SUSTAINABLE MOBILITY IN A MID-SIZED CITY – A MULTIMODAL APPROACH

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ABSTRACT

Transportation systems of mid-sized cities play an important role in guaranteeing a sustainable development of the surrounding areas. Sustainable principles applied to the study of urban mobility involve the consideration of all different travel modes, as well as the territory where all modes interact and establish points of connection. Consequently, a multimodal approach is necessary, especially to encourage a more effective and sustainable use of the system and to promote greener modes of transport, like pedestrians and cyclists, or other less pollutant modes.
The paper presents a case study on the city of Viana do Castelo, which is located in the North of Portugal with approximately 37000 inhabitants in 33.6 square kilometres. It is considered a mid-sized city with a large number of different transport modes, namely trains, buses, ferryboats, cyclists and pedestrians, which provide an opportunity to develop and apply a multimodal approach towards a more sustainable city environment.

1 INTRODUCTION

The mobility concept is usually associated with the circulation function provided by a street network to a certain area. However, this is a limited vision, based on the traditional theories of functional classification of road networks. This approach has been changed to a broader point of view, which considers that the circulation and accessibility functions are not the only two principal functions to be used in the study of urban street networks. New trends on this issue have highlighted a new set of functions for streets or groups of streets, such as the link and place functions, which include a much larger number of street users, such as drivers, pedestrians, cyclists, residents and others.

This new perspective of the role of a street per se and within a street network, considering the application of the sustainability premises presented in the Brundtland report in 1987, has strongly influenced the way urban transportation in an infrastructure should be treated in the present and what citizens should expect from it in the future.

Transportation systems of mid-sized cities have an important role in guaranteeing a sustainable development of the city and, in a broader sense, of the whole region, since the system is open and interacts with other cities, as well as the surrounding rural areas. In this paper, the management of an urban transport system will be presented and discussed, considering its major urban district and the whole city area.

The application of sustainability concepts on mobility planning of a mid-sized city has to

take into account the premises of urban sustainable standards, related with spatial equity in time, the minimization of the use of non-renewable natural sources, the viability, vitality and economic diversity, the individual and community well-being and finally the satisfaction of human basic needs. All of these principles applied on the study of urban mobility embrace the consideration of all different modes of transport and its users, as well as the territory where all modes interact and establish points of connection. Consequently, a multimodal approach is necessary, especially to encourage a more effective use of the system and to promote greener travel modes, or other less pollutant modes.

The paper presents a case study on Viana do Castelo, a mid-sized city with a large number of different transport modes like trains, buses, electric buses, trams, ferryboats, cyclists and pedestrians. This provides an opportunity to develop a multimodal approach for the management of the transport system of the city. A methodology to produce a sustainable mobility plan will also be presented with special emphasis to three concepts: innovative mobility and transportation solutions; railway management; and environmental quality.

2 RELATION BETWEEN SUSTAINABILITY AND A MULTIMODAL TRANSPORT APROACH

Urban transport management and planning often requires an integration of a large number of travel modes, especially when concerning big cities, or major urban environments. However, some smaller cities could have this scenario and the question is whether the use of different travel patterns is economically possible and sustainable.

The concept of sustainability has a vast diversity of interpretations and applications and for that reason there is some difficulty in getting a practical definition. This concept was primarily formulated by the World Commission on Environment and Development (Brundtland), who defined sustainable development as – "…development which meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987).

For example, on the study of urban streets with high performance of traffic and accessibility functions, a problematic street cannot be seen as a single element but as a part of a whole street network system, mainly when sustainable solutions are being carried out for that particular street. That said, for a given system, it should be possible to design and manage individual streets so that they contribute to different aspects of sustainability, in order to accomplish greater overall sustainability. This may be done by encouraging the appropriate mix and levels of social and economic activity for an area, while minimising environmental damage (Jones *et al*, 2007).

As a methodological guide, the ten "Bellagio Principles" (Plowright, 2002) have been proposed to assess progress towards sustainable development. These principles were selected by a group of practitioners and researchers from five continents, and serve as guidelines for an assessment process including the choice and design of Indicators, their interpretation and the communication of the results of a European project named ARTISTS. They have been summarised as:

1. What is meant by sustainable development should be clearly defined.
2. Sustainability should be viewed in a holistic sense, including economic, social and ecological components.
3. Notions of equity should be included in any perspective of sustainable

development. This includes access to resources as well as human rights and other "non-market" activities that contribute to human and social well being.

4. Time horizon should span "both human and ecosystem time scales", and the spatial scale should include "not only local but also long distance impacts on people and ecosystems".

5. Progress towards sustainable development should be based on the measurement of "a limited number of indicators based on standardised measurement".

6. Methods and data employed for assessment of progress should be open and accessible to all.

7. Progress should be effectively communicated to all.

8. Broad participation is required.

9. Allowance should be made for repeated measurement in order to determine trends and incorporate the results of experience.

10. Institutional capacity in order to monitor progress towards sustainable development needs to be assured.

The treatment of sustainability focusing on tangible and immediate considerations for addressing the design of urban streets should include (Svensson, 2005):

- accessibility for a range of users;
- the street as a destination for social and economic activity, and as a conduit providing accessibility elsewhere;
- promotion of 'greener' modes - bearing in mind not only immediate emissions but also long term environmental consequences;
- minimisation of the environmental impacts (including accident risk and loss of amenity) due to motor traffic.

Some of the key characteristics of urban sustainability often mentioned in the literature and in policy documents are, among others (Marshall *et al*, 2004):

- intergenerational equity (including social, geographical and governance);
- protection of the natural environment (and living within its carrying capacity);
- minimal use of non-renewable resources;
- economic vitality and diversity;
- community self-reliance;
- individual well-being; and satisfaction of basic human needs.

Urban mobility is a complex issue which involves the interchange between different travel modes, such as pedestrians, cyclists, motorized public transports and private cars with time and space. In these cases, a multimodal approach could be necessary to get a more sustainable way of travelling around urban environments even in mid-sized cities. The size of the city has great influence on the viability of the transport system of the city due to scale problems, especially in terms of economic self-sustainability which can be achieved in case of lack of demand for some of the modes.

In the past, transport systems were studied separately and that has brought some problems related with the establishment of connections and interchanges between the different existing urban transport modes. With the application of sustainability principles on the management and planning of urban mobility, an integration of different visions and expectations of all stakeholders must take into account the definition of strategies and actions that may influence the performance of the entire transportation system of the city.

3. MULTIMODAL APROACH

3.1 Characterization and evaluation of the transportation system of the city

The characterization of a transportation system requires the knowledge of the functioning and main problems that affect the whole system. In general, three groups of entities must be analysed, namely:

- Users (different travel modes)
- Collective Transport Operators (public and private)
- State or local authorities (municipalities or transports).

A transportation system is basically the supply of mobility to the different urban users through the development of a physical infrastructure and logistics provided by local transport authorities and the operators of collective transports.

A multimodal approach involves the analysis and description of two main points:

- The diagnosis of the existing situation for the different travel modes
- The definition of the role and strategies of local transportation authorities

3.3.1 Diagnosis of the existing situation

In order to identify the main problems affecting the sustainability performance of the entire transportation system of the city, in terms of its three main dimensions, namely social, economical, and environmental, it is necessary to evaluate the following aspects:

- relation between supply and demand of transport;
- travel patterns;
- environmental impacts on the quality of air and noise;
- social-economical impacts, namely in terms of road safety.

The diagnosis should match the following issues:

- Social-economical characterization of the population of the urban space in study;
- Characterization of the supply and demand of transport by mode;
- Evaluation of the relation between demand and supply of transport;
- Restrictions to the evolution of mobility.

In the end of this process, some zones of the city may be identified as priority areas of urban intervention in order to solve some important problems on the transportation system, particularly related with social-economical and environmental aspects such as road safety, air and noise pollution. In another words, those areas have problems that should be resolved in the short term. The encountered solutions should have, if possible, a strong public stakeholder participation in order to obtain a more efficient and equitable solution for all.

3.3.2 The role and strategies of local transport authorities

In mid-sized cities, local authorities responsible for the management of the transportation system have an important role on the achievement of sustainable travel patterns, especially on the promotion of the use of more sustainable travel modes like buses, trains, boats, cyclists and pedestrians. This can be done through the definition of the main concepts and objectives to come up with a more sustainable transportation system, based on a more

organized system and with better relation between supply and demand, particularly for green modes.

In this phase it is important to identify the specific objectives and priority actions to be developed and achieved in terms of sustainable mobility, for the problematic areas identified in the diagnosis of the existing situation. Those objectives and actions should focus on the following domains: accessibility to work, schools, retail, business and services; parking; public spaces and respective space segregation by travel mode; environmental quality (air and noise); road safety (residential areas and schools), and multimodal journeys.

The multimodal concept mobility must be developed at this stage and the objective should be the optimization of the use of different travel modes, especially green modes like cyclists and pedestrians, with the aim of improving the urban environment and reducing the energetic and environmental impacts. For this reason, the multimodal concept should integrate issues related with: road network (hierarchy and legibility); supply of public transport and its multimodal articulation; parking policies; and non-pollutant travel modes (pedestrians and cyclists).

The practical application of the main ideas of the definition of the multimodal concept is dependent on the summary characterization and identification of the key actions that must be implemented in a short period of time. For those actions, the costs, time schedules, and type of resources should be estimated, as well as the responsible entities and the main actors to be mobilized for its accomplishment.

3.3 Definition of intervention proposals

The integration of the results of the existing situation diagnosis with the strategic vision of the responsible entities for the management of the urban territory and local transportation system opens a window of possibility for the definition of a set of intervention proposals towards the improvement of mobility and accessibility conditions and consequently the increase of the vitality and viability of the problematic areas.

An intervention proposal on the transportation system should include the organization of the mobility of an area, based on the development of preliminary and detail studies related with the management and regulation of transit, as well as the green travel modes, mainly on the following themes:

- road hierarchy and traffic orientation
- regulation and functioning of the main intersections
- allocation of public space through different users and their needs
- parking regulation and management
- main routes of mass collective transport
- goods load and unload
- pedestrian and cycling spaces.

Finally, all intervention proposals should give some indications and orientations regarding the main changes to the management and planning of the urban places, which could restrict or improve the application of the principles leading towards more sustainable travel patterns.

4 CASE STUDY

The city of Viana do Castelo is a mid-sized city located in the North of Portugal, and the case study area refers to the most important urban agglomerate of the city and its surroundings, with an area of 33.6 km^2 and a resident population of 36545 inhabitants. It is a very attractive city, because of its natural landscape on a spread valley around the mouth of the River Lima, where most of the resident population lives, as illustrated in Fig. 1.

Fig. 1 –Aerial view of the city of Viana do Castelo *(Google Earth, 2008)*

The infrastructure of the transportation system of the case study area is very wide and reflects an offer of a large number of travel modes, especially mass transport, as well as more sustainable ways of mobility, some of which are rare in Portuguese cities, such as: green modes (pedestrians and cyclists), and public transports (trains, buses, and ferryboats). However, there is a major part of the system that was, and is, designed for the circulation of private cars, particularly in the adjacent area of the historic city centre, which in turn is almost exclusive to pedestrians, as illustrated in Fig. 2.

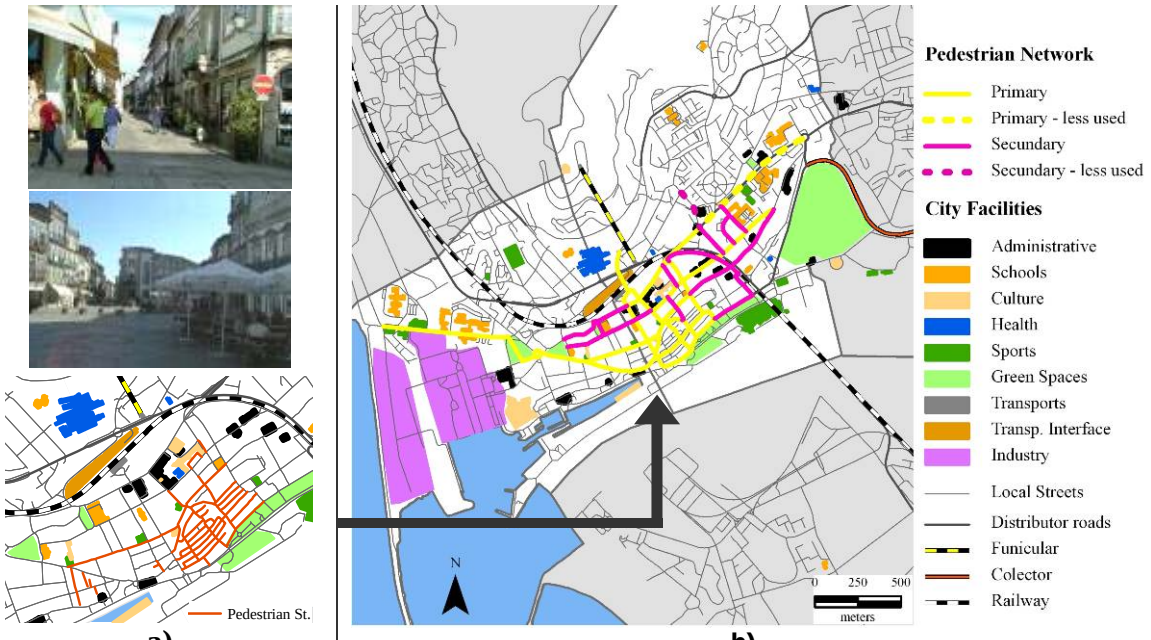


Fig. 2 – a) Pedestrian streets; b) Main pedestrian routes

In the previous figures, the maps provide spatial information regarding the main

infrastructure, allocated to the different travel modes. Accordingly to Fig. 2, the core of the case study area has a good offer of pedestrian streets that correspond to the main pedestrian routes. The pedestrian network spreads along the city, mainly around the most important facilities.

Cyclists are another important green mode that has a physical associated infrastructure, which is being improved with time. Another important aspect of this cyclist network is the integration with an elevator, the "funicular", which is another singular travel mode best suited for tourism and sport activities, enabling to travel up and down the most important hill of the city.

Table 1 - Length of the cycle network

Cycle lane	Length (m)
In construction	1372
Built	6403
Connection by funicular	894
Planned	10421
Planned - Approved	2352

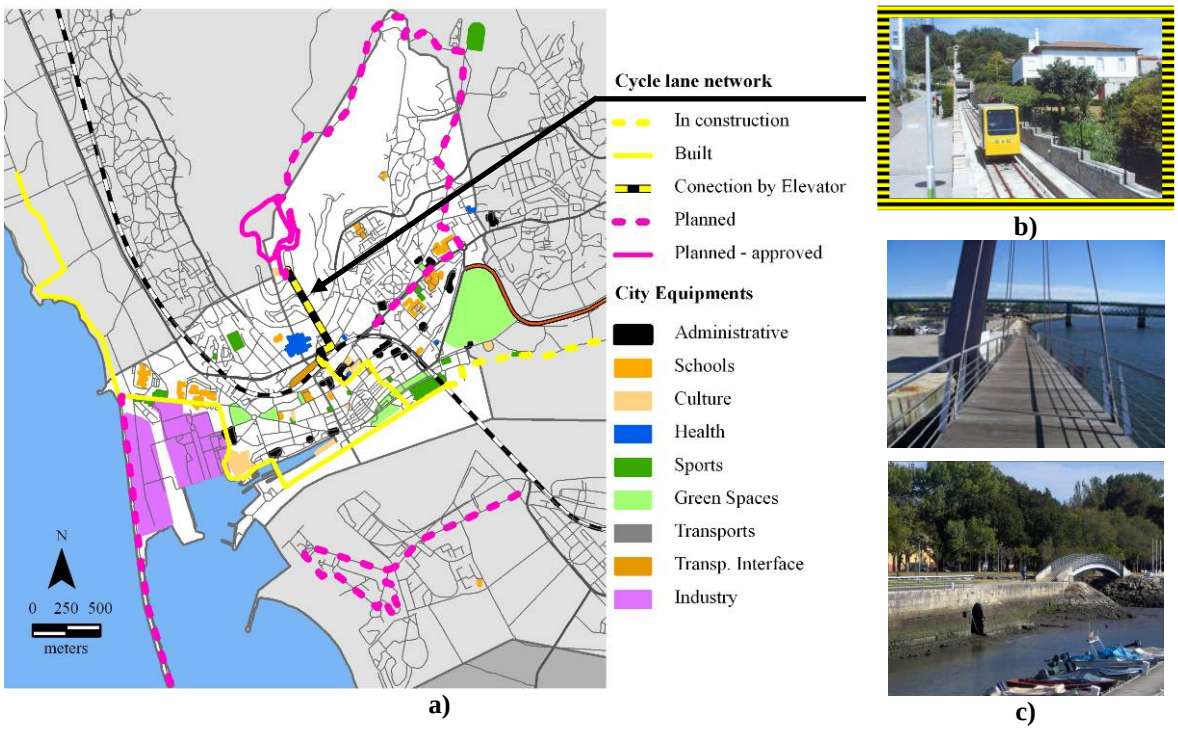
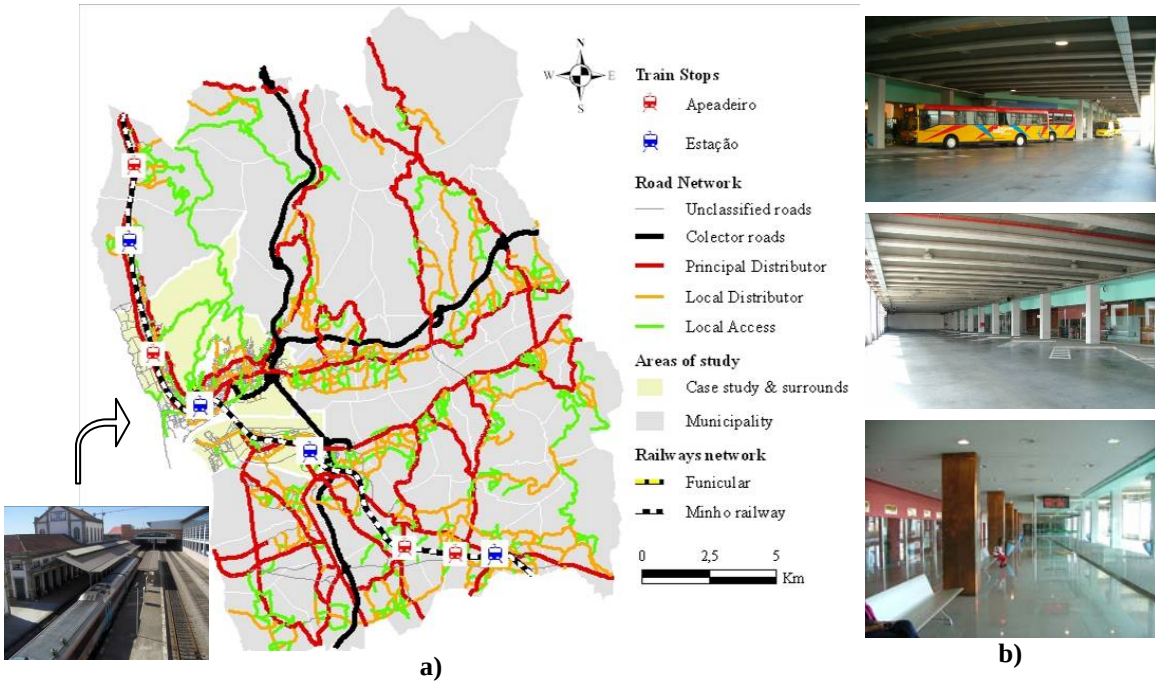


Fig. 5 – a) Cycle Network; b) Elevator – "Funicular"; c) Examples of cycle lanes

In terms of public transport, trains have a strong influence in the life of the city, since the railway passes through it, creating a physical barrier between the centre and old town, and the new neighbourhoods that have been developed on the last decades. However, the main station of this region - "Viana do Castelo"- located next to the city centre and the Hospital, was recently reconstructed and integrated into a multimodality platform, an interface between trains, buses, cyclists, and also taxi services. This interface has been supported by the biggest shopping centre of this region.



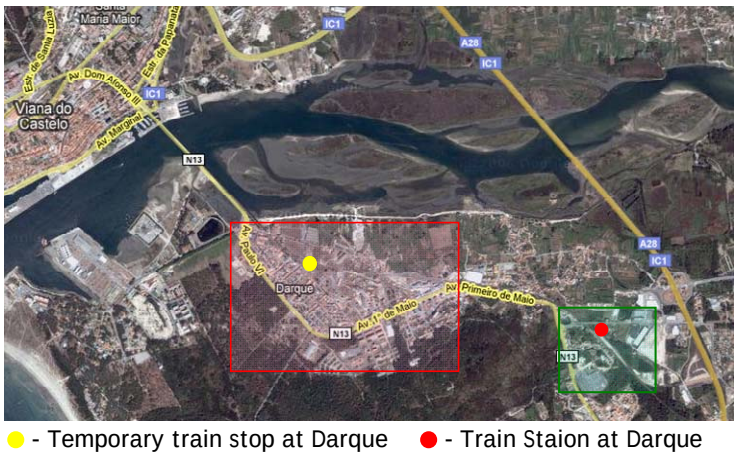
a) b)

Fig. 6 – a) Railway Network; b) Interface – Bus facilities

The railway network analyses have shown that almost all train stops are spaced by about 10 km and for some of them the location is not the most appropriate. The station of Darque is one of such cases, where the original and official station is located far away from the resident population. However, at the moment, there is a temporary station that ensures the service to Darque inhabitants, due to the repair of the old bridge for about one year, which restricted the circulation exclusively to trains. Anyway, this provisional situation, which offered a better and more sustainable way of travel for the closest population to the city centre of Viana, was not intended as an improvement to intermodality, instead it resulted simply as a consequence of the reconstruction of an infrastructure.

Table 2 – Distance between train stops centred in Viana

Train Stops		Distance (km)
Type	Name	
Station	Gelfa	12,5
Stop	Afife	10,0
Station	Carreço	7,2
Stop	Areosa	2,9
Station	V. do Castelo	-
Station	Darque	5,4
Stop	Alvarães	10,1
Stop	Sra. Neves	12,0
Station	Barroselas	13,5



● - Temporary train stop at Darque ● - Train Staion at Darque

Fig. 6 – Problems in the location of train stops

Almost every mid-sized city has different types of services in its public transportation system, but just a few of them have an urban network of buses, mainly due to the dimension of those urban environments, which lead in some cases to an obviously negative cost-benefit balance. But in this case study, besides a regular urban network of bus services, there is associated an electric bus (Fig. 7) which serves important historic areas

due to its smaller size (5.30 x 2.07 meters) with a capacity of 22 passengers, providing high circulation flexibility, especially for a network of narrow streets, and also high environmental performance in terms of low noise levels and zero emissions of pollutants.

Fig. 7 – Urban bus network system (itinerary and vehicle)

Viana do Castelo is, however, one of the cities with about 130 urban buses circulating on a regular day (outside the scholar period), which represents a good service of this travel mode, reflected on a frequency of around three buses per hour on most parts of the urban bus network. On the other hand, as shown in Fig. 8 there is a good spatial coverage of the case study area by the urban network: in the figure, circles have been drawn from the centre of each bus stop of 250 and 500 meters, representing the geometric places corresponding to walking distances to a bus stop of 5 and 10 minutes, respectively.

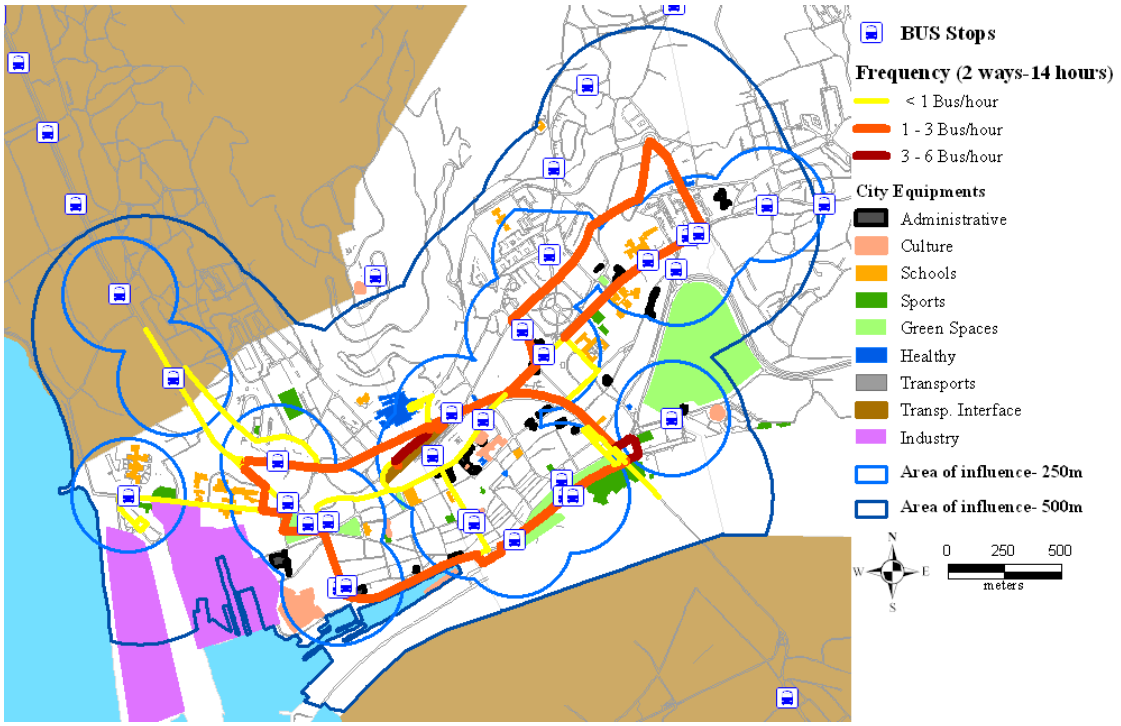


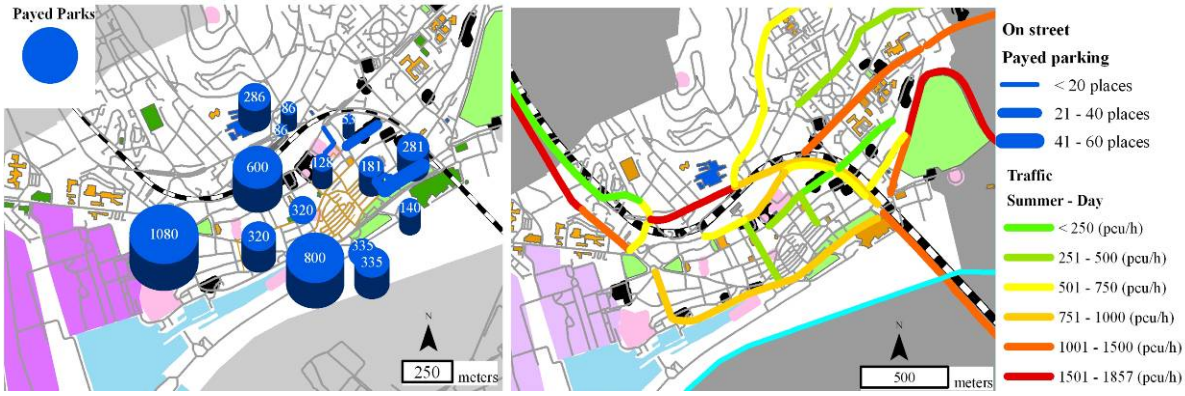
Fig. 8 – Urban bus network system

The city of Viana do Castelo has a strong relation with the River Lima and the Atlantic Ocean, which is expressed in many activities, developed for many years, such as the sea

harbour, the construction of naval boats, and other regionally important sea related industries. On the other hand, the river can be seen as a natural barrier that must be crossed and, with the closure of the most important motorized traffic bridge of the city, the link between the South side (Darque) and the city of Viana was improved by another travel mode - the ferryboat, which in a certain way contributes to the improvement of the overall sustainability of the transportation system.

Fig. 9 –Ferryboat and its infrastructure

Finally, the multimodal approach for the case study area was completed with the identification of the main traffic corridors and the existing parking system, which serves the entire area. In terms of traffic, a main road crossing the city can be identified, which involves the historic city centre and links to the Eiffel Bridge (traffic and trains) thus providing the connection with the South side of the municipality. On the other hand, almost all the existing public parking places on the street in the city centre are taxed, representing a supply of only 166 places, while 4290 parking places can be found in paid parks, divided in 12 car parks. Outside this area, the parking demand is not significant.



a) b)

Fig. 10 – a) Paid parking (on street and car park); b) Car traffic flows

After a brief characterization of the transportation system of the city, it is necessary to understand the main strategies and concepts of the city authorities related with the achievement of more sustainable urban transport mobility (Mendes *et al*, 2008), namely:

- adopt innovative solutions of mobility;
- explore the importance of railway transport on the global transportation system;
- assume the status of healthy city, with the control and monitoring of the negative impacts of the functioning of the transportation system.

In order to cross and compare the results of the summary characterization and diagnosis of the transportation system of the city with the main concepts of a strategy developed by the transport authorities, it is inevitable to adopt a multimodal approach interlinking and coordinating all travel modes available. However, this must be done with a policy of

improvement of the conditions offered to green or mass travel modes, and the application of restrictions to circulation and accessibility for private cars, without compromising the social-economical evolution of the city.

For this case study, a basic solution has outcome from the multimodal analysis, which is the creation of a large group of interfaces between the different modes of transport, or travel modes, and not only between public mass transport as at present, with the interface located near to the train station of Viana. In fact, that is a good starting point but some restrictive measures, such as a reduction on the offer of parking places, could also have a significant impact on the use of private cars on daily journeys to work. Contrary to these solutions, it is worth mentioning that the most recent public car park was concluded this year with a capacity of around 1000 places.

Fig. 11 illustrates some proposals of interface points, especially related with the connection of green modes routes to the other travel modes. Indeed, based on the cycle lane network, it is possible to develop an integrated concept of global multimodality for this city. Nevertheless, other improvements on buses, trains, and ferryboats must be developed to allow, for example, the transport of bicycles. Moreover, the creation of multimodal tickets for all of this mass public transport could be developed in order to promote more sustainable travel patterns.

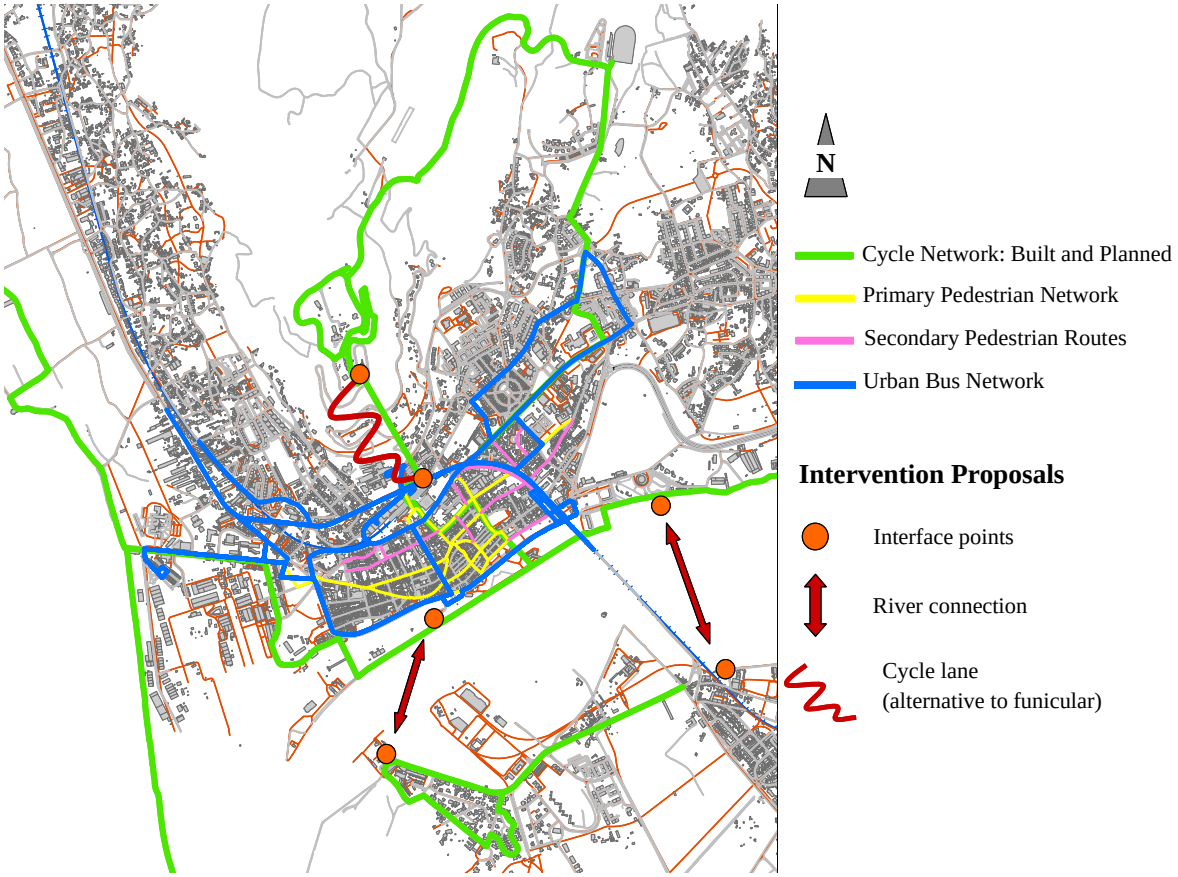


Fig. 11 – Multimodal approach – Intervention proposals

5 CONCLUSIONS

The existence of a large number of different travel modes, which are available and can be potentially used, is the core issue of the evaluation of an urban transportation system. In

this situation, a characterization and diagnosis of all modes must be made in order to get a clear picture of the weaknesses and strengths of the transportation system, towards the introduction and application of sustainable development principles on the planning and management of the system, especially in terms of a multimodal approach.

Bearing in mind the results of the diagnosis and characterization study of the transportation system of the city, it can be concluded that a large number of actions have been developed in order to restrict transit in the inner city and to improve the usage of more sustainable travel modes like trains, buses, and even pedestrian. However, in this context of a city of less than 3 km of radius, there is an opportunity to enhance cycling and to encourage the use of ferryboats on daily commute journeys, with the integration of these travel modes in the transportation system. Such integration can be achieved through the creation of strategic points of connection of these modes with the entire transportation system – the interfaces -, and with the implementation of cycling facilities along the cycle network, namely with parking places, resting areas with seats and water services, city information, among others.

Green modes and public mass travel modes play an important role in obtaining a more sustainable transportation system, though this is strongly dependent on political intentions, and key concepts must be clearly defined by local transport authorities to promote an integrated model of transports. A key point to encourage citizens towards the accomplishment of this goal is the development of comfortable physical interface infrastructures.

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