The south expansion of the Porto Metropolitan Area light-metro system

A. Antunes,(1) A. Seco,(1) and A. Pires da Costa(2)
(1) Civil Engineering Department, University of Coimbra, 3049 Coimbra, Portugal
EMail: antunes@dec.uc.pt
(2) Civil Engineering Department, University of Porto, Rua dos Bragas, 4099 Porto, Portugal
EMail: amcosta@fe.up.pt

Abstract

This paper presents a study recently made to establish guidelines for the south expansion of the Porto Metropolitan Area light-metro system in the short-, the medium, and the long-term. The Porto Metropolitan Area, in northern Portugal, has approximately 1,200,000 inhabitants and is one of the fastest-growing regions of the country. The initial solution adopted for the light-metro system will properly serve the north part of the area, but it is far from matching the transport needs of people living in the south part (municipalities of Vila Nova de Gaia and Espinho).

1 Introduction

Light-metro is an increasingly popular urban transport mode. According to Simpson [1], there are now at least 110 cities throughout the world where a light-metro system is installed. The Porto Metropolitan Area will soon have its own system. The initial solution adopted for the light-metro system will properly serve the north part of the area, but it is far from matching the transport needs of people living in the south part (municipalities of Vila Nova de Gaia and Espinho).

This paper describes a study made to establish guidelines for the south expansion of the system. The first part contains a brief presentation of the Porto Metropolitan Area. The second consists of a description of the light-metro system, followed by a short comment on its strong and weak points. The third part contains expansion proposals for the short-, medium-, and long-term development of the system. The short and medium-term proposals apply to the city of Gaia, and were established after a detailed analysis of the few alternatives.
consistent with the development guidelines set out in the Municipal Master Plan (Vila Nova de Gaia City Council [2]). The long-term proposals apply to the suburban areas of the municipality of Vila Nova de Gaia.

2 The Porto Metropolitan Area

The Porto Metropolitan Area (PMA), in northern Portugal, occupies a total of 817 km², along the Atlantic Ocean, on the two banks of the Douro River (Figure 1). The region comprises eight municipalities, six in the north bank (Gondomar, Maia, Matosinhos, Porto, Póvoa do Varzim, Valongo and Vila do Conde) and the other two in the south (Espinho and Vila Nova de Gaia).

The cities of Porto and Gaia are the heart of the metropolitan area. Porto was already an important industrial and trading town in the XIX century. At that time, Gaia was a very small town. The two urban centres have always been closely linked, particularly because Port Wine companies, which make Porto famous world-wide, are in fact established in Gaia.

The total population living in the PMA is approximately 1,200,000, and the total employment is 390,000 (Table 1). The two main municipalities are Porto and Vila Nova de Gaia. Together they account for 44.8 and 57.4 percent of people and jobs.

The PMA is one of the fastest-growing regions of the country. During the last 40 years the population growth rate exceeded 40 percent. While the municipality of Oporto lost over 10 percent of its residents, the population of neighbouring municipalities increased at rates ranging from 68.8 to 141.5 percent.

The rapid growth observed in the PMA led to an extremely large increase of car-ownership rates and traffic flows. Transport authorities initially reacted through improving the road system external to the Porto-Gaia area, thus favouring road transport modes. However, only recently a new Douro bridge was built to accommodate the intense national, regional and local north-south flows. This put a lot of pressure on the two existing bridges, D. Luiz and Arrábida. But, even if other bridges were built, this would only mean more traffic congestion problems in and around Porto and Gaia central areas, which were not prepared to receive more traffic, and, given their internal structure, will hardly ever be.

Table 1. Population and Employment in the Porto Metropolitan Area

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>Espinho</td>
<td>23084</td>
<td>36180</td>
<td>56.7</td>
<td>11732</td>
</tr>
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<td>Gondomar</td>
<td>84599</td>
<td>152020</td>
<td>79.7</td>
<td>28452</td>
</tr>
<tr>
<td>Maia</td>
<td>53643</td>
<td>102410</td>
<td>90.9</td>
<td>39349</td>
</tr>
<tr>
<td>Matosinhos</td>
<td>91017</td>
<td>164690</td>
<td>80.9</td>
<td>40126</td>
</tr>
<tr>
<td>Porto</td>
<td>303424</td>
<td>270060</td>
<td>-11.0</td>
<td>150335</td>
</tr>
<tr>
<td>P. Varzim</td>
<td>40444</td>
<td>58120</td>
<td>43.7</td>
<td>17779</td>
</tr>
<tr>
<td>Valongo</td>
<td>33300</td>
<td>80410</td>
<td>141.5</td>
<td>14021</td>
</tr>
<tr>
<td>Vila do Conde</td>
<td>48806</td>
<td>67300</td>
<td>37.9</td>
<td>20588</td>
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<tr>
<td>V. N. Gaia</td>
<td>157357</td>
<td>265660</td>
<td>68.8</td>
<td>65732</td>
</tr>
<tr>
<td>AMP</td>
<td>835674</td>
<td>1196850</td>
<td>43.2</td>
<td>390108</td>
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</table>
Figure 1. The Porto Metropolitan Area
3 The Light-metro System

In the early ’90s, the Metropolitan Board became conscious that the existing mobility problems could not be overcome without putting a much stronger emphasis on public transports.

Light-metro was then considered to be a good solution, undoubtedly the best one when both speed, capacity, reliability, comfort, and environmental issues are taken into account. The main drawback is the fact that it requires important initial investments.

In 1998, after a long and complex decision-making process, the PMA light-metro system plan was finally completed (Figure 2). According to the plan, the system will consist of four lines:
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- Line S: Santo Ovideo - Hospital de São João;
- Line C: Matosinhos - Senhora da Hora - Campanhã;
- Line P: Póvoa do Varzim - Senhora da Hora - Campanhã;
- Line T: Trofa - Senhora da Hora - Campanhã.

The total extension of lines will be 70 km. Of this total, 17 km will be new and the remaining 53 km will use the Guimarães and Póvoa railway lines, where the train will be replaced by the light-metro after extensive adaptation works, including electrification. In fact, only the corridors and the stations will be kept for the future, particularly because the system will be based on the standard rail width (1435 mm) instead of the metric rail width currently installed.

The total number of stations will be 67. Of this total, 45 will be new and the remaining 22, located on the Guimarães and Póvoa railway lines, already exist. Several stations will be part of inter-modal interfaces, some of them including park-and-ride facilities. They will provide easy connections with rail and road transport.

The highest frequencies will occur in the Salgueiros - General Torres and Senhora da Hora - Campanhã sections, respectively with 15 and 13 vehicles per hour per way (in winter, during the peak periods).

As a general comment, it can be said that the PMA light-metro system is an ambitious project which goes well beyond the expectations set out by a strategic transport study presented a few years earlier (HP Consortium [3]).

The system will serve the city of Porto especially well, significantly improving the accessibility to its three largest traffic-generation areas (Baixa, Boavista and Campanhã) and to the most important health-care and higher-education facilities. However, it will not serve the Pedras Rubras Airport and the EXPONOR Fair and Convention Centre, located nearby. The municipalities of Maia, Matosinhos, Póvoa do Varzim, and Vila do Conde, will also be properly served by the system. The municipalities of Gondomar and Valongo were left out of the system. This is surprising because the strategic transport study indicated Gondomar as a priority area for the light-metro system. The municipalities of Espinho and Vila Nova de Gaia will be poorly served. Indeed, only 3.1% of the total line extension will be located on the south bank, whereas 25.2% of the area’s population lives there (Table 2). For the solution to be equitable with regard to the north and south banks, the latter should have 22.9 km, instead of the 2.2 km retained on the plan.

In addition to this, the terminal station of Line S (the Gaia line) will be located right in the middle of Gaia, in an area densely occupied by people and activities. The area is characterised by intense traffic flows, and it will certainly continue to be when the reorganisation of the municipal road network currently under way is completed. This means that people from outside Gaia who want to enter the system in Gaia will have to travel deep into the city centre, thus making circulation and parking conditions there even more difficult.
Table 2. Quality of Service in the North and South Banks

<table>
<thead>
<tr>
<th>Area</th>
<th>Population (hab)</th>
<th>Line extension (km)</th>
<th>Population (hab)</th>
<th>Line extension (km)</th>
<th>Population (hab)</th>
<th>Line extension (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>%</td>
<td>Total</td>
<td>%</td>
<td>Total</td>
<td>%</td>
</tr>
<tr>
<td>North bank</td>
<td>895010</td>
<td>74.8</td>
<td>67.8</td>
<td>96.9</td>
<td>67.8</td>
<td>74.8</td>
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<tr>
<td>South bank</td>
<td>301840</td>
<td>25.2</td>
<td>2.2</td>
<td>3.1</td>
<td>22.9</td>
<td>25.2</td>
</tr>
<tr>
<td>Total</td>
<td>1196850</td>
<td>100</td>
<td>70</td>
<td>100</td>
<td>91</td>
<td>100</td>
</tr>
</tbody>
</table>

4 The Light-Metro South Expansion

The study presented in this paper was made under contract with the Vila Nova de Gaia City Council to establish guidelines for the development of the light-metro system on the south bank. The City Council wanted to reconsider the options made some years before within the Municipal Master Plan, and to prepare its own intervention on the discussions about the short-, medium- and long-term expansion of the system to be held within the Metropolitan Board.

4.1 Objectives

The guidelines were established to accomplish the following three major objectives:

1. To balance the quality of service offered by the system in the north and south banks;
2. To protect the urban area limited by roads IC1/2 and VL9 from receiving external traffic willing to enter the system (Figure 3);
3. To take the system to the other main traffic generation areas in Gaia.

4.2 Short-term Proposal

The obvious, easiest way of responding to objective (2) would consist of extending Line S down south to a new station located at Laborim, next to the Santo Ovideo IC2 interchange. This solution would require the construction of 1.3 km of surface line, along Avª da República, Gaia’s main street.

The Laborim station would become the system’s best entrance for people coming from the south through IC1 or IC2 who want to reach Porto’s central areas (Baixa and Boavista) without facing the traffic congestion risks inherent to road transport modes (which are particularly high at the Arrábida bridge). This station should receive the park-and-ride facility planned for the Santo Ovâdeo station, leaving the corresponding space free for other uses.

4.3 Medium-term Proposal

The extension of Line S down south to Laborim would only marginally respond to objective (3), as no new main traffic generation areas would be visited. After a detailed analysis of the city’s internal structure and development plans, it became clear that the best answer to Gaia’s demand for rapid public transport would be given through
the extension of Line S eastward to Vila d’Este following VL9 and Rua Conceição Fernandes; and

the construction of Line A, a new, “diagonal” line connecting Afurada, and further north Boavista, to Cravelos, near the EN222-VL9 interchange.

The extension of Line S, with 2.6 km, would serve important facilities, like the Monte da Virgem TV Studios and the Santos Silva Hospital, as well as the high-density residential area of Vila d’Este (approximately 20,000 inhabitants).

The construction of Line A, with 5.1 km, would serve the VL8 development axis (where some of the largest PMA shopping centres are located), the Devezas train station (Gaia’s main station), the high-density mix-uses area of Soares dos Reis, and some large factories located at Cravelos. The line would have to be underground for 0.9 km, between the Soares dos Reis and Santo Ovideo stations. The remaining 4.2 km could be installed at the surface.
Lines A and S would cross at Santo Ovideo station, thus duplicating access to the system for the population living in the surrounding areas. This has the advantage of allowing this population, which is numerous and more numerous will be upon completion of existing important land development projects, to travel to Porto’s central areas without transshipment.

The terminal stations of the two lines would be quite near. This can also be seen as beneficial, for similar reasons. In fact, people coming from the south to Boavista could easily find a direct light-metro connection just by travelling north an additional 2 km on VL9, from Laborim to Cravelos. And people coming from the east to Baixa, could also find a direct light-metro connection by making the opposite.

The implementation of this proposal faces a major obstacle: it requires the construction of a new Douro bridge, connecting the Afurada area to one of the most congested areas of Porto. However, it should be said that the new bridge is unlikely to aggravate the existing congestion problems. Instead, it will probably contribute to their attenuation, because congestion is mainly provoked by traffic internal to the Porto-Gaia area. By lack of alternatives this traffic is forced to use IC1/2 and the Arrábida bridge, being responsible for the traffic jams frequently observed at the Afurada and Arrábida interchanges, and in the streets of Boavista close to the latter. With the new bridge some of this traffic would be diverted to public transport. And the interchange traffic jams will possibly be eliminated.

The itinerary followed by Line A could alternatively connect the Devezas station to General Torres, C.M. Gaia (Vila Nova de Gaia City Hall) or Parque. The General Torres option was discarded because the line would then develop through low-traffic-demand areas, and would leave the highest-density areas unserved. The other two would be better from this point of view, but they are located in excessively congested areas. Additionally, none of the three would prevent EN222 traffic from entering into the city centre (particularly traffic going to the Boavista area).

4.4 Long-term Proposals

If implemented, the short- and medium-term proposals presented above would greatly improve public transport conditions in the Municipality of Vila Nova de Gaia, but they are not enough to balance the quality of service in the north and south banks. For this to occur, 22.9 km of railways are needed, and the proposals only include 9.9 km. Although the remaining 13.0 km are unlikely to be built in the next 10-15 years, it is important to have a clear view on what the expansion corridors should be, for land-use planning and management purposes.

The methodology used to define the long-term expansion proposals consisted of three stages. In the first stage, the set of road segments offering appropriate conditions to accommodate light-metro lines was identified (Figure 4). Preference was given to: segments assigned to local traffic; segments with a appropriate width conditions; and segments with significant amounts of side construction. In the second stage, production and attraction indicators for the 69 traffic-generation zones into which the PMA was divided were calculated. The indicators take into account the current trends for the spatial distribution of population and employment, and the municipal intentions regarding the development of the area. In the third stage, six alternatives for the south
expansion of the light-metro system were formulated. These alternatives were then classified according to two criteria, “aggregate accessibility within the system” (Handy and Niemeier[4]) and “aggregate accessibility to the system”, respectively measured by:

\[ X_W = \sum_{j \in N} P_j \cdot \sum_{k \in N} \frac{A_k}{T_{jk}} \]

and

\[ X_T = \sum_{j \in N} P_j \cdot \min_{k \in N} (T_{jk}) \]

where: \( N \) is the set of zones served by the light-metro system; \( X_W \) and \( X_T \) are indicators for accessibility within and to the system; \( P_j \) is the traffic-production index for zone \( j \); \( A_k \) is the traffic-attraction index for zone \( k \); and \( T_{jk} \) is the travel time between zones \( j \) and \( k \).

The six alternatives were as follows:
1. Vila d’Este - Grijó (via Carvalhos);
2. Laborim - Grijó (via Carvalhos);

![Figure 4. Long-Term Expansion Network](image-url)
3. Vila d'Este - Lever;
4. Cravelos - Avintes (via Oliveira do Douro) and Vila d'Este - Brandariz (via Carvalhos);
5. Cravelos - Avintes (via Oliveira do Douro), Laborim - Canelas, and Devezas - Lavadores;
6. Avintes - Vila d'Este - Serzedo.

The classification of the six alternatives according to the two criteria is shown in Figure 5.

Alternatives 4 and 5 clearly dominate the others. Alternative 4 is the best one for the traffic-generation zones not directly served by the system (43% gains) and the second-best for the zones served by it (36%). Alternative 5 is the best one for the zones served by the system (51% gains) but the worst for the zones not directly served by it (28%). Depending on the weights put on the criteria, one or the other should be selected for implementation.

References