The Public Space as a Consequence of Subway Expansion

The Case Study of Lisbon Subway – 1959 through 2009

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Abstract

Up to the mid XXth century the city of Lisbon grew obeying to traditional urban drawing principles. It grew through the fundamentals of the Projected/Planned city, but in both cases it was the public space that defined the structure of the urban lattice. At that time the grandiosity and symbolism of public spaces created attraction points that generated dynamics that made the city prosper. Today this logic is different.

The subway development revolutionizes the way cities grow. The opening of a new subway station potentiates a chain of opportunities in different sectors. The urban economy of that place can progress and also can progress the public space and the architecture around a new station.

Cities drawn in a pure grid system are easy to navigate since they provide multiple routes between any pair of locations and therefore minimize the number of navigation instructions. Although this morphology minimizes descriptions, it doesn't differentiate the main urban spaces. Alternatively if cities are purely hierarchical systems, they will clearly have a main central place from which others grow and span. This creates a highly segregated system that will have though social consequences. Cities are neither trees, nor perfect lattices, but a combination of structures that emerge from the social and constructive processes. The interplay of the topology of the communication networks (roads, subway, tram, etc...) and the morphology of the urban space create the dynamics necessary to have some local hierarchy and structure and still keep some relation to distant parts of the city.

Through the historic analysis of the subway network evolution, the impact of subway expansion in the city growth is put in evidence. A mathematical graph theory analysis of the historic networks, provided measurements of the relative importance of different subway stations according to different network concepts like closeness, betweenness, average path lengths, etc…

This work qualifies the impact of subway planning in the growth of the city. It shows how a change in the topology of the underlying network affects the dynamics of the urban fabric and shows how different approaches to subway expansion and consolidation will result in changes in the centrality of certain areas of the city.

Introduction

Is it possible that we are seeing the death of the city? Or is it a renewal of its structure? How will transportation, mainly the subway, constrain and change the growth and design of the city?

Through the continuous impact of globalization and information technologies, no place in earth is safe and all kinds of business can be relocated. Will this lead to the cities death as it been announced by Gates and others? Most certainly it wont (Hall, 1999, p. 961).

J. Borja and M. Castells also defend that globalization, with global information and generalized urban diffusion, don't imply the disappearing of the city as a specific relation between territory and society, allowing even a dynamical and creative relation between the local and the global (Borja, 1997, pp. 12-13).

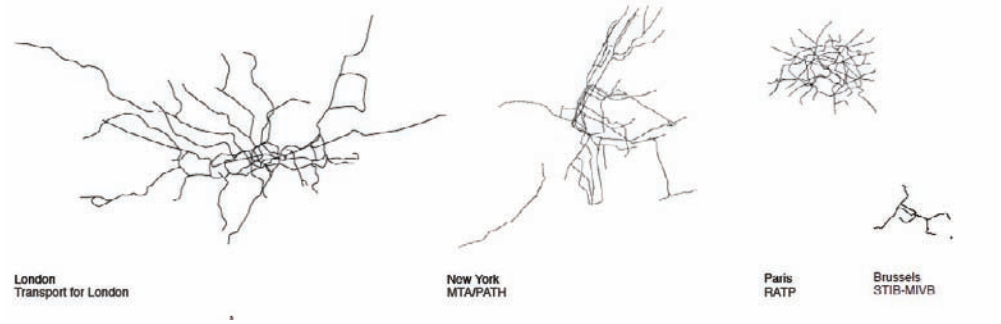
Is in this modern city that mobility and fast transportation gained a greater then everything else relevance. We can say that the evolution of transportation means is responsible, in part, for the diffusion of information and news. The subway network allowed the shortening of the geographical, economical and consequently the socials distances.

It is known that this evolution influenced the development of the urban form. The appearance of the railway, while reducing the time to travel between places, facilitated the dispersion and growth of the metropolitan areas.

We can say that the city image is then associated with the notion of path and time and simultaneously to others places in the territory. The way one perceives the notion of territory changes constantly due to the change in the notion of speed, not only through new and faster transportation means, but also due to new technologies, bypassing the geographical boundaries for this notion of territory.

Fast transportation (be it train or subway) allowed the suppression of the importance of distances, valorising instead the importance of time instead of space, subverting in a certain way the natural rules of territorial organization. It's effects on the territory are perverse, reinforcing its heterogeneity, making it non-continuous, polarizing it and potentiating hierarchies changing the territory image and its underlying social structures.

Subway networks are, in part, responsible for the urban design of the underlying structures and are a reflex of the plans of those cities. In the case of Lisbon, the subway followed the city growth and enriched the areas served by it. The opening of a new station was a driving force of the economical and social development of that area.



[fig. 1] – Several subway networks at scale.

Analysing Lisbon's subway network, and its evolution through time, we can observe small changes in the economical and social dynamics of the areas near each station. The subway acts as an attractor and potentiates different city uses, with respect to the station localization. We then observe areas that are more prone to commerce, office buildings, residential, etc… The subway infrastructure conditions and promotes at the same time the development of the urban fabric.

This attractiveness (relative to the city functions) of the subway, will constantly change the way the city works as a social structure and the city architectonic/urban image.

Although affected by the subway, architecture and urbanism – as agents of spaces transformation – are the instruments capable of planning (and re-planning) the subway areas through interventions at different scales (SAMPAYO, 2003):

In the design of the new city;
In the design of the periphery city;
In the design of the city in the urban voids;
In the design of the city in consolidated urban fabric.

In the design of the city in consolidated urban fabric (process of city regeneration) through the implementation of the subway network, one saw several improvements in Lisbon at the level of the public space (facades renovation, for example). The subway positively contributes to the society, to the public space and to the city in a general perspective, through the increase in mobility and urban regeneration, as it is the case of "Baixa"(Downtown) in Lisbon.

The Lisbon Subway

The story of the Lisbon subway goes back to 1885. By that date, in the reign of D. Luís, the engineers Costa Lima and Benjamim Cabral suggested the construction of a subway for the city of Lisbon. The subject was being discussed through out Europe. London was the first to inaugurate its subway in 1863, New York in 1968, in 1896 it was Budapest turn and in 1897 Glasgow inaugurated its subway. The city of Paris started the construction of its subway in the year 1898. (ROLLO, Novembro/Dezembro 2005).

The old railway system, with its stations, is responsible for the creation of urban centralities, but also for the fractioning of the territory, in the sense of generator of barriers and wals. The subway changes this, eliminating those fractures. With the ability to elevate the tracks or hide them under the earth, the subway solves the fractures and crossings that the traditional railway implied.

In 1888 the military Engineer Henrique de Lima e Cunha, presented a project to the Portuguese Civil Engineering Association called "Sketch of a plan for a Lisbon Subway"[1] (CUNHA, Julho e Agosto de 1888). This project didn't have any continuity as there where many other proposal, more or less ambitious, some even naïf, or without viability that never left the drawing boards, because in practice the country didn't had the financial conditions for the concretization of such project (ROLLO, Novembro/Dezembro 2005).

1 Translated: "*Esboço de traçado de um Caminho de Ferro Metropolitano em Lisboa*" in the original.

Only in 1949 was constituted a company that would build and explore, in exclusive terms, a transportation system based in the subsoil of the city of Lisbon (ROLLO, Novembro/Dezembro 2005). Ten years later in 1959, the first phase of the Lisbon subway was finally ready and the subway opened its doors with 11 stations and 6,5km length.

[fig. 2] – Lisbon Mayor visitng the subway tunnels in 1958 (Serôdio, 1958)

The initial stations (Restauradores, Avenida, Rotunda, Parque, S. Sebastião, Palhavã, Sete Rios, Picoas , Saldanha, C. Pequeno and Entre Campos) had a fundamental role in the development of the city, although with the subsequent subway expansions their roles changed.

One can say that the subway expansion in Lisbon is somehow short of others subway systems of the main capitals of Europe. The expansion was slow and only had great improvements when big international events occurred in Lisbon. From the different phases, one can state those relatives to the years of 1959, 1998 and 2004, which are respectively the start of the infrastructure, the world exhibition of Lisbon in 1998 and the soccer championship in 2004 (UEFA Euro2004).

In 1998, the subway had 27,7 Km and 40 stations. Its connection with the 1998 exhibition was very determinant in the urban success of that area. It allowed the urban integration of all the Expo area. The urban success of the post exhibition of 98 when compared with the previous world exibition in Sevilha 92, can be attributed in part to the existence of the subway and the interface at Gare do Oriente (train, subway, bus, taxi).

In 2004, with the soccer championship, Lisbon had two soccer stadiums in the outskirts of the city. The subway expansion at this time expanded those lines that would benefit the areas near these two stadiums (Luz and Alvalade). The stations of Alfornelos, Amadora Este, Ameixoeira, Lumiar, Odivelas, Quinta das Conchas and Senhor Roubado where built. These stations where localized in the periphery of the historical city, many of which resulted from the unordered urban sprawl. With these stations the land value increased and new business opportunities arose.

One can't say that the small expansion of the Lisbon subway is due to the morphology and history of the city, as the example of Oporto subway in the north seems to contradict this, showing great advances in a short time. The present Lisbon subway might be justified by political and economical reasons. For the future the Lisbon subway faces two challenges. One is the increase in the network density; the other is to gain a regional dimension (Pereira, 2001).

Graph Theory Fundamentals

One can study the city at different levels and using different tools. Graph theory, had it's first application in the solving of a urban problem: the problem of the Königsberg bridges was solved by Euler in 1735 (Euler, 1741). During the 1980-1990s, Space Syntax has taken a new revitalized approach of graph theory to measuring city features (Hillier & Hanson, 1989). One aspect of this theory of particular interest is that of defining the volumes of space seen from a point in the city, called Isovist (Benedikt, 1979). More recently Agent-Based simulation has gained particular interest, as some non-linear features are not possible to account with traditional reductionist approaches (Batty, 2007). The non-linearity of social aspects of life systems is also manifested in the cities and the mathematical analysis of urban spatial networks as been given a particular attention with the work on random walks by Blanchard and Volchenkov (Ph Blanchard & D. Volchenkov, 2008; Philippe Blanchard & Dimitri Volchenkov, 2008).

In particular the subway system by its nature, seems particularly appropriate to be studied under the graph theory framework. The network of lines can be mapped to a topological space where one can abstract the relations between stations without taking in consideration the effective geographical distribution of such stations. In this topological space one can determine certain properties that are independent of the semantic content and still hold important information about the underlying reality they map (Rodrigues, 2009).

The Graph Analysis

For this work we draw the networks of the several stages of the Lisbon subway expansion and measured (for each of the resulting networks) some properties of interest in terms o networks. Interested mainly in the notion of centrality and the role of each subway station in the global dynamics of the network, we analyzed the network for Closeness and Betweenness.

Closeness

Closeness is a centrality measure of the vertices of a graph that gives an insight on the distance a node is from the rest of the network. It is defined in terms of the geodesic distance – the number of hops it is necessary to take in order to go from one vertex to another through the shortest path – summed over all the nodes of the network.

$$C_i = \frac{1}{\frac{\sum_{j=1;\, j\neq i}^{n} GP(i,j)}{N-1}} \qquad (1)$$

In the previous equation *GP(i,j)* is the geodesic distance and N is the total number of nodes of the network (number of subway stations).

Betweenness

The betweenness centrality measure (Anthonisse, 1971; Freeman, 1977) accounts for the role of a certain node in the flux of information through the network. In the subway case the betweenness centrality measure gives the importance of a subway station in terms of the flow of passengers that have to go through it in order to connect two other stations. Mathematically it is given in terms of the fraction of geodesic paths that go through a particular vertex:

$$B_i = \frac{\sum GP(i)}{\sum GP_N} \qquad (2)$$

Results

[fig. 3] – Lisbon Subway Network in 2007.

We calculated the values of Closeness and Betweenness for all stations in the network at different dates: 59/12/01; 63/01/01; 66/09/01; 72/06/01; 88/10/01; 93/04/01; 97/10/01; 98/11/01; 02/11/01; 04/05/01; 07/12/01 and 09/12/01[2]. From the results we present the top 3 stations at 4 particular times: 1959, 1998, 2004 and 2009. This is shown in [fig. 4] for Closeness and [fig. 5] for Betweenness and in Table 1 and Table 2. From the results it is observed that there's a change in the most central stations of the network with the subway expansion.

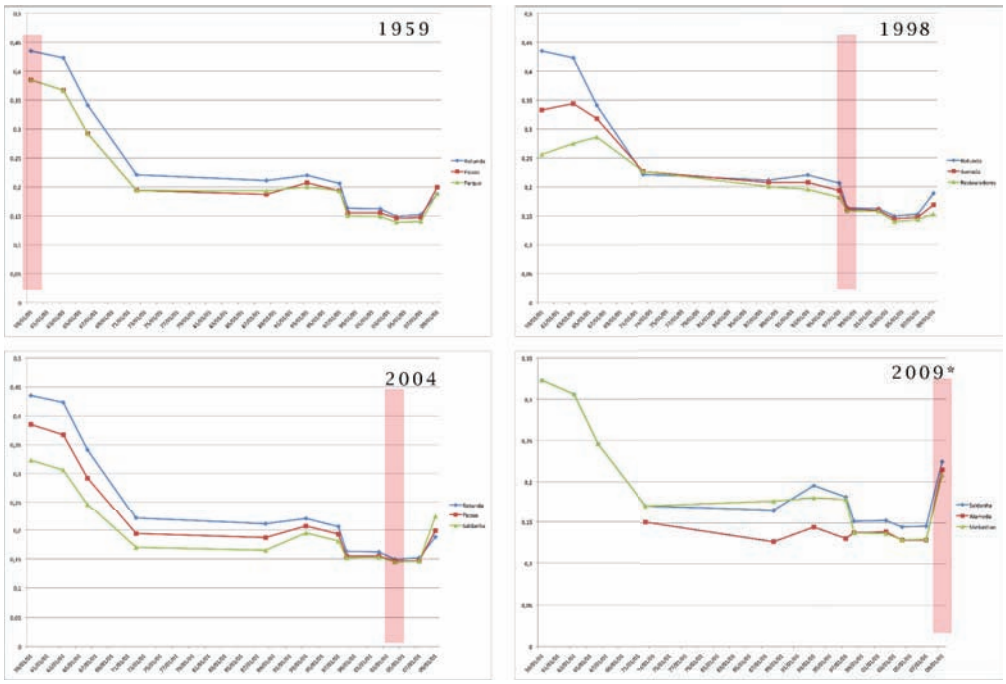
1959	1998	2004	2009
Rotunda	Rotunda	Rotunda	Saldanha
Picoas	Avenida	Picoas	Alameda
Parque	Restauradores	Saldanha	S. Sebastião

Table 1 – Closeness Top 3 Stations

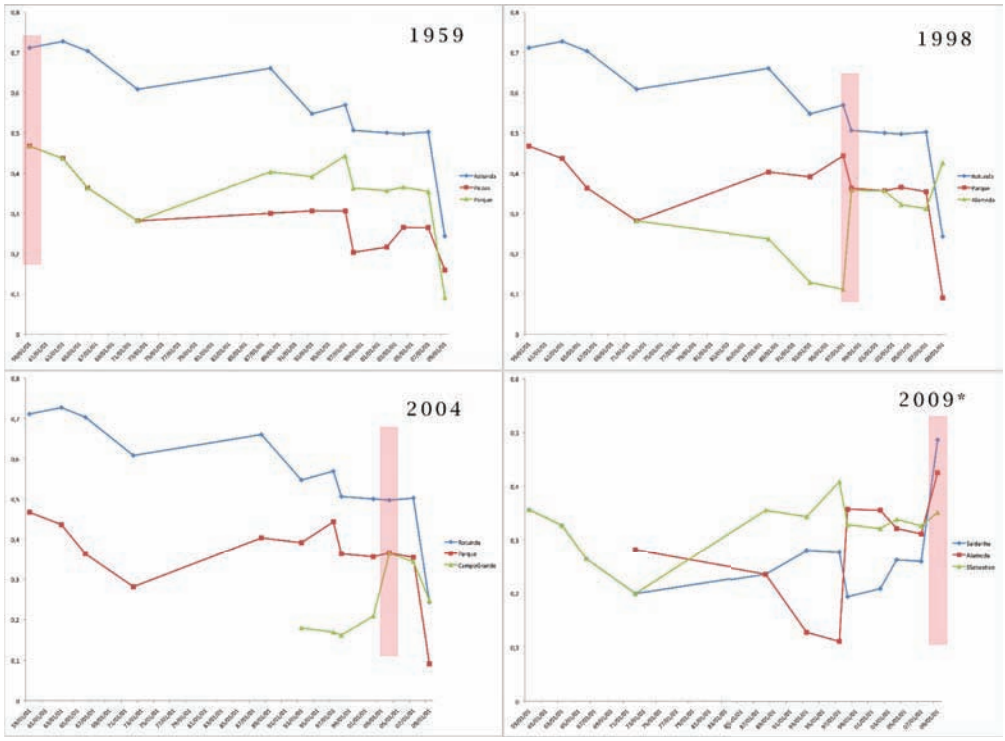
2 The network is presently undergoing the final states to connect the stations of Alameda and Saldanha and S. Sebastião, with the opening of this line scheduled to the end of August 2009. This date was chosen to reflect this change.

1959	1998	2004	2009
Rotunda	Rotunda	Rotunda	Saldanha
Picoas	Parque	Parque	Alameda
Parque	Alameda	Campo Grande	S. Sebastião

Table 2 – Betweenness Top 3 Stations



[fig. 4] – Closeness evolution of the Top 3 stations at different phases of the subway expansion (1959, 1998, 2004 and 2009). * - Projected plan for the end of year*



[fig. 5] - Betweenness evolution of the Top 3 stations at different phases of the subway expansion (1959, 1998, 2004 and 2009). * - Projected plan for the end of year*

Conclusions

In the present work we showed the evolution of two centrality measures (Closeness and Betweeness) in the expansion of the Lisbon subway network. We shown that in both cases changes in the network topology affect the importance of different areas of the city in terms of centrality.

It was shown that in 1998 and 2004, with the world exhibition (Expo 98) and euro soccer championship (Euro 2004), when the network suffered great expansions in terms of new stations being added to the network, the most central areas, both in terms of Closeness and Betweenness, basically remained the same. This is due to the fact that this expansion didn't increase the density of the network expanding it to connect to remote areas of the city and neighbourhood populations. On the other hand, in 2009, the change in the network is simply a change in the configuration, increasing the density of the network. This makes a big impact in the centrality of the different stations as can be seen in Table 1 and Table 2. Saldanha, Alameda and S. Sebastião are now the most central stations of the network, be it in terms of proximity to all other stations (Closeness), be it terms of the traffic that goes through them (Betweenness). These 3 stations correspond to an younger layer of the city while the pre-2009 top 3 stations correspond to a inner and older layer of the city fabric. This shows a shift in centrality and importance of the city areas. The downtown "Baixa" isn't now the most important and central part of the city. Gradually it is losing it's place in favour of a new centrality in "Avenidas Novas".

The observed results allow us to identify the two different approaches to the subway expansion proposed by Pereira (2001): The expansion to the periphery (1998 and 2004) of the city and the densification of the exiting network (2009). With the periphery expansion reaching it's limits, the subway network development is entering the consolidation phase. This phase will have a predominant role in the change of the urban fabric as it will be the most responsible in changing the centrality of the city, as shown in the paper.

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