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EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

Edited by
Sabina Pulawska and Silvia Rossetti

Applying Accessibility Tools to Address Urban and Transport Planning

The Case of the Eurocity of Valença-Tui and the Euroregion of Galicia-Norte de Portugal

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ESF provides the COST Office through an EC contract

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COST is supported by the EU RTD Framework programme

APPLYING ACCESSIBILITY TOOLS TO ADDRESS URBAN AND TRANSPORT PLANNING

The case of the Eurocity of Valença - Tui and the Euroregion of Galicia-Norte de Portugal

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ISBN 978-88-916-0900-7

Published by Maggioli S.p.A.

47822 Santarcangelo di Romagna (RN) • Via del Carpino, 8

Printed in october 2014
by DigitalPrint Service s.r.l. – Segrate (Milano)

This publication is supported by COST.

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Making the connections: ideas for a cross-border transport network

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Abstract

Cross-border cooperation has received increasing attention over the past few decades. It implies a greater institutionalized collaboration between contiguous subnational authorities across national borders. In this chapter, we argue that the creation of a cross-border transportation network is a fundamental step in order to reinforce and foster neighborly relations between territorial communities. In particular, we point out that a common vision based on accessibility and mobility might be a good step forward. The chapter start with the examination of the current transport situation in the Eurocity of Tui-Valenca. Then a brief discussion about the planning principles that inform our view of a unified transport infrastructure is introduced. Based on this discussion, some hypothesis of intervention on the actual transport system are presented. Focusing our attention on the development of a common public bus system, we show how simple accessibility measures can be used to evaluate alternative transportation strategies. Our contribution seeks to provide new insights in order to develop a cross-border transportation network, here considered as a powerful tool to further the trans-border cooperation between the two municipalities. This preliminary exploration is not intended as final answer, but rather as the opening of a debate about the use of accessibility measures in a both fascinating and complex context, as the territorial context of the Eurocity.

Keywords: Accessibility assessment; Public transport; Bus routes; Bike paths; Cross-border transport network; Euro-city.

1 Background and aim

Transportation is an important infrastructure in our society. It affects both the economic development of a city as well as the quality of life of its inhabitants:

- Transportation may enhance economic growth by increasing the local customer base for services, such as medical facilities, shopping malls, and local educational facilities. It also contributes to improvement in economic efficiency by allowing unemployed individuals to find and keep a job (Tumlin, 2012).
- Transportation may also influences the quality of peoples' life by providing access for quality interactions that are essential for life's necessities as well as social and emotional well-being (Spinney et al., 2009).

If there can be no discussion that a well-functioning transport system can enhance economic development of a city while improving the quality of life of its citizen, what could be the positive effects of a cross-border transportation system serving two different communities? In our view, a proper, unified transport infrastructure and services which would cover the areas of both cities and ensure a link between them, could contribute to their economic development, by providing to citizens access to jobs and essential goods as well as particular services and locations like shops or cultural spots, also on the other side of the border. Both cities could gain benefits as a cross-border transport system may improve life conditions for all inhabitants (including children, elderly people and handicaps) in a way of expanding the range of possible destinations where they could fulfill particular needs (health, education, leisure and free time). Furthermore, a unified transport infrastructure could reinforce and foster neighborly relations between territorial communities by supporting both social and economic interactions between individuals of the two municipalities.

Some examples of policies implemented for linking border communities with a common transport infrastructure support this view. The "Green Path" project in the Eurocity of Gubin (Poland)/ Guben (Germany), for instance, is an interesting example of cross-border cooperation aimed at the development of a shared transport infrastructure. It focuses on the renovation and construction of pedestrian and bicycle paths connecting the two municipalities as well as on the modernization of existing parks and memorial sites of historical interest. Bicycle and pedestrian paths currently link the most important activities located on both sides of the border, providing a new functional and usable quality for inhabitants and tourists (Ministerstwo Infrastruktury i Rozwoju, 2014). The towns of Weil am Rhein (Germany) and Huningue (France) have decided to build a footbridge over the Rhine for cyclists and pedestrians. The project has a great symbolic value for both towns. Indeed, the bridge not only allows a real junction of bicycle routes on both sides of the river. It also enables cultural, economic and leisure links between the inhabitants of the two municipalities (Knowledge and Expertise in European Programs, 2014). The cities of Gorizia, Nova Gorica and Šempeter-Vrtojba are located in a cross-border area between Italy and the Republic of Slovenia. These cities participated in the ADRIA project, a

collaborative effort aimed to provide a transport link between them through the implementation of an integrated rail service. In May 2010, within the ADRIA framework, the first EGTC (European Grouping of Territorial Cooperation) between the three cities was created, giving an important legal basis for cooperation in the field of planning and transport. The implementation of an integrated rail service intends to support the development a functional trans-border region and provide a common and structured response to some socio-economic challenges (ADRIA A, 2014).
The aim of this chapter is to provide new insights in order to develop a cross-border transportation network serving the Eurocity of Tui-Valenca, considered as a powerful tool to further the trans-border cooperation between the two municipalities. In doing this, we first examine the current transport situation in the Eurocity by the identification of the actual patterns of the transport system. Then we provide a brief discussion about the planning principles that inform our vision of a unified transport infrastructure and services. Based on these planning principles, we develop some hypothesis of intervention on the actual transport system aimed to further the process of territorial integration. We focus our attention on the development of a common bicycle networks and of a common public bus system. The latter has a central role in our analysis. First, we provide two alternative bus lines that connect the densest populated zone with a set of common every day destinations. Then we develop and apply a detailed evaluation tool aimed to assess witch of the two planned options provide the highest accessibility benefits for the Eurocity population. Finally, we evaluate how these benefits are distributed between the two municipalities.

2 The analysis of the current situation

The first phase of our work consisted of an inventory of the current transport situation in Valenca and Tui.
The city of Tui inhabits around 17.000 people. Valenca inhabits around 14.000 people. With approximately 35 thousand inhabitants, this cross-border cities form an old link between the two countries, now including one of the most important road connections between the two countries.
Although the Tui–Valença cooperation was officially recognized as a Eurocity in February of 2012, results of inventory showed that there is no common planning in framework of transport infrastructure and service. There are plans though for the establishment of common services such as healthcare and a police department.
An identification of road, public transport, rail and bike infrastructure and connections was carried out on the base of existing documentation:

- Roads: Two bridges connect Tui and Valença: Tui International Bridge (known in Portugal as Valença International Bridge), completed in 1878 and a modern highway bridge build in the 1990s. Within the cities, a local road network is available.
- Public transport: Taking bus-transport into consideration, local connection between two cities does not exist, apart from few

international express buses per day. Both cities provide bus services that operate to near areas, ensuring transport to and from town centers. These connections are mostly used for work and school purposes. Municipality of Valenca established also special service – school bus that operate during weekdays.

- Rail: Inhabitants of Tui and Valenca can use a rail connection between the cities and further two times per day, during peak hours in both directions. Next to this, national rail connections from out the two cities exist on an hourly basis.
- Proper bike infrastructure can be observed only in the area of Valenca. Few bike paths exist in this city, whereas there are no bike paths in Tui.

The figure 7.1 shows the main infrastructures of Tui and Valença. Local roads and cycling paths are not specifically highlighted.

Interviews with local planning experts and fieldwork showed the road connection via the old bridge might be vulnerable in peak hours. As it is the shortest connection between the cities cars will prefer the shortest route. The bridge was originally not designed for this flow of traffic. Next to this quantitative problem, a qualitative challenge may appear as the bridge forms a landmark and connection for slow modes of traffic.

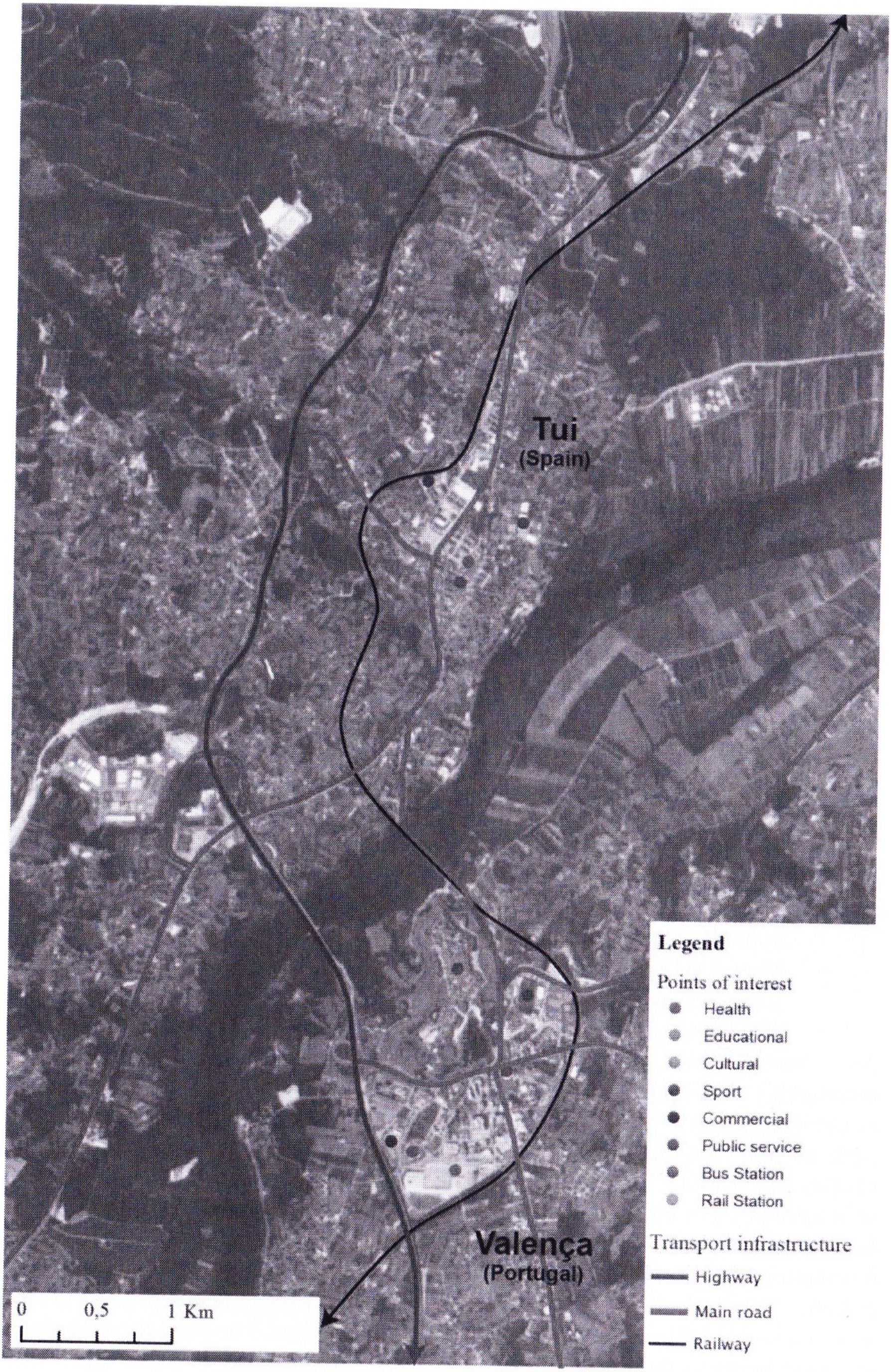

Figure 7.1 The current situation

3 Planning approach and vision

In order to create a Eurocity, a further cooperation between the two cities is important. A common vision on accessibility and mobility might be a good step forward. Presented solely vision is based on several approaches:

- **One coherent mobility system.** This approach includes a vision of one coherent mobility plan for the two areas. In order to do so, firstly borders between the two cities, including planning systems and look at the infrastructure should be excluded;
- **Multimodal network design.**This vision implies a multimodal network design. With this, different modes of transport such as car, train, bus, cycling and walking are interconnected designed.
- **Sustainable accessibility and mobility management measures.** Mobility management is an approach to the passenger transport, oriented on promotion of the sustainable mobility modes as alternatives to car usage. Taking this concept into consideration, in presented approach slow modes of mobility, such as walking and cycling are the main 'backbone' of infrastructure, which means these modes will be prominent within the network design. Car accessibility -within the urban areas- becomes secondary;
- **Economic and social development as goals.**The aim of this concept is not only to provide smooth mobility, but our vision-included accessibility be the provider for economic development and social cohesion of and between the two cities.

In the current situation, the main trans-border connection between the cities is the old bridge, which is being used by both car and slow modes of transport. In addition, the highway bridge makes the other main connection between Tui and Valenca. The vision implies the following:

- The main bridge is primary accessible for slow modes of transport, public transport, taxis and emergency services.
- Motorized transport only have limited access as mobility management measures will be taken, which allow only passing through in one direction at a time.

As a result, travel times for cars between the cities will become longer, comparable to driving along the highway bridge.

A cycling network will be designed connecting the cities and main attractions such as train stations, sports and health facilities, recreational sites, shopping centers and schools. The cycling network is provided with a bike sharing system, so inhabitants and tourists can travel easily without having to own a bike.

In addition to this, a bus network will be designed connecting these important destinations. These buses are small and flexible and can be adapted when possible. When implemented, all intra- and intercity trips in and between Tui and Valenca will be able to be made by foot, bike and/or bus. The need for motorized transport between the cities will be limited and discouraged as travel times will be longer. The result is that people are - as in the old days- connected again through a safe and vital transport system: the cities will function as one daily urban system, accessible by slow modes of transport.

This vision does not only have mobility aspects, but will benefit economic, ecological and social aspects as well. A safe and relatively quiet connection between the cities will further enhance touristic development: people are able to walk and cycle the environment, being able to easily explore both cities and therefore both countries. It is recommended towards the municipalities to create a unified Eurocities-touristic cycle network, providing tourist and inhabitants (local and regional) nice spots to see and taste local products. Here the mobility aspect stops and further integrated planning issues will start, such as a further integration of touristic, sports and recreational facilities.

Overall vision was presented on the Figure 7.2. The green line symbolizes primary slow mobility infrastructure backbone (walking, cycling), red line – primary intercity car connection (local traffic), whereas purple line presents primary secondary intercity car connection (regional traffic).

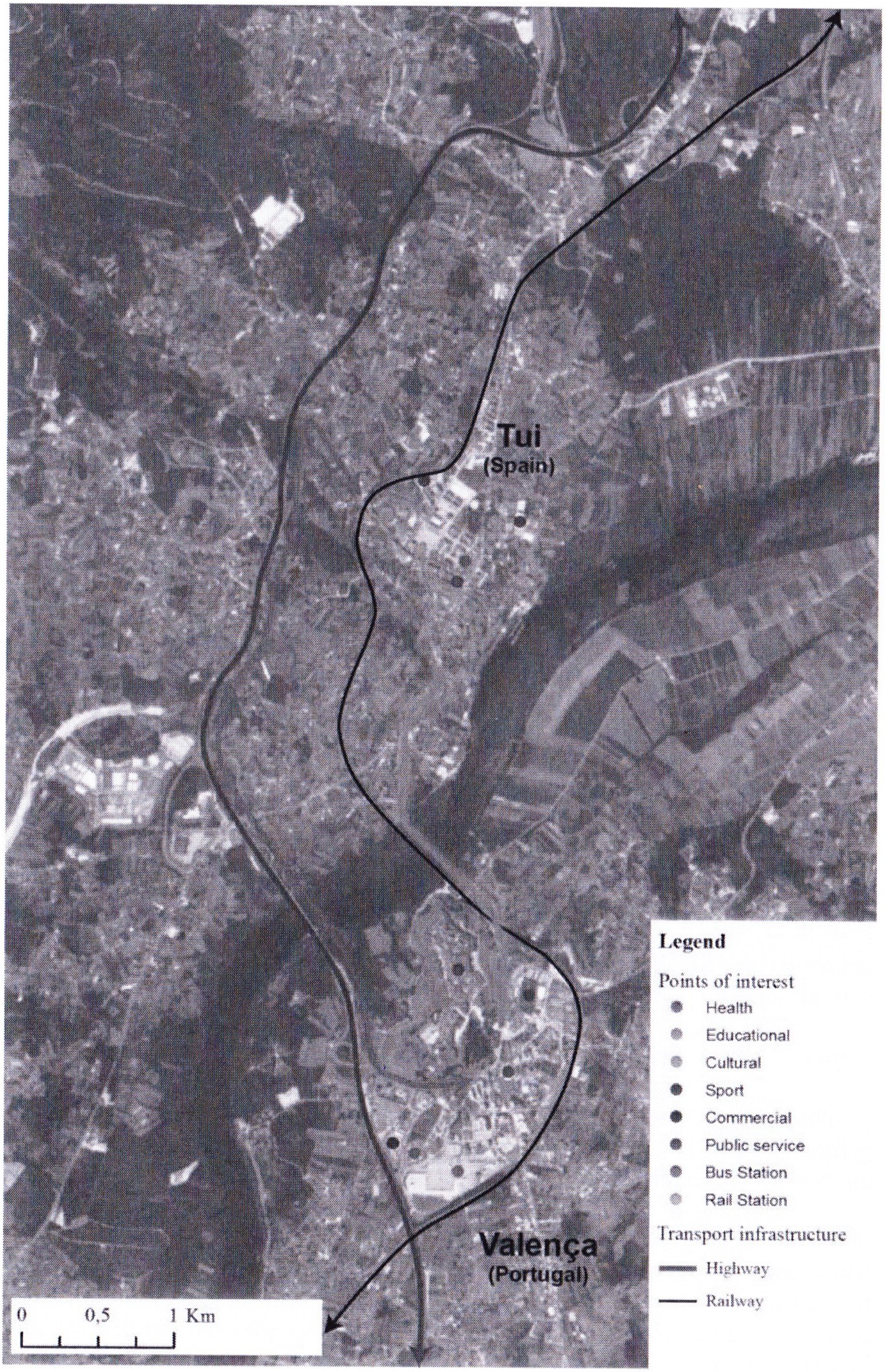

Figure 7.2 Overall vision

4 Ideas for a cross – border cycling network

The cycling network will be elaborated in phases. Firstly (after implementing mobility management measure on the bridge), the main cycling backbone will be designed, which runs between the trains stations of Tui and Valenca and both town centers, partly along the Santiago de Compostela route. The design is -as much as possible- disconnected from the main car routes in the centers and - where possible- have separated bike lanes. Next to this main line, two sublines in Valenca will be designed so the main part of the city will have primary access to bike lanes. As a third phase, additional bike lanes will be designed in the outer areas of both Tui and Valenca, so more people have access to primary bike lanes. This will further improve bike use in the cities. Additional bike share facilities might be considered.

Figure 7.3 presents planned bike infrastructure. Orange line symbolizes primary cycling network, orange dotted lines – secondary cycling network and orange squares – bike-sharing facilities.

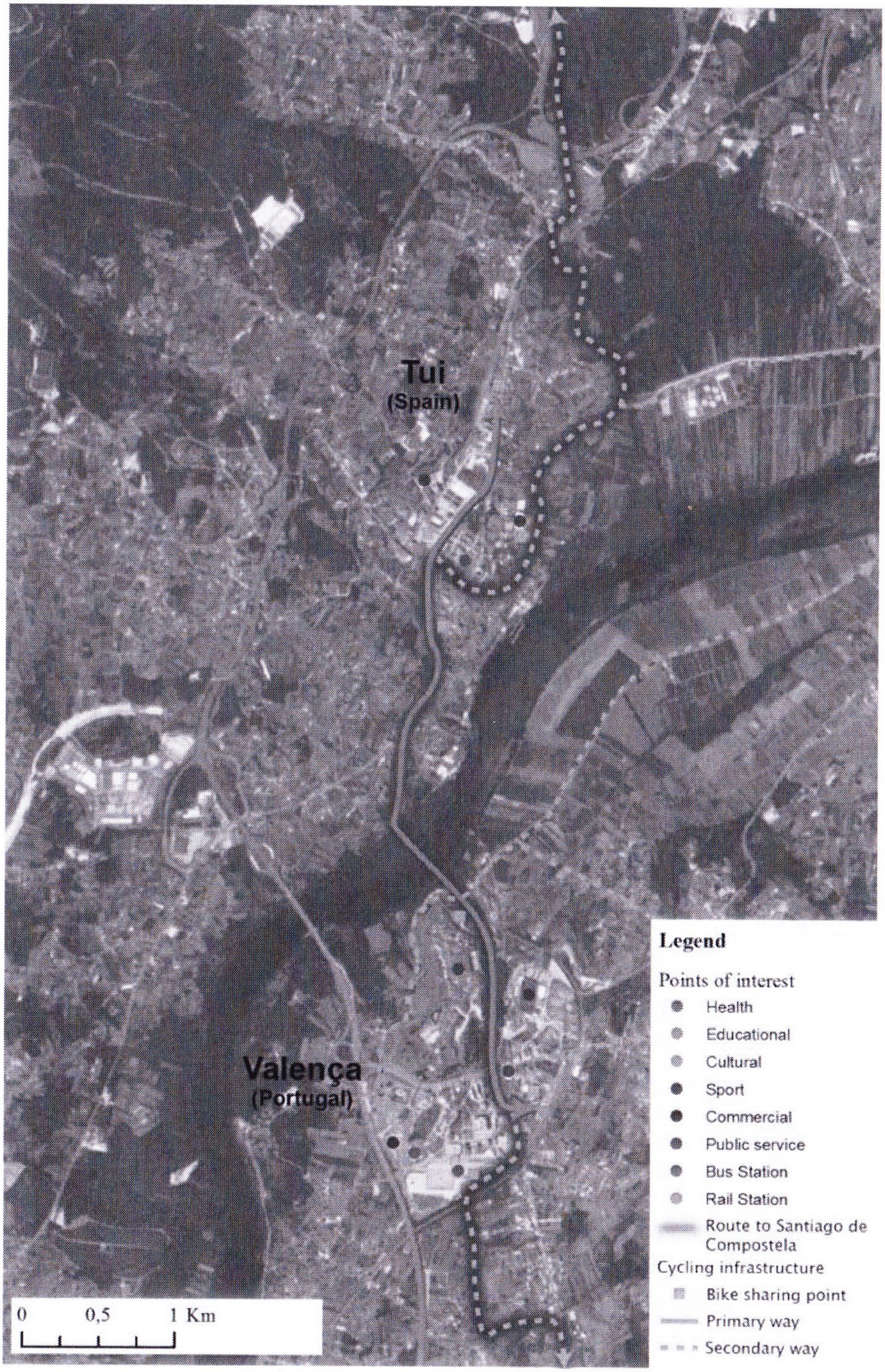

Figure 7.3 Planned cycling infrastructure

The main bottleneck is the old bridge, which is narrow and is not' inviting' enough towards pedestrians and cyclists. In order to be able to give slow modes of transport between the cities more space, the use of car on the bridge must be discouraged. A fully closure of car accessibility might not be wise, as also buses, taxis and emergency vehicles might be able to use it. Next to this, a full transfer of all traffic towards the highway might cause other problems there.
Our proposal includes traffic signals, which provide motorized access on the bridge in one direction at a time, changing after a few minutes. So only one lane will be sufficient and will case a more safe traffic situation on the bridge, inviting more non-motorized passengers.

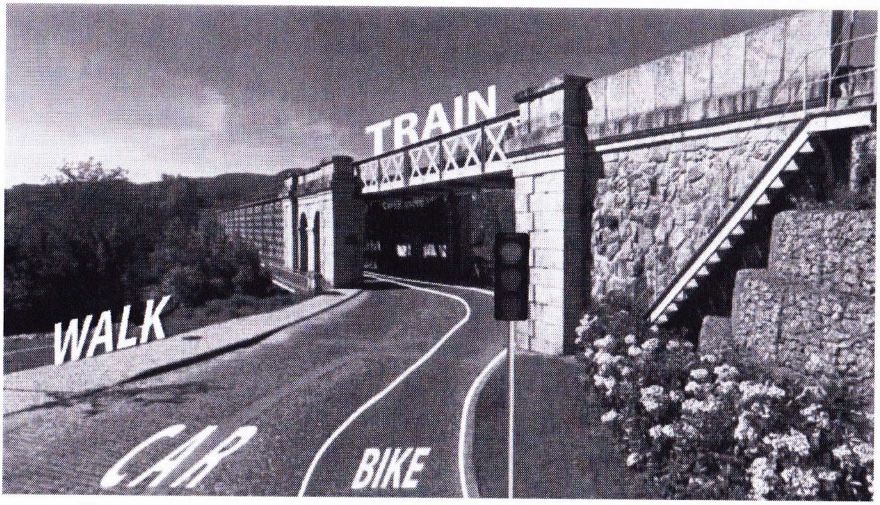

Figure 7.2 Presents proposed traffic organization on the bridge

Next to these mobility measures, one must keep in mind the symbolic and environmental function of the bridge, being an important aspect of the valley and 'branding' of Eurocity Tui-Valenca. The bridge therefore has a 'symbolic' function: being the connecter of cities and nations, therefore people.

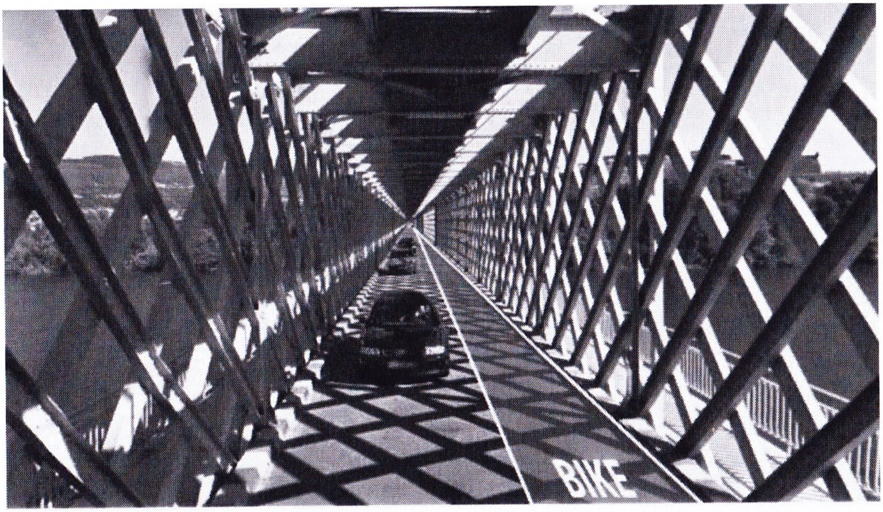

Figure 7.3 Proposed traffic organization on the bridge

5 Ideas for a cross-borders bus system

As no bus connection is provided by local authorities, we developed two alternative bus lines that connect the Spanish and the Portuguese municipalities. Considering that the final aim of any transport system is to connect people with the desired opportunities, we first carried out an analysis of the population distribution within the study area. In doing this, the entire study area has been classified as high, low and medium densely populated, according to the ratio between the coverage, urbanized area and the territorial surface. Both the territorial and the urbanized area were calculated using open data from Google Earth.

Based on the previous chapters' findings (§ 2.3, 3.3, 3.4) we defined a set of common every-day destinations for which data was readily available. These destinations represent a set of opportunities that the two municipalities intend to share in order to reinforce and foster neighborly relations between the two territorial communities. Given the most populated zones of the two municipalities as origins and a set of common every day opportunities as destinations, we designed two alternative bus routes that connect the households with a selected number of opportunities. The two lines has been labelled as "old line bridge" line and "modern bridge line" as they cross the two trans-border bridges that connect the two municipalities. The two lines connect the densest urban areas with the same set of predetermined destinations. However, they vary in terms of path, length, number of bus stops and service areas. The old bridge line (figure 7.6) is characterized by a shorter length of 7,8 km along with 14 bus stops have been located. In contrast, the modern bridge line (figure 7.7) is 13,8 km long and along its path, 16 bus stops have been located. Despite being characterized by a longer path, the modern bridge line takes advantages of higher commercial speeds as its routes is part-highway. This different feature of the two public bus lines have been used in the next paragraph to carry out an accessibility analysis aimed to defined witch line provides the higher accessibility benefits and how these benefits are distributed between the two municipalities.

Figure 7.4 Old bridge line

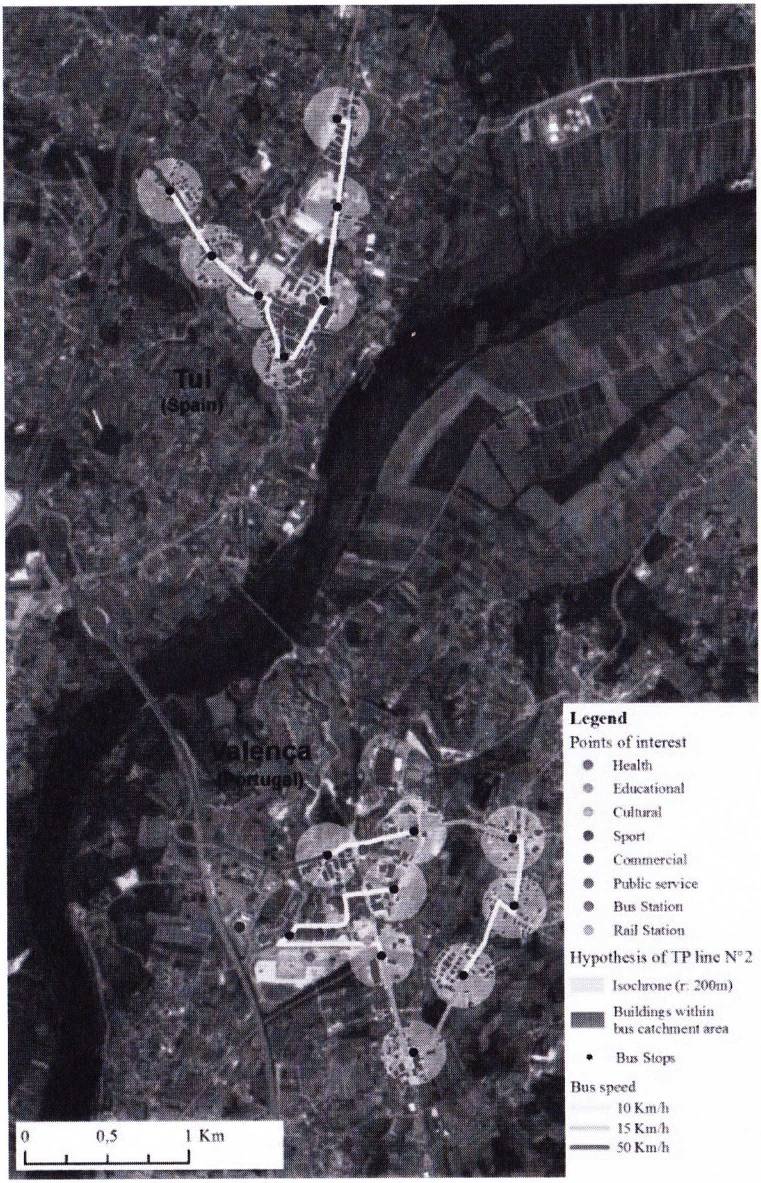

Figure 7. 5 Modern bridge line

6 An accessibility assessment of alternative bus lines.

In order to compare the relative benefits of each bus line, an accessibility assessment method has been developed and applied to the two planned options.
The accessibility assessment method has been developed considering the following four relevant issues:

- Access to transit stops;
- Land use destinations;
- Travel time and travel speed;
- Territorial distribution of public transport benefits.

6.1 Access to transit stops

Access to transit stops is important in public transit planning, as this is the mean by which service is provided to riders. In fact, the proximity of demand (population) to stops or stations on the network to a great extent explains its greater or lesser usage by potential users (Gutiérrez et al., 2011). An essential element in modelling access to transit stops is the modelling of the transit stop' service areas. The transit stop service areas may be calculated using two different methods: Euclidean buffer/distance (see for instance Ayvalik & Khisty, 2002) or network/buffer distance (Foda and Osman, 2010). The first method is based on the creation of buffers around transit facilities based on Euclidean (straight-line) distance; while the second method is based on the calculations of distances along a street network. In both case the design of the transit service area can be used to evaluate the population with walking access to the bus stops.

In this study, access to public bus stop is measured using the Euclidean buffer method.

The land use information readily available about population's distribution consist of the census track of the two municipalities. However, evaluating population with walking access to a bus stop using an administrative unit as a proxy for the home of all residents within the unit can lead to errors (Currie, 2010). Furthermore, the overestimation of the population may be particular relevant when administrative units are wide, like in the case of the Portuguese ones. Given the fact that the available information were not sufficient to estimate accurately the population with walking access to a bus stop, we explore alternative ways to obtain the needed information. We found in the aerial photography provided by Google Earth a useful source of information on which develop a method to overcome some shortcomings of the use of census tracks as minimum spatial unit. In doing this, first we recorded aerial photography in a digital format using Arc Info software. Then, we select all the buildings within a buffer of 400 meters from each bus station. We classified each building as "single family house" or "multifamily building". The latter category has been further specified according to the number of floors. Then, for each buildings, we calculated its foot print area. In order to evaluate the number of people living in each building we made the following hypothesis:

- The street level floor is dedicated to non-residential use (i.e. commercial or other use)
- The gross residential floor area of each building, $GFA,$ is equal to its foot print area,FPA, multiplied for the number of its floor, n (excluding the street level floor).
- For the City of Valenca, 120 square meters of gross residential floor correspond to one dwelling unit (INE-Portugal, 2011) while for the City

of Tui 100 square meters of gross residential floor correspond to one dwelling unit (INE-Spain, 2011).

- For the city of Valenca, the average number of people living in each dwelling is equal to 1,73 (INE-Portugal, 2011), while for the City of Tui the average number of people living in each dwelling is equal to 2,31 (INE-Spain, 2011) .

Given the previous hypothesis, it was possible to calculate the number of people,p_i^o, living in the building i within 400 meters from each bus stop o. In particular, for the city of Valenca:

$$p^{b,o} = \frac{FPA.(n-1)}{120} \cdot \frac{1}{1{,}73}$$

While for the city of Tui:

$$p^{b,o} = \frac{FPA.(n-1)}{100} \cdot \frac{1}{2{,}31}$$

Thus the number of people with walking access to the transit facility o:

$$pop^o \sum_{i=i}^{b(o)} p_i^{b,o}$$

Where $b_{(o)}$is the number of buildings within a buffer of 400 meters from the bus stop o.

6.2 Land use destination

While being able to find transit facilities locally is important, the places and opportunities that can be reached by transit is also an important factor that has only recently begun to receive attention. Taking this in mind, we select a range of common every-day destinations for which data was readily available. This destination represent opportunities that the two municipalities are intend to share in order to further the process of territorial integration. These opportunities have been grouped in four main domains: i) cultural ii) health, iii) sport and iv) commercial.

6.3 Travel time

As origins and destinations are important, considering travel time taken to travel between each origin and each destination is another important factor in performing accessibility assessment (Lei and Church, 2010). In this study, this is achieved by developing a multi-modal network combining transit and walking modes and using travel time as the network impedance. Total travel time, t_{total}^{od} between a given origin o and a generic destination d (e.g. commercial mole) has been calculated as the sum of three components: i) time taken to reach a transit

$$t^{od}_{total} = t^{o}_{acc} + t^{o}_{w} + t^{od}_{on\ board}$$

The time taken to reach each bus stop has been considered the same for each household living within a circular buffer of 400 meters from the transit facility and equal to 5 minutes. An average waiting time of 10 minutes has been included at each bus stop. To evaluate on-board travel time we divided each of the two bus routes in m street segments with the same characteristics. Then we associated to each street segment i a commercial travel speed cts_i, considering several aspects that may affect travel speed such as the number of bus stops, the width of the roadway and the location of the street in the urban context. Once we associated to each street segment its commercial travel speed and its length, l_i, then we calculate on boar-travel time as:

$$t^{od}_{on\ board} = \sum_{i}^{m} l_i . cts_i$$

6.4 Accessibility analysis

To assess the accessibility of the two planned options, we use a comprehensive measure of accessibility that combines the above-mentioned issue. First, for each bus stop we calculate the number of households living within a circular buffer of 400 meters from the transit facilities, pop^o_i, as specified before. Then we calculate total travel time from each bus stop o to each destination d, $t^{od}_{total,i}$. Then an accessibility score for each destination has been calculated as:

$$Acc_d = \sum_{i=1}^{n} \frac{pop^o_i}{t^{od}_{total}}$$

A simple aggregated accessibility score for each bus routes was obtained by summing the single destination score. This method have been applied to the two planned bus routes. The results are summarized in table 7.1.
In this table, for each destination is reported the accessibility score provided by the old bridge line and the modern bridge line, as well as the aggregate accessibility score.

Table 7. 1 Accessibility assessment

Destinations	Accessibility Score	
	Old bridge line	Modern bridge line
Health	293	280
Commercial	400	370
Cultural	356	390
Sport	336	372
Aggregate Accessibility Score	**1385**	**1412**

6.5 Territorial distribution of public transport benefits

In order to evaluate and compare the territorial distribution of public transport benefits of the two planned options, we classified the population with walking access to a bus stop according to nationality.
Then we calculate two accessibility score, one for each municipality. The first score is a proxy of the ease to reach a certain destination for people living in the city of Tui, using one of the two-planned bus line. The second is a proxy of the ease to reach a certain destination for people living in the city of Valenca:

$$Acc_d^{Tui} = \sum_{i=1}^{n} \frac{pop_{Tui,i}^{o}}{t_{total}^{od}}$$

$$Acc_d^{Valenca} = \sum_{i=1}^{n} \frac{pop_{Valenca,i}^{o}}{t_{total}^{od}}$$

As before, two simple aggregated accessibility scores for each bus routes was obtained by summing the single destination score, as shown in table 7.2.

Table 7. 1 Territorial distribution of public transport benefits

Destinations	Old bridge line		Modern bridge line	
	Tui	Valenca	Tui	Valenca
Health	191	102	178	102
Commercial	281	119	251	177
Cultural	234	122	213	177
Sport	188	148	237	135
Aggregate Accessibility Score	**894**	**491**	**879**	**591**
	65%	35%	60%	40%

From the analysis of the two tables, the modern bridge line has emerged as:

- The line that reaches the maximum accessibility score. This means that the modern bridge line is able to connect a greater number of people with the desired opportunities in less time.
- The line where the territorial distribution of transit benefits are more equally distributed between the two municipalities. Regarding this aspect, one can observes that both the modern and the old bridge lines show a better accessibility for people living in the municipality of Tui. This result was expected as the majority of opportunities are located in the Spanish side of the Eurocity.

Conclusions

Cross-border cooperation has received increasing attention over the past few decades. It implies a greater institutionalized collaboration between contiguous subnational authorities across national borders.

In this chapter, we argued that the creation of a cross-border transportation network is a fundamental step in order to reinforce and foster neighborly relations between territorial communities. In particular, we pointed out that a common vision based on accessibility and mobility might be a good step forward. At the same time, we shown how simple accessibility measures can be used to evaluate alternative transportation strategies aimed to further the process of territorial integration within the Eurocity. This preliminary exploration is not intended as final answer, but rather as the opening of a debate about the use of accessibility measures in a both fascinating and complex context, as the territorial context of the Eurocity.

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