s marketplace. On the other hand, the service provided by public transport (mainly buses) is oriented for inter-parish and, sometimes, inter-district council trips, which do not fulfil the specific needs of urban passengers mainly in terms of buses and frequencies. Thus, it is important to study the implementation of an urban bus line to suit the expectations of urban passengers, since private cars are the principal mode of transport used on daily trips, instead of more sustainable modes like public transport, walking and cycling.

The main guidelines for the definition of the concept and intervention objectives concerning mobility management towards achieving a more sustainable transportation system for the city of Barcelos are (Mendes et al, 2008): i) gradually adopt multiple and

innovative mobility solutions, as far as possible; ii) adopt parking policies compliant with more sustainable transport policies; iii) assume and explore the importance of public transport in the overall mobility system; iv) assume the status of a city belonging to the “National Network of Cities and Towns with Mobility for All”.

Mobility management in short and mid-term in the city of Barcelos will comprise a political integration of four key action lines, which are: i) parking management in the central area of city; ii) creation of a purely urban system of public transport (buses); iii) articulation of the transport system with the main transport interfaces, along with park-and-ride solutions; iv) improve accessibility and circulation in the central area, especially for disabled people, by removing parking from the Campo da Feira – the marketplace – together with an urban requalification in this area.

In Figure 3 is represented the scheme of interventions that could be carried out to promote a more sustainable mobility. From this map, it is possible to understand the level of interconnection between the various solutions proposed. The isolated application of the key actions may strongly affect their success. However, it is important to emphasize that its application, simultaneous or in stages, will lead to a effective protection of the city centre from private cars, as well as to the promotion of more sustainable modes of transport, such as the pedestrian ways and public transport of passengers, which could contribute to change the current patterns of mobility in the city of Barcelos.

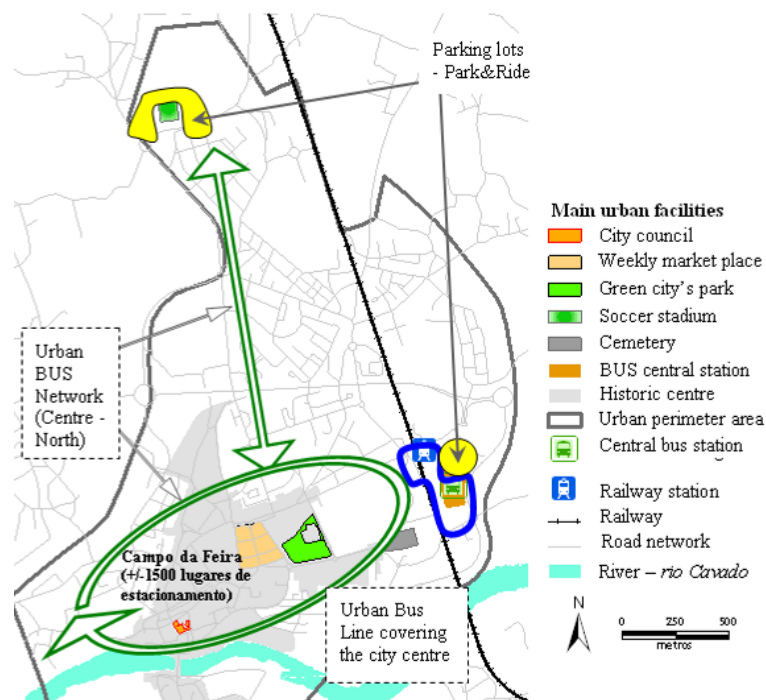


Figure 3 – Schematic representation of the proposed intervention

3.3 Parking management in the central area of Barcelos

To ensure economic development and to improve quality of life in urban areas, it is necessary to optimize the use of the parking system of the city, through a strong control on parking supply and demand. The simplest way to proceed implies the use of mechanisms of parking control, conventionally used in the definition of parking policies, namely: provision of different types of parking places; spatial location of parking places; conditions for access to parking places; and, definition of parking fees.

In 2006, the Municipality envisaged a strong intervention in the parking system of the central area of this case study, by controlling and regulating the supply of parking places in the area of Campo da República, of approximately 1500 places. This situation represented a huge number of free non-regulated parking, associated with a strong negative visual impact on streetscape, especially due to the location of this area in the historic city centre. Additionally, there were a reduced number of paid parking places (car-parks and streets), mainly located at the major streets around the historic centre to promote parking turnover, as shown in Figure 4.

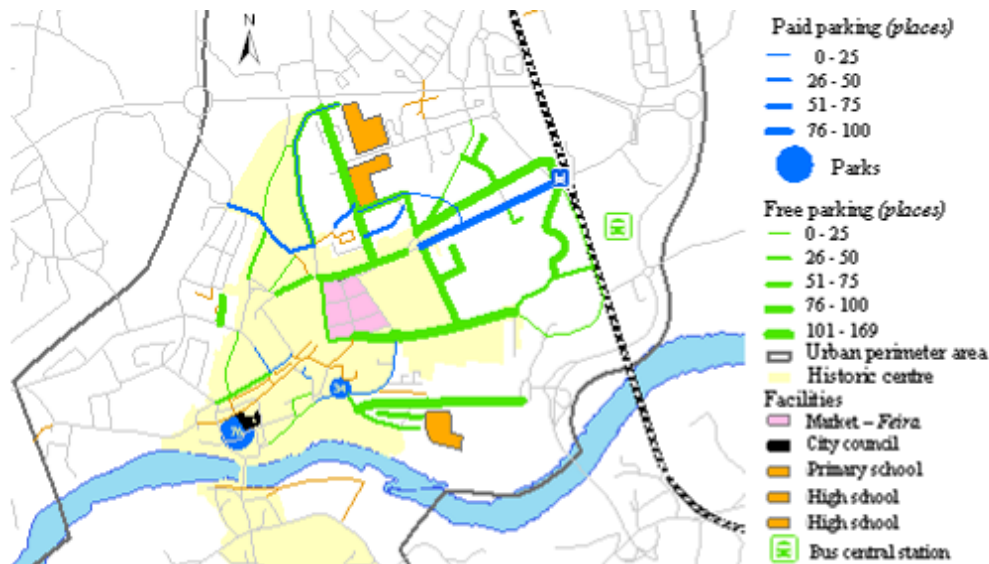


Figure 4 - Provision of parking in the central area of the city of Barcelos

To solve this issue, parking forbiddance was proposed in the surface park – Campo da Feira – which should be replaced by an underground car park at the same location, with a capacity of about 800 stables, together with the implementation of paid parking on several streets located on the surrounding areas. It was expected that this measure would have a serious impact on car drivers who use the Campo da Feira to park on a daily basis, since the offer in the area would be reduced by about 500 places, besides being paid.

However, this would certainly have a major impact in changing the current patterns of mobility of the transport system of the city of Barcelos. Thus, it was necessary to increase the alternatives to private cars, for people who regularly use this area to park, namely by improving the public transport service.

3.4 Urban bus line proposal for the city of Barcelos

Regardless of the implementation of the proposal for reorganizing parking management in the city centre of Barcelos, the introduction of a purely urban transport system allows to minimize the weaknesses of the local public transport service provided by the existing operators in this area. This service may also help to promote a transfer of private car users to a more sustainable mode (buses), especially for the home-work and home-school commuting trips. The case study area comprises the area located in the north of the river Cávado and represents the urban perimeter of Barcelos, constituted by the parish of Barcelos and part of the parishes of Vila Boa and Arcozelo, as illustrated in Figure 5.

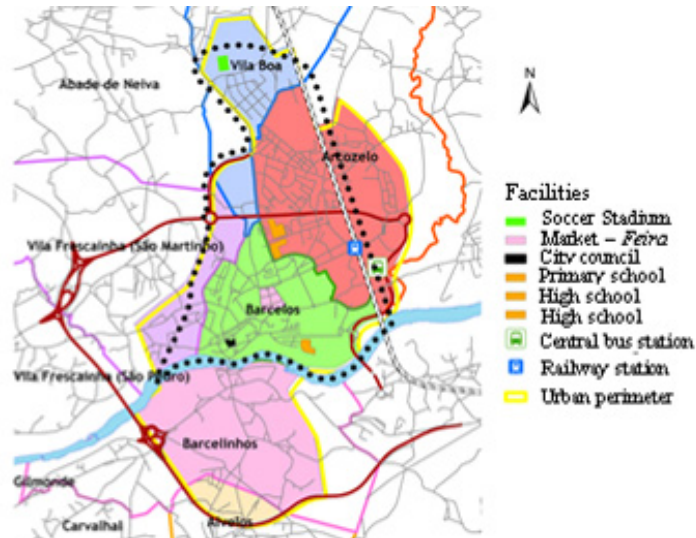


Figure 5 - Definition of the area covered by the urban transport of Barcelos

This area is characterized by a consolidated urban continuity centred on the parish of Barcelos and its historic centre and with a predominant occupation of commerce and services, while the areas of the parishes of Arcozelo and Vila Boa are mostly residential. Thus, it is expected that the residential areas act as powerful trip generators and the parish of Barcelos act as a trip attractor, due to the nature of the equipment located therein, such as the city council, court, finances, weekly marketplace - Campo da Feira, hospital, major schools, major cultural facilities, public library, cemetery, among others.

From Table 1, it can be observed that the volume of trips undertaken in the parishes belonging to the urban perimeter (UP) of Barcelos is only about 4% of the annual volume of trips in the Municipality. However, this value will be settled as the benchmark to indicate the minimum amount of trips expected for proposed future urban transport service.

Table 1 – Origin/ destination trips in the parishes of UP (Mendes et al, 2008)

Parish (O/D)	Trips per year	
	Number	Percentage
Arcozelo	26 877	2.2%
Vila Boa	23 587	1.9%
Barcelos	4 639	0.4%
Others	1 193 878	95.6%

The following charts (Figure 6) present the behavioural patterns of the current bus users with origin, or destination in the central area of the city of Barcelos.

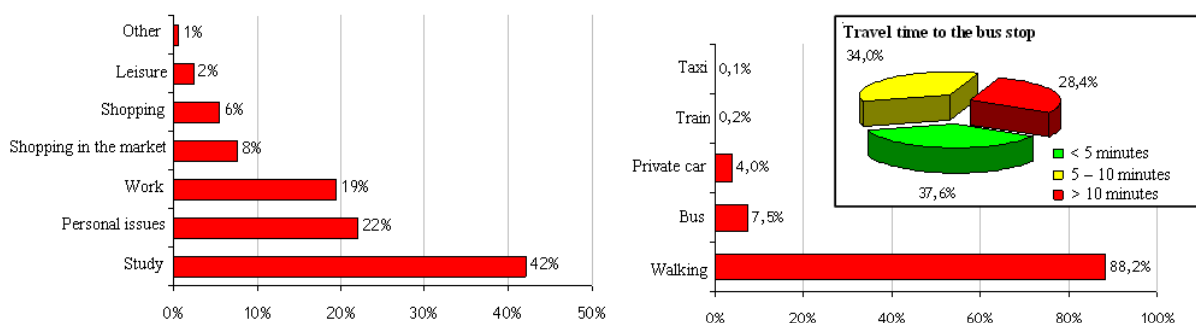


Figure 6 - Behavioural patterns of the current bus users of Barcelos

From these charts it is possible to highlight that the majority of passengers use the bus to travel to school, moving on foot and in less than 10 minutes to the bus stops. On the other hand, it was found that about 82% of inquired passengers commute (GBN, 2006).

In the diagnosis phase of the Sustainable Mobility Plan for Barcelos, it was possible to define the main weaknesses and threats of the current bus service (Mendes et al, 2008):

- lack of an urban transportation system serving the urban perimeter of Barcelos;
- rural character and municipal coverage, especially among the parishes;
- poor time coverage with a strong concentration at the peak periods of schools, since about half the bus users are students (GBN, 2006);
- poor spatial coverage in the north-south axis, in opposition to east-west axis (Braga-Barcelos-Esposende).

Planning and design of an urban bus line for Barcelos

One of the main aspects in the creation of a bus line is the definition of their adequacy to the real needs of the population, especially for major residential areas, and its connection with the principal facilities of the city, essentially located in the city centre.

The bus service to the city of Barcelos should be oriented by the following objectives:

- lines should serve the main residential areas of the city
- lines should provide the link between the main trip generators, such as municipal services (e.g. C.M. Barcelos), health equipments (e.g. Hospital), leisure and cultural facilities (e.g. Town Park and marketplaces), main transport interfaces, among others.
- bus stops should be located near the main facilities of the city and additionally should intersect the main pedestrian routes
- bus stops should be accessible for distances of less than 250 meters, so according to the topography of the city should correspond to a walking time of less than five minutes.
- lines should enable the passengers to transfer to other city lines (if they exist), as well as to local and regional lines plus to other modes of transport such as train;
- lines should enable park-and-ride solutions.

According to these objectives, three bus line proposals for Barcelos (Figure 7) will be presented, guided by the scheme presented on Figure 3, *i.e.* an urban bus service should always be assured in the centre and north of the urban perimeter.

The blue line service is based on a single route that serves different trip generators in one journey. However, the main drawback is its extension that requires a travel time of about an hour to complete one journey, since it is predicted only a one-way trip. Moreover, this line does not cover all residential areas located in the western side of Barcelos.

To reduce the impact related with time travel and spatial coverage on passengers, two other proposals were developed, with an urban bus service based in two lines.

The second proposal is composed by two lines - red and green - standing in two complementary types of services. The red line was conceived to provide a fast connection from the centre to the northern end of the urban perimeter, where the municipal stadium and a large car-park will support a future park-and-ride system at this location. Moreover, it will serve some residential areas near the city centre. The green line was defined to

complement the red line service in the central area of Barcelos and some residential areas located in the North. According to the plan of Figure 6, it is possible to observe some overlap of services by the red and green line. Moreover, it enables greater travel mobility since it has two points of possible transfer between the two lines at the Campo da Feira and at the residential area in the North.

Finally, the third proposal was thought to completely separate the service in the central area where the main equipments and some important residential neighbourhoods are located, from the service orientated to the northern areas, mainly residential. Regarding the red and green lines, this proposal only has one possibility to transfer passengers between the yellow and grey lines at the Campo da Feira.

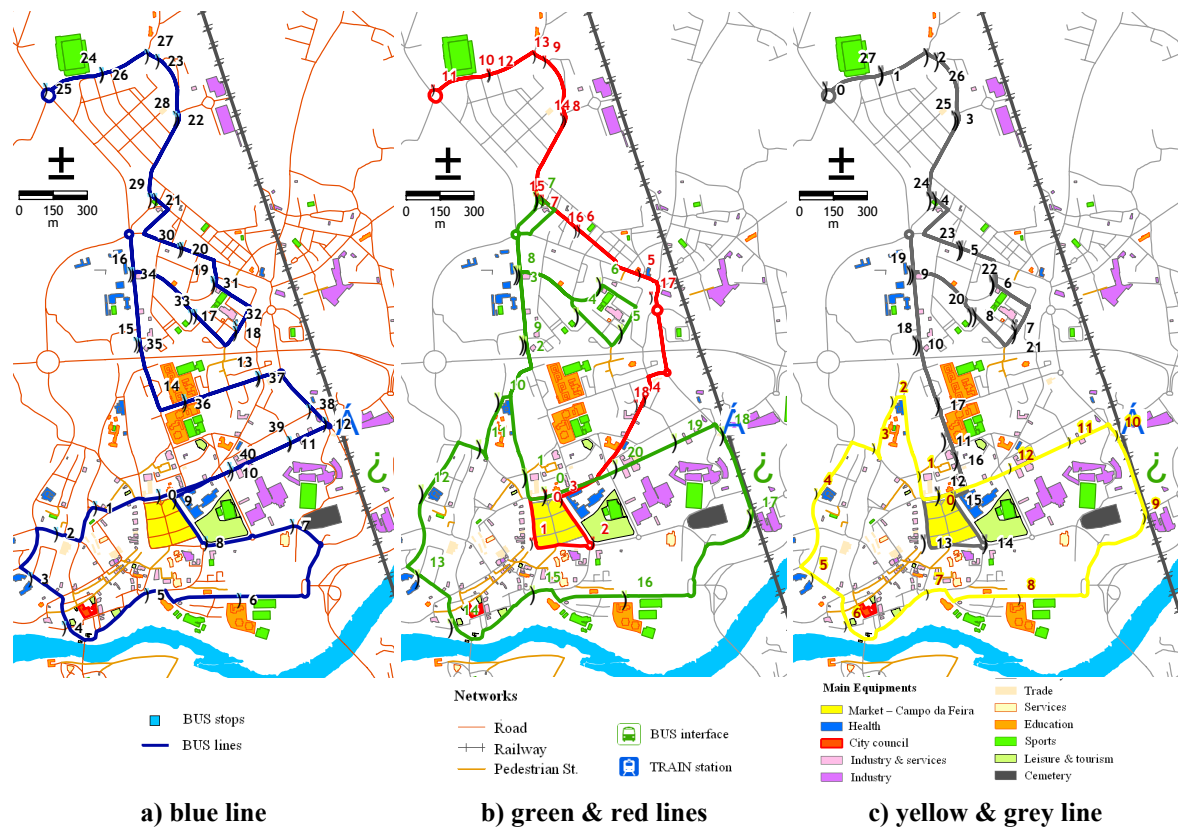


Figure 7 - Route and stops on the lines of the urban transport of Barcelos

Characterization of Bus Lines

The evaluation of the spatial coverage of the three proposed lines for the case study area provides a good characterization of the service availability for all citizens, and for this purpose the following indicators were used:

- Total length of the bus network (sum of distances of the lines with overlap)
- Total length of the bus axial network (no overlap)
- Spatial coverage rate (extension of the bus axial network/ area of the urban perimeter)
- Coverage of the road network index (extension of the bus axial network/ extension of road network)
- Spatial coverage index (area served by bus/ area of the urban perimeter)
- Population coverage rate (area served by bus/ area of the urban perimeter)

In order to determine the indicators, it is necessary to evaluate the area served by the lines. Thus, considering that the entries and exits of passengers must take place only at the stops, it was possible to assess the area of influence, which corresponds to a distance of a 5 minutes-walk to the bus stops, clearly shown in the cartograms of the Figure 8.

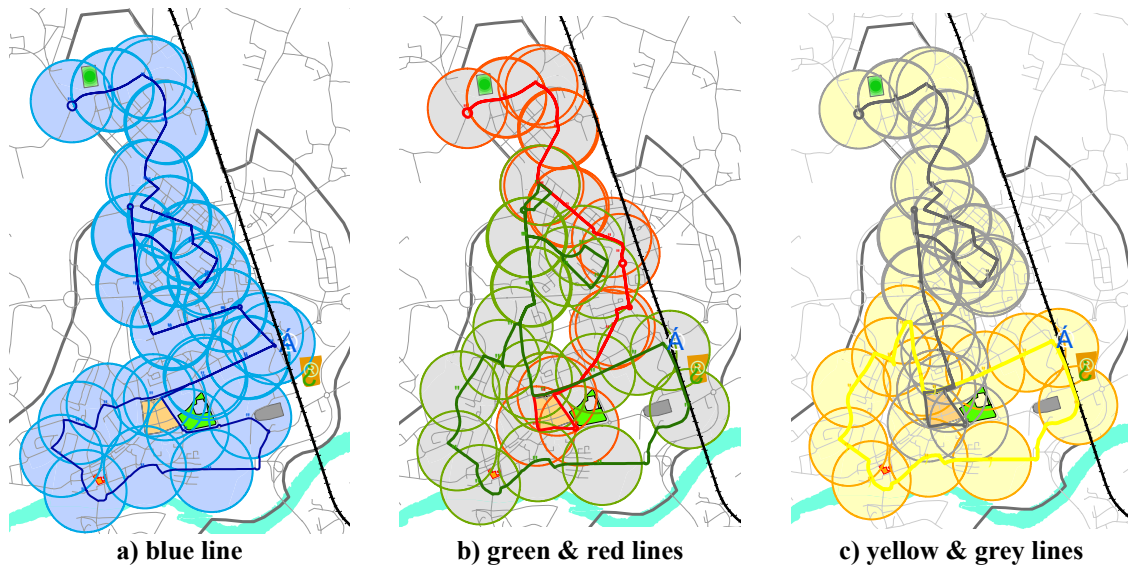


Figure 8 - Area of influence of the stops (for a radius of 250m)

In Table 2, it can be seen that almost all indicators of the service provided by the grey & yellow lines are very close to those of the green & red lines, but with a lower route length, of about 1.5 miles, which could represent a significant lower consumption of energy and operating costs per year.

Table 2 - Performance indicators of the proposals

Urban Bus Lines - Proposals	Length of the bus network	Coverage of the road network index	Spatial coverage index	Spatial coverage rate	Population coverage rate
	km	-	-	km/km ²	km ² / 1000hab
blue	14,30	0,13	0,69	2,16	0,145
green & red	15,63	0,17	0,78	2,78	0,163
yellow & grey	14,16	0,15	0,75	2,43	0,158

The study for the creation of an urban transport (bus) system implies the knowledge or the estimate of the number of users throughout each route, i.e. the number of passengers per line, in order to enable a viability economic study for the bus service, taking into account that the "recipe" has some uncertainty over time and city space. In another words, it is necessary to assess the potential demand for each bus line. In Table 3 are presented some demand indicators for the three proposals.

Table 3 - Performance indicators of the proposals

Urban Bus Lines - Proposals	Influence Area	Covered Population (Production)	Families	Homes	Residential buildings
	km ²	Inhabitants	nr	nr	nr
blue	2,909	17217	5538	6944	2026
green & red	3,285	19343	6200	7714	2437
yellow & grey	3,167	18227	5857	7318	2271

It is also necessary to establish an estimate of the number and types of buses to affect to each bus line. For that, indicative values were computed for the minimum bus fleet required to provide and ensure a frequency between successive vehicles of 20 minutes at peak-hour and of 40 minutes off-peak periods, as shown in Table 4.

Table 4 - Minimum number of buses per line

Urban Bus Lines - Proposals	Length of the bus line	Time	Minimum number of buses	
	(km)	(minutes)		
Blue	14,500	54,375	3	3
Green	7,900	29,625	2	4
Red	7,200	27,000	2	
Grey	9,200	34,500	2	3
Yellow	4,900	18,375	1	

Note: the commercial average bus speed adopted was 16km/h.

Finally, the bus service to the city of Barcelos should operate on daily basis between 6:30 am and 21h30m. In specific situations related with the increase on demand, a strengthening of the bus supply may be set, such as in the days of the weekly market, as well as a decrease in frequency during the weekends, allowing for some flexibility and adjustment capacity to the demand to the public transport system of Barcelos. Timetables should be proposed by the operator in agreement with the municipality and transport authorities.

Another aspect considered in the comparative study for the three proposals refers to the type of vehicles to be used: large and small vehicles. Moreover, for all proposals comparisons were made for different fuel options, namely diesel and other cleaner energy sources (natural gas and electricity). One of the main conclusions is that diesel vehicles have a much lower purchase price than the more environmentally-friendly solutions and that the investment made in its initial acquisition, either for the natural gas buses or electric minibuses, cannot be recovered within a few years. Thus, the adoption of a fleet of vehicles that use less polluting energy sources reflects a lack of economic sustainability of the proposals, forcing a further subsidization of the bus service by municipalities.

3 CONCLUSIONS

The proposals herein presented represent a set of structural and functional interventions in the current transport system in the area of the urban perimeter of Barcelos taking into account sustainable development principles applied in more susceptible urban areas in terms of social, economic and environment issues. It should be noted that these actions should not be separately applied so that the recommended solutions are fully functional, integrative and justified. The proposals consist in the organization and management of the parking of the central area of the city of Barcelos, through the elimination of 1500 free informal parking spaces, replaced by an underground paid parking at that location, with a capacity of 800 places. Given the chance to introduce a real modal shift in the city, a system of peripheral car-parks was presented, which allow for the introduction of Park & Ride policies in the current transport system, while strengthening the public transport system. On the other hand, an extensive study for an urban bus service was described, mainly to serve residents studying or working in the northern urban perimeter.

The study included mainly the production of three possible proposals for the urban bus service, consisting of one or two lines. For each proposal, a set of bus stops was defined, which distance each other about 400 meters on average, allowing almost all the inhabitants located in the north area of the urban perimeter to be less than 5 minutes away. In addition, a spatial coverage, frequency and potential demand study was developed, which allowed to conclude that the blue line had a lower coverage, whereas the proposed two red and green lines had the greatest network extension covered, as well as the higher spatial and population coverage rates. A frequency of 20 minutes for peak periods was previously adopted, resulting in a minimum fleet of 3 to 4 buses per line.

In sum, the collective public transport in mid-sized cities usually consists of the bus service which should be promoted to the commuting population. However, the service offered is usually weak, inadequate and is rarely exclusively urban. In those cases, the best way to promote sustainable patterns of mobility is the creation of an urban bus service, together with measures restricting private car usage, namely by parking regulation policies.

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