

Sustainable public urban transport systems: The case of Curitiba

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Abstract

This paper describes the present urban public transportation in the city of Curitiba, Brazil.

The city was chosen for this research because of its urban public transport system, which had a major role in urban planning development; this consists of an integrated network of busses, developed in combination with land use, population density and road hierarchy, as a consequence of the Master Plan implemented by the city in the late 60s.

The sustainability of the system was analysed, using as the main framework, the United Nations Habitat Agenda recommendations on sustainable transport and applying these criteria to the public transport system of Curitiba, making use of available literature, interviews and observations.

From the analyses of the system, it was evident that it achieved positive indicators regarding its sustainability in the criteria of accessibility, economical feasibility and coordination of land use and transport system. However, negative indicators were also evident, that leads to the conclusion that it is not a sustainable system. These aspects were in the criteria of intermodal transportation, disincentives for private motorization traffic and the use of diesel fuel.

Keywords: *Curitiba; Sustainable public transport; Land use; Public urban transport system; Integrated Transport Network; Urban Planning; Sustainable transport system.*

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Acronyms and abbreviations

BRT – Bus Rapid Transit	CIC – Curitiba’s Industrial City
COMEC – Curitiba Metropolitan Region Coordination	CWB – Curitiba
IPPUC – Curitiba Institute of Research and Urban Planning	LRT – Light Rail Transit
PM ₁₀ – Particulate Matter 10	R\$ – Brazilian Real
RMC – Metropolitan region of Curitiba	RIT – Integrated Transport Network
URBS – Urbanization of Curitiba	µg – microgram

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1 Introduction

Today the cities are residence to half of the world's population, and in 2030, 60% of the population will live in a city (UNFPA , 2004). The urban areas have an increasing importance in our society as they are continually growing, along with all the issues related to them. Therefore urban areas should be seen as the answer to those issues, as Mr. Lerner (three times Mayor of Curitiba and twice Governor of the State of Paraná) pointed out. Problems, as the ones related to urban transport, and their interrelated impacts on the environment, economy and society, are always getting bigger as the cities are growing in their size and population.

Nowadays the transport system worldwide relies heavily on non-renewable resources. In the EU25 gasoline and gas account for 44 and 55 percent of final energy consumed by transportation (EEA, 2003), while it is a major consumer of two exhaustible resources, oil and land (Greene et al, 1997). Road and rail respectively are the first and second largest land consumers (EEA, 2002), and cause several negative consequences such as pollution, subsequent health-related problems, traffic congestion or accidents.

Implementing more sustainable transport systems within human settlements is fundamental in order to limit those issues related to transportation. This can also have positive impacts on the city itself, for example alleviating many problems afflicting disadvantaged social classes – such as the poor, women or elderly people – by providing accessibility to the transport system (OECD, 2002), to have an easier access to jobs, goods or services (OECD, 2000).

The city of Curitiba is today used as a world reference for its integrated public transport system, as Mr. Lerner himself used to point out (Phillips, 2008). This innovative system is the consequence of a switch in planning and city's government during the late60s/early 70s.

As will be exposed in this paper, Curitiba's public transport system today transports the majority of its population, while the costs of its implementation were relatively low; now the system is financing itself, without recurring extra expenses from the municipality, and is pivotal in having brought a lower consumption of oil per capita compared with the surrounding Brazilian cities.

1.1 Purpose of the paper

With this paper, the author intended to develop a better understanding of what a sustainable urban public transport system is. Furthermore, the paper highlights what the main features and criteria are for a city in order to move towards a sustainable urban public transport system. This is achieved through an analysis of the city of Curitiba as a case-study. The main research question is:

- **Is Curitiba's public transport system sustainable?**

This paper will expose a specific example about what can be done to reach sustainability in an urban public transport system, giving the reader the opportunity to gain knowledge from Curitiba's experience. To answer the main question, sub research questions have been developed to guide the research:

- What development occurred in Curitiba to get to the current system?
- What future developments are planned by the city?
- How does the Curitiba public transport system compare to the UN Habitat recommendations?

1.2 Thesis outline

In order to address the research questions proposed, City and State general background will be presented (chapter two), the methodology used in this research (chapter three), the main agencies responsible for the city and transport planning, the history of the city and public transport system planning, until the present time (chapter four), as the basis to analyze the sustainability of the system. Plans for the future are presented (chapter five) in order to know what the development of the city will be. The theoretical framework of the paper is presented, and additional criteria of sustainable urban transport systems will be developed by the author (chapter six). Then the seven recommendations proposed by the UN Habitat Agenda document will be presented and the Curitiba transport system will be analyzed against the criteria (chapter 7.1) and it will be presented what, in the author's opinion, resulted to be (after the analysis of the Curitiba public transport system) the main features in order to move towards a sustainable public transport system (chapter 7.2).

2 Background

2.1 Brazil

Brazil's surface covers almost half of the entire South American continent. It is the fifth largest country in the world, with a total population of around 190 million people, concentrated in coastal areas, and a very low

Picture 1. Map of Brazil. Source: www.destination360.com



population density with 22 inhabitants/km², almost the same as the Sweden (UN, 2006).

It is a Federative Republic made up of 27 states (Pic.1), which has most of its economic and financial activities in the states of the south and the southeast region of Brazil (Macedo, 2004).

2.2 Curitiba

Founded in 1693, Curitiba became the capital of the south-eastern Brazilian State of Parana in 1954; today it has around 3.2 million inhabitants in its greater area

(IBGE, 2006) – with an estimated increase of one million in the next ten years. Curitiba itself has 1.8 million citizens (IBGE, 2007), four times more than in the 60s, becoming one of the fastest growing cities in Brazil during this period, and unlike most of the other South American cities, its rapid increase and development were not left to its own organic growth (a natural sprawling). In fact, the current development of Curitiba is the consequence of the adoption of a planning process that based most of its policies on the integration between the development of public transportation, road system and land use (Rabinovitch et al., 1995).

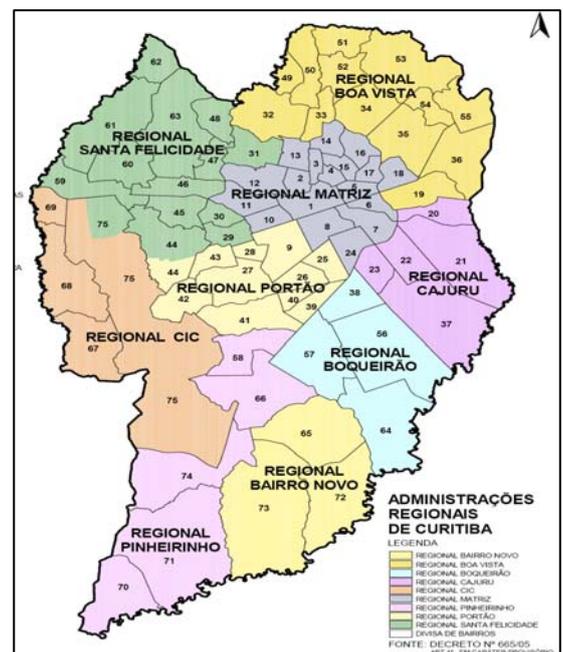
Curitiba is located about 400 km to the south west of Sao Paulo (Pic.1), the city spreads out on a 435km² territory (Pic.2) (IBGE, 2008), and with a density of almost 4100 person per km². Greater Curitiba has 26 municipalities – including the city itself, which is divided into seventy-five neighbourhoods, distributed in nine so called Regional Administrations of Curitiba (IPPUC, 2008).

2.3 History of the city

At first Curitiba was a small settlement and based its economical activities on cattle trading and agriculture. Increasingly it started to become more important and became a magnet for commerce and companies. In the 30s tea, timber, cattle and coffee were leading the city's economy (Macedo, 2004). After the second World War rapid increase in the demography went side by side with its growth in industries and commerce (Adielsson & Friberg, 2001), so that the last 30 years were characterized by the highest urbanization and growth rate than any other city in Brazil (Macedo, 2004). Curitiba's population was around 80,000 in the 20s, by the beginning of the 40s it reached 130,000 and was growing at 3.57% per year (IPPUC, 2008). In the beginning of the 60s the city already had a population of 400,000 and was still experiencing rapid growth.

The city, in those years, had the same rampant problems of the other Brazilian cities, such as poverty, unemployment traffic congestion and housing; this was also a phase with the growth of the *favelas* (slums) phenomena – the first in Curitiba were reported to [Picture 2. City of Curitiba. Source: www.ippuc.org.br](#) appear in this period (Macedo, 2004) – connected with the migration to the urban areas. Consequently Brazil experienced an overthrow of government by the military in 1964, when raised the fear of the upcoming communist regime due to the increasing social and economic issues (BBC, 2004).

In addition as a result of extraordinary climate condition due to frosts, a vast part of the coffee production – which at that time represented an important share of the Paraná economy (and also Brazilian; it represented 50% of all exports) – was destroyed (Macedo 2004). Agriculture production, after this experience, was modified. More products, such as maize or



soybean, that can be produced with the help of machinery reducing the number of employees (Macedo,2004), were adopted; Ms. Daher also pointed out that the coffee industry, which normally requires lots of workers and a small use of technology (similar to the grapes/wine industry), reduced itself, creating huge immigration flows to the cities (although coffee still represents an important part of the Paraná agriculture), where people were hoping to find employment in the local industries. The population distribution of Paraná started to change radically: rural population decreased from 64% in 1970 to 19% in 2000 (Macedo, 2004).

As explained by Mr.Ficinski, unlike what happened a couple of centuries ago in Europe, the modern factories did not need such a large amount of manpower anymore, creating a huge wave of unemployment, with people that lost their job in the countryside but were not able to find one in the city; they were not able to buy houses, pay rents and so on, and the phenomenon of the favelas, that was already present but in a minor way, began to grow rapidly.

Therefore, in order to avoid organic growth and the issues related to it, the city implemented an urban plan; it was thought by the city planners to create physical structures, such as main corridors, that guided the development of the city (Wilheim, 1969). It was understood the necessity to implement an urban plan constantly integrated in every administrative decisions; to this extent, the Agache Plan in 1943 – the first real city plan of Curitiba – turned out to be a fundamental decision.

As a result of its planning and policies implemented in issues as housing, recycling, and especially its transport system (Macedo, 2004), the city was describe as “a model of urban ecology planning” (Pedreira & Goodstein, 1992), “the best city in the world” (Meadows, 1995) or “the ecological capital of the world” (Kroll, 1999).

2.3.1 *General data about Curitiba*

The city is the capital which has the lowest index of illiteracy in the entire country (Curitiba.org, 2008), with an index of only 3.4% illiterate inhabitants older than 15 years, against a national index of 13.6% (IPPUC, 2008a).

It has 51 m² of green area per citizen (ibid.), with innovative waste management policies; amongst them the “*lixo que nao è lixo*” (garbage that it is not garbage) and “*cambio verde*” (green trade), in which the city gives to people food, bus tickets and books, in exchange for garbage. With the programme “garbage purchase” Curitiba won an international award from the United Nations Environment Program (ibid.).

The state of Paraná and Curitiba have a GDP index per capita higher than the Brazilian average, R\$12.339, R\$16.059 and R\$11.658 respectively (IBGE, 2008).

3 Methodology

This thesis is based on the review of quantitative and qualitative data collected from scientific articles, reports, official documents from the municipality of Curitiba and its institutions, statistical data from the

Brazilian governmental institutes, mass media and books concerning the subject; in addition interviews and observations were conducted in the city of Curitiba itself.

In order to gain a deeper understanding of the system, interviews were conducted; semi-structured interviews were used with the citizens (Appendix 2), so to be able to be more flexible during the interview (Bryman, 2004). In semi-structured interviews, the interviewer asked a series of questions so as to cover specific topics, but the order may not have followed the pre-established questions, for instance if the interviewer wants to focus more on some answers of the interviewee (ibid.). A combination of closed and open-ended questions were used, sometimes probing for a more complete answer or better explanation of the question.

Non probability sampling methods were used (ibid.), as the author wanted to be aware of what the younger generations (subjects of the interviews) feel about the system and its development in the future, because they will be more involved in the future choices and developments. A convenience sample method was adopted (ibid.), interviewing only citizens that were already known to the author as it was not feasible to stop the users outside the bus stops, as the author did not have any particular formal identification and also because of time related issues (the users would not have stopped for a long time). Users from different areas of the city were chosen, so as to have different users of different lines, different economical situations between the richer central areas and the poorer peripheral zones. Interviews were conducted always in an informal environment, private houses or public spaces and in the last weeks of the author's stay in Curitiba; thus creating an even more informal atmosphere in order to reduce the possibilities of biased response (Powell et al., 1997). The aim of these interviews were to understand what were the main positive and negative aspects of the transport system perceived by the people, and if the public transport was seen as a good alternative to private motorization. In addition other users of the system or simply citizens were subject of informal conversations.

Prominent people were also interviewed in order to provide a better comprehension of the system, its history and future implementation, always with semi-structured interviews (Appendix 1), which was used in order to highlight the interviewees' point of view, what they thought was more important to explain, leaving the author the possibility of asking new questions while important ideas were coming out from the answers (ibid.). Those interviewed: (a)Almeida Clever, Engineer, IPPUC (Curitiba Institute of Research and Urban Planning); (b)Ceneviva Carlos Eduardo, former President of IPPUC and former president of URBS (Urbanization of Curitiba); (c)Costa Daniel, Engineer, URBS (he was interviewed by email due to logistical problems); (d)Daher Ariadne, Architect, Lerner Arquitetos Associados; (e)Ficinski Lubomir Dunin, former president of IPPUC; (f)Lerner Jaime, former Mayor of Curitiba and Governor of Paraná, former President of IPPUC; (g)Soares Anive, Architect, URBS; (h)Vallicelli Liana, Foreign Affairs Advisor, IPPUC.

In order to not cause intervening variables (ibid.) from having people answer questions in non-native language, the author of this study decided that it was of paramount importance to learn Portuguese so as to conduct research in the language of the interviewees; the author achieved a fluent level of Portuguese, being

able to access large quantities of data available only in Portuguese. Unobtrusive methods were also adopted, with simple observation of the situation inside busses, bus stops and terminals. The author did not want to let the users and the employees of the system know that they were being studied, so as to observe normal actions (ibid.); the author spent many days using the system trying to comprehend how the system really worked and the users' natural reactions to the daily issues when using the public transport system.

3.1 Limitation

This paper will not discuss in depth the issues regarding the use of alternative fuels to fossil fuels such as biofuels or electricity, the use of alternative systems such as light rail or metro, and the future capacity of the system, due to the broad scope of the paper. Though this cases could be addressed in further research about the public transport of the city.

3.2 Stakeholders

The stakeholders of public transport system are represented by the municipality, URBS, IPPUC, users of the system, citizens, private bus companies, COMEC.

4 The planning of the public transport system

4.1 Agencies

In order to give a description of the history of the public transport system in Curitiba and its planning, some agencies that operate at a metropolitan or urban level need to be presented.

4.1.1 Metropolitan level agencies: COMEC

The 26 municipalities that form the Metropolitan Area of Curitiba (RMC – from Região Metropolipolitana de Curitiba) experienced a significant growth rate in the second half of the last century, especially during the 50s–70s (Table 1); together with Curitiba (CWB) (Table 3) – with a growth rate higher than 7% and 6% respectively during the 50s and 60s (Schwartz, 2004) – saw its population become ten times greater in the last 50 years (Hawken et al., 2004).

It was common belief among the policy makers of the end of the 60s / beginning of the 70s, that even if it was impossible to stop the growth of the metropolitan and urban area, at least something could have be done in order to guide this growth.

	POPULATION GROWTH RATE					
	1970	1980	1991	1996	2008	2020
CWB	5,34	2,29	2,34	1,83	1,24	1.08
RMC	5,38	2,90	3,32	2,87	2,8	-
RMC without CWB	5,45	4,04	4,88	4,37	-	-

Table 10: Growing rates of CWB, RMC with and without CWB, 1970-2008, with 2020 predictions from IPPUC. Sources: (IPPUC,2008; Almeida,2008; IPPUC,2008b)

Table 11: Population of CWB, RMC with and without CWB, 1970-2008, with 2020 predictions from IPPUC.

	POPULATION						
	1970	1980	1991	1996	2000	2008	2020
CWB	609.026	1.024.980	1.315.035	1.476.253	1.587.315	1.797.408	2.088.897
RMC	907.931	1.532.383	2.099.558	2.471.771	2.768.394	3.172.357	4.540.000
RMC without CWB	298.365	507.403	784.523	995.518	1.181.079	1.374.949	2.451.103

Making the municipalities better coordinated between themselves was seen as an important step to assure the development of the area, so the creation of a coordination body in 1974, called COMEC – Curitiba Metropolitan Region Coordination – became necessary, with the purpose to “integrate and organize the planning and execution of the common interest public functions of the population and the municipalities that compose the metropolitan region of Curitiba” (COMEC, 2008, translate by the author). The areas under COMEC coordination today are land use and transportation.

4.1.2 Urban level

4.1.2.1 IPPUC

Guiding the growth of Curitiba required a functioning urban plan, and in order to execute and develop this plan there was the necessity to create a municipal agency; therefore the Curitiba Institute of Research and Urban Planning (IPPUC) was created on December 1st, 1965, with the main purpose of putting into practice measures that were aimed at increasing the living condition of the Curitibaanos (citizens from Curitiba), and include these measures in the planning of the city (IPPUC, 2008a). Created as a municipal autarchy – autonomous and decentralized – the IPPUC has now the function of coordinating the process of urban planning and monitoring of the city, making compatible the municipality and the metropolitan region in the process of achieving sustainable development, conducting research, projects, programmes, developing plans and collecting the necessary resources (ibid.). Its projects are presented to the municipality, and once approved, are managed by IPPUC.

4.1.2.2 URBS

Another fundamental organisation for the urban transportation in Curitiba is the URBS (Urbanization of Curitiba); Ms. Soares, noticed that it was created in 1963 as a company specializing in paving and it gained important functions to define all the operational parameters of the public transportation. The main objective of URBS is to improve the capacity, quality and efficiency of the public transportation to reach economic sustainability, which is seen as reaching an economic-financial equilibrium of the services performed (URBS, 2008).

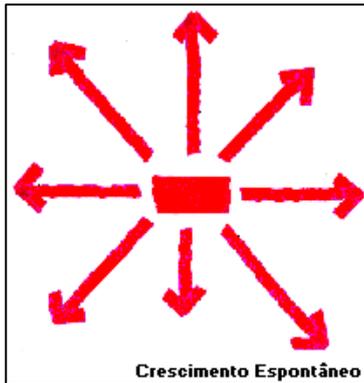
Ms. Soares, pointed out that the municipality owns 97% of its shares and the president of URBS is appointed by the mayor of Curitiba, highlighted how for many critics, the fact that the company is not completely public owned, effected the way the agency works, making it more efficient and so earning it more functions from the municipality.

4.2 City Planning

4.2.1 The Agache plan

In 1943 the “Agache Plan” (after the name of the leading architect) was implemented, an urban plan with the aim to guide the growth of the city, by dividing it in two main areas: the city centre and the residential peripheral district. To avoid traffic issues, it was decided to create concentric ring-roads that encompassed

Picture 4. Organic growth of a city. Source: IPPUC, 2008



the central area, which were linked by radial avenues (Adielsson & Friberg, 2001).

The main component was the construction of huge road in order to move in and out from the city center, giving in this way the priority to vehicular traffic (Garrick et al., 2006) instead of a collective transport system. As claimed by Mr. Arzua, former Mayor of Curitiba, it was not that the plan had defects, but the problem was that it was not following the evolution of the city (IPPUC, 2008). The only part of the plan that was eventually put into action was the construction of the radial avenues; and with the city facing an organic growth

(Pic.4), the concentration of all the services in the central area, created congestion (IPPUC, 2008). However, even if the city did not implement the plan, the recognition that an urban plan was necessary to solve the city’s issues was crucial.

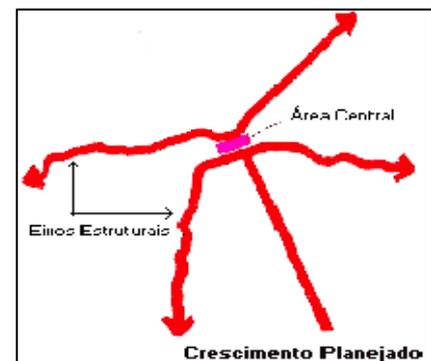
4.2.2 Plano diretor (Master Plan)

In 1964 a national contest was created to find a new urban plan due to the rapid growth of the city. The contest was won by Jorge Wilhelm; his “Preliminary Urban Plan” was converted into the “Master Plan”, and in order to follow and lead its execution the IPPUC was created, which revised the plan on a three year basis. The new plan followed a linear model of growth (Pic.3) implementing zoning laws and integrating the road system with land use and public transport (IPPUC, 2008a).

The entire urban planning is based on the principle that land use could have been regulated by norms. Zoning and land use are used as stimulators and organizers of the city development; they delineate the characteristics of the different areas of the city, defining the parameters, public and private, of occupation of the land, financial, economic, housing, etc. (IPPUC, 2008).

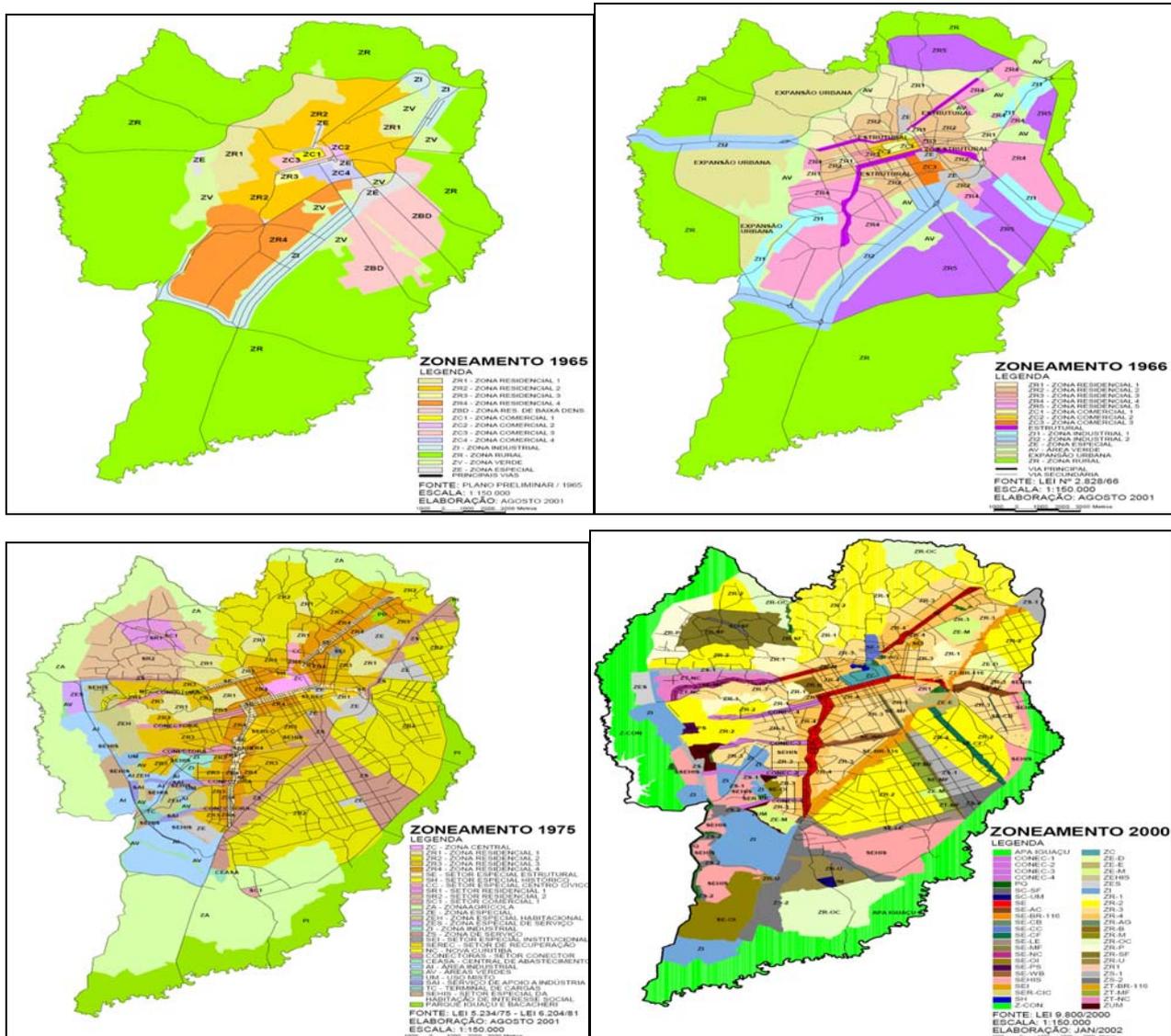
The growth of the central zone was limited by the law nº 2.828/66, which also established the development of services and commerce along the structural axis following a linear development of the city; defined the residential zones and areas predisposed to further development of the city. In time new laws were adopted, defining and regulating new zones and their development (ibid.).

Picture 3. The five structural corridors. Source: IPPUC, 2008



With the law n° 4.199 in 1972, it was established that along the structural corridors, equipped with infrastructures for the development of a mass transit system, the housing density should increase (ibid.); also some areas of the city center were converted into pedestrian areas, as the street “Rua XV de Novembro” which became the first exclusively pedestrian street in Brazil – it previously was one of the most congested roads in the city (ibid.).

The industrial area of the city was created (CIC) with the law n° 5.234, in 1975, and limited the occupation of the peripheral areas of the city promoting the occupation of the areas next to the structural sectors (ibid.); on the structural corridors the ground and first floors of buildings were left to commercial and financial activities and services. To reduce the consequential issues of rapid growth, the city was developed along main corridors instead of organic growth, decentralizing its commercial and industrial activities and its residential areas (Goodman et al, 2007).



From the top left to the right, clockwise

Picture 5. Zoning in 1965. Sources: www.ippuc.org.br

Picture 6. Zoning in 1966. Sources: www.ippuc.org.br

Picture 7. Zoning in 1975. Sources: www.ippuc.org.br

Picture 8. Zoning in 2000. Sources: www.ippuc.org.br

In the pictures 5, 6, 7 and 8 can be seen the evolution of the zoning in Curitiba, especially from 1965 onwards (Pic.5), when the city was left still to its organic growth and 1966 (Pic.6), when the linear development starts to be seen discerned (purple lines).

4.2.3 Road hierarchy

With the zoning laws and land use, a hierarchy was given to the road system; every street was classified, with a fixed function, capacity or characteristic (IPPUC, 2007). The classification was the following:

- *Structural* sector; the structural corridors, created around the idea of the ternary system (that will be illustrated later). These roads consist of *central* roads, which have a central separated lane exclusive for public transportation skirted by two small one-way lanes for low-speed traffic flows (see Pic.9), and parallel *outer* one-way road for rapid-speed traffic flows, and *other* roadways.
- *Normal* streets; the regular roads.
- *Collector* roads 1, 2 and 3; medium-small roads, integrated with the principal road system or just located inside the districts, have medium-small commercial activities and services.
- *Sectoral* roads; axes that connect the near municipalities, central area and peripheral areas.
- *Priority* 1 and 2; corridors with high-volume traffic, establishing links between structural sectors and other main roads of the principal road system
- *Capacity-Building Job Line* (Linhao do Emprego) road; large road with high job density.



Picture 9. A structural corridor in Curitiba, with the middle lane reserved for bus only. Source: The Author

The real innovation were the structural avenues, which were defined in order to guide the development of the city, so as to attract the population density next to these (five) corridors developing commerce, activities and services along these roads, jointly with a mass transit system. The creation of the structural roads (Pic.9,10) represented the key point in which the IPPUC decided to prioritize public transport in Curitiba providing incentives for people to use public transportation instead of private vehicles. Particularly between 1979 and 1983 there was a considerable development in public transportation (Macedo, 2004).

4.3 Urban public transport system

4.3.1 Historical development

In this section the historical development of the public transport of the city is presented.

4.3.1.1 The beginning

The implementation of an urban transportation system can produce desired developments or generate unwanted situations in the cities (Rabinovitch et al., 1995) and Curitiba represented the prior.

In the beginning (1887) the public transport of the city was trolleys carried by mules and later substituted by electric trolleys. The first bus circulated in 1928, but it wasn't successful mainly due to higher fares in comparison with the trolleys, ten years later the trolleys were still used by 11 million citizens annually and bus only by 2.6 million (IPPUC,2000). However, in the 40s busses started to replace the trolleys and in 1952 the last trolley stopped operation in the city (ibid.).

Initially the public system did not cover some areas of the city, and also many areas of the city were not directly connected, but most of the routes had the city center as their terminal, resulting in an obvious congestion of the central area as dwellers were forced to reach the city center even if they did not want to (Rabinovitch et al, 1995). Busses had truck chassis, and in order to avoid users eluding fares they had steep stairs and small doors, reducing the timing for boarding/exiting the bus, and so creating delays in the system (ibid.).

4.3.1.2 From Jaime Lerner era onwards

Mr Lerner, appointed Mayor in 1971, had a fundamental impact on the public transportation system; in 1974 the new transit system was implemented, after a preliminary plan created in 1968 (Macedo, 2004).

With the implementation of the urban plan, which gave the priority to the public transportation along the construction of the five main corridors, the situation started to change.



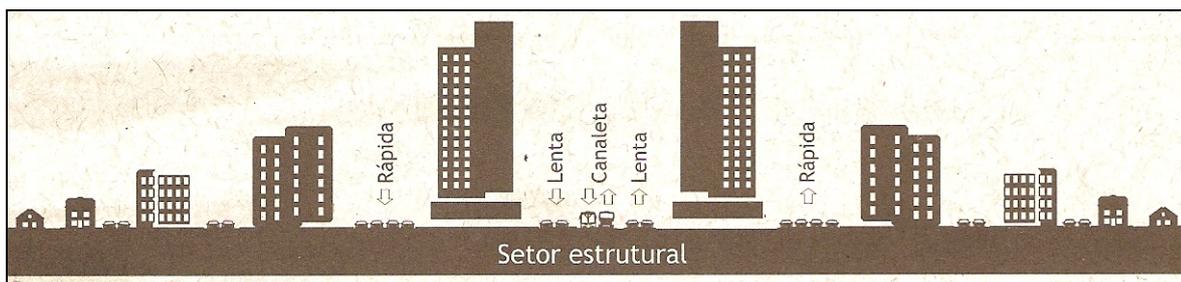
Picture 11. Example of structural corridor with its parallel high speed roads.
Source: IPPUC, 2008a

In 1972 began the construction of structural roads (Pic.9), formed by a triple layout; the central route consisting of a reserved double-lane for busses, whilst on its sides, two one-way roads created for slow speed traffic, which run in opposite ways. The corridors are characterized by the construction of large buildings in their proximity, with decreasing size as the distance to the corridors increases. Parallel to

main roads, spaced out by the large buildings blocks, run two one-way roads created for high speed traffic,

thus generating the ternary system (Pic.10) – the construction of the South-North corridor was finished in 1974 (Demery,2004). It was called the ternary system because of the three main roads, the main corridor and the two high speed roads, as it can be seen in Pic.10 highlighted by the arrows.

This system was adopted because the initial idea was to make the structural roads 60 meters wide, but due to low economic returns in expropriating lands and also the unwillingness to create a huge highway through the city, it was thought to utilize already existing parallel streets, thus creating the ternary system (Pic.10,11) (Meurs,1994). For the construction of the corridors grants from the International Bank for Reconstruction and Development of the World Bank was fundamental (IPPUC,2007)



Picture 121. Section of a structural corridor. Source: IPPUC, 2000

The central section, composed of the reserved lane for the busses (canaleta) and the low speed traffic road (lenta), is characterized by the presence of higher buildings, to increase population density; moving further to the right or the left it is possible to see the different level of zoning, from zoning level 4 –next to the main axis, spaced out by the fast speed traffic lanes (rapida), to zoning level 1, corresponding to the population densities requested by the city(Pic.12).



Picture 13. A structural corridor from above. Source: Skyscrapercity.com

With the completion of the first structural corridors in 1974 this implemented the “express” lines together with “feeder” lines, creating the basis of the new public system that will see the implementation of new lines as the “interdistricts” in 1979.

As it was seen in the 40s, the fares influence the choice of the citizens in Curitiba,

becoming a sensitive subject. A single ticket price was implemented in 1980 (tarifa social,

social ticket), so that the people were paying the same price regardless of the distance traveled (IPPUC, 2000). In the same year the “Integrated Transport Network” (RIT, Rede Integrada de Transporte) was implemented, which consists of integrated bus lines. The RIT gave to the users the possibility to ride different bus lines, the feeder and express, paying only a single fare; this transfer occurs in special closed terminals, and nowadays in the tube stations as well. The terminals, initially uncomfortable and too small for the demand, evolved over time and, as in underground stations, now they offer flower shops, bars and other

facilities, and their entrances are regulated by turnstiles. Today there are 29 terminals in the RIT (URBS, 2008).

The municipality was continuously prioritizing its public transportation, due to the oil crisis, encouraging people to not use private vehicles but instead using busses, and giving different working times for different activities so as to spread them over the day in order to avoid congestion of the bus routes. For instance the groceries and industries had to start working at 7 a.m., schools at 8 a.m., banks at 9 a.m., liberal professions at 9 a.m. and public servants at 9.30 a.m. (IPPUC, 2008a).

In 1980 the articulated busses, with 80% more capacity than the older ones, started to replace the previous express busses. Fifteen years after the implementation of the urban plan, the 673 busses of Curitiba were transporting 515,000 Curitibaños everyday (URBS, 2008). The mass transit fleet, which represented only 2% of all the vehicles that were running in the city, was transporting 75% of the people that were commuting. The RIT, which in 1990 transported only 54% of the total users of the system, in 1995, transported 84% (ibid.).

In 1982 the physical integration of the RIT with the metropolitan area was initiated.

Demand was increasing continuously and infrastructures were increased; In 1986 URBS became manager of the system (ibid.) and as Ms. Soares said URBS became the concessionaire of the service, while the private bus companies became the licensee.

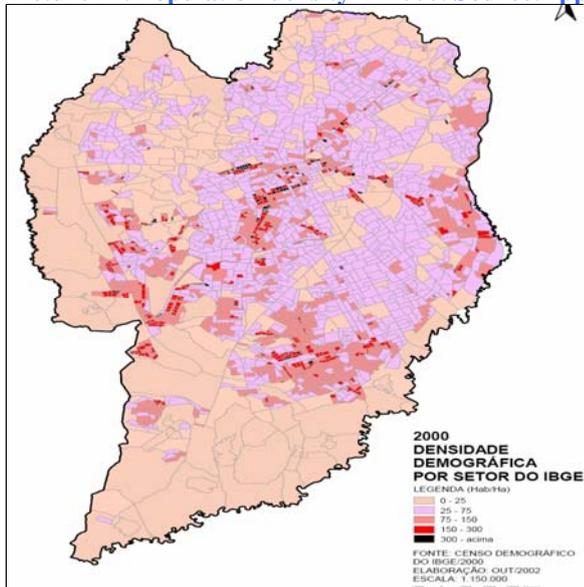
It must be said that the public transport system in Curitiba is characterized by private participation; there are different bus companies – today 10 for the urban line and 18 for the metropolitan – that are responsible for the busses and their routes. It does not suffer from an uncoordinated system of private minibus or van, which characterizes many cities in the developing world, including Rio de Janeiro.

Mr. Costa reminded how, in 1955, there were around 150 private bus operators – that joined in groups and started to sign contracts with the municipality (ibid.) – and in 1960 every group formed a company. When Curitiba started to give full priority to the public transport system, it won the trust of its users, who were then not looking for alternatives. For Ms. Daher, the solution to avoid the issues regarding regulated private companies consists in implementing a system that is comfortable, safe and effective. For Ms. Soares the quality of the system in Curitiba, the integrated network and the single fare were fundamental because in other cities where these qualities are not present the mini vans are the “answer of the market” for badly attended areas. Also the main features of the transport in Curitiba are the tubes and terminals, which vans cannot access.

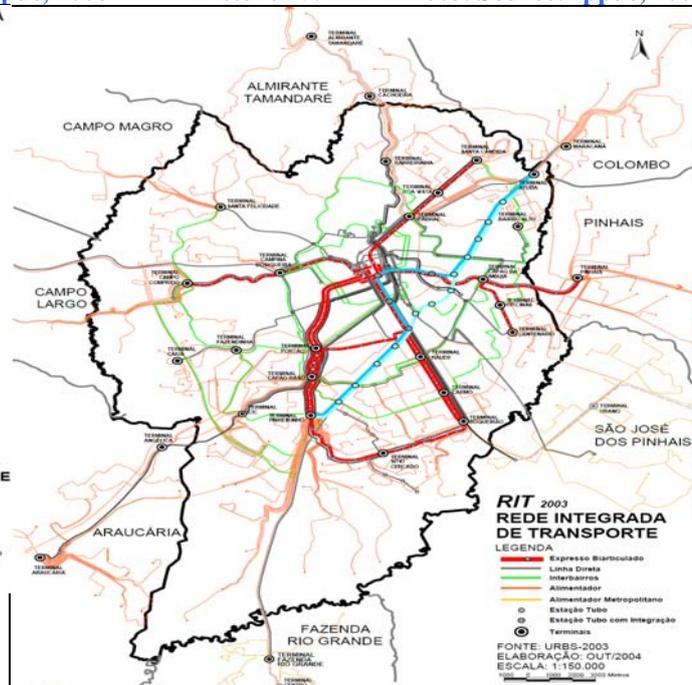
As Ms Daher said about the public transport system: “it began with an “equation of co-responsibility” in which the participants (public, private initiative and civil society) decided to achieve a project altogether for the city. Political willingness, determination and a good financial equation for the private companies was

needed; but convincing the different private companies needed negotiations, presentation of a good project and firm hand from the municipality”. There was necessary a discussion between all the stakeholders. She also underlined how at that time there was the possibility of credit loans for the companies investing in public transport in urban areas, that permitted the private sector to collect the financial resources needed to buy the fleets; so the system was set up and the isolated operators were losing competition and thus quitting. Until the 70s the municipality gave private companies the possibility to operate in non-overlapping areas of the city and the companies were charging the users – the fare was negotiated with the municipality as well (Rabinovitch et al., 1995). As Mr.Lerner said, “in the beginning, if I changed one stop, there was always a fight between the bus companies and us”, because the companies were earning a percentage of the tickets they sold while operating in the allotted area (Rabinovitch et al., 1995), so they were depending also on the routes and the number of stops. Though with the creation of the RIT, the users were able to purchase the ticket from one company and transfer to another route run by another company, therefore profit-sharing was needed. To share the revenues, it was decided in 1987 to pay the companies per km traveled and not anymore per person transported (ibid.). The URBS was setting the fares, giving to the companies scheduled routes with given km and timetables; this was important, as Ms Soares stressed, because now the private companies were put in a situation of not competing between themselves as they did not have to care about the number of users transported, but just to respect the route and the timetable assigned to them.

Picture 14. Population density in 2000. Source: Ippuc, 2008



Picture 15. RIT in 2003. Source: Ippuc, 2008



In 1991 the first direct line (ligeirinho, which means fast) was created. The innovation of the direct line was the introduction of the tube-stations (Pic.15, 17) bus stop (tube shaped, normally 10m. long and 3m. wide) that became one of the symbols of Curitiba’s system – they will be described more in the next pages.

In 1992 the first bi-articulated busses were introduced in the reserved lane way in the structural corridors. The boarding-exiting parade consisted of the same tubes-stations successfully used in the direct line, but with a stop every 500 meters (IPPUC, 2000). As mentioned before everything related to land use, hence population density was integrated with the transport system planning, and so in 1992 almost 40% of the population was living not farther than 3 blocks from the structural corridors (FTA, 1998).

Picture 12 shows the population density of Curitiba in 2000, with lighter colours indicating lower density; it can be seen how the higher population density coincides with the express bi-articulated lines (Pic.13), which run in the five main corridors.

4.4 The public transport system today

In order to reduce the delays generated by the steps of the conventional bus entrances, the boarding operation in tube stations are at the same level of the bus floors, thus producing a “metro” effect characterized by its fastness and easiness of embarking (Pic.14). To regulate the flow in and out the tubes there are doors provided with turnstiles, while sometimes at the exits there are no turnstiles. The tubes have lifting platforms for users with mobility problems (Pic.16). The boarding operation at every tube stop is efficient: 15 to 19 seconds per stop (Goodman et al, 2007), this is however an average, as through observation the author noted that it can take much longer or a shorter time.

Mr. Ceneviva, underlined how “everything was planned in order to reproduce the metro-effect, with the platform and boarding level, as that is the most important feature both for an underground system, and for Curitiba”.

There are several different lines operating in Curitiba that can be better observed enlarging by Pic.14:



Picture 16. Boarding on a biarticulated bus in Curitiba. Source: The Author

a) The direct line (ligeirinho); this line normally runs on the fast speed road of the ternary system, parallel to the structural corridors, thus shares the road with private vehicles. It uses the tube stations for the boarding/disembarking operation, which happens through three wide doors, two for exiting and one for embarking. It stops at fewer points located at long intervals (2-4 km), avoiding boarding time loss, thus diminishing the time to reach a destination; the lines are normally used by people who have to travel long

distances inside the city. The direct routes, with an average speed of 30km/h, are represented by the grey-coloured lines in Pic.14, as the color of its busses.

b) The express line (expressa) represents the main trunk of the system; today it consists of biarticulated busses that operate in the reserved lanes of the structural corridors. These busses, which can transport a high number of users (270), are characterized by five wide doors and three coaches connected between them through a rotating system that allows the busses to turn without occupy more than one lane.



Picture 17. Elevator for people with disabilities at a tube stop. Sources: The author. Picture 18. Tube-stations.

As the direct line, it uses tube stations for boarding operation (Pic.15). This line is the one that works more as a metro system, because it has the same features of a metro system as already remarked by Mr. Ceneviva. Its average speed is 20 km/h.

The line, that is perhaps the most distinctive element of the city transport system today, is connected by the feeder lines and the inter-districts routes. In Pic.14 it is represented with the red lines, as the colour of its busses.



Picture 19. Biarticulated bus in Curitiba. Source: The author

c) The feeder (alimentador) line shares the road with the private vehicles; links the low-density zones with the terminals where people can switch lines, without occurring any extra cost; therefore this line “feeds” the transport system; in Pic.14 the color that distinguishes the feeder line is orange, as the colour of its busses. There is also the metropolitan feeder line that, as suggested by the name itself, operates in the metropolitan-peripheral area, and in the Pic.14 can be recognized by the yellow lines.

d) The inter-districts (interbairros) routes connect different areas of the city or different terminals without driving through the city center, thus operating in a concentric way. There are six different inter-districts lines,

some run both clockwise and counter clockwise. In Pic.14 the line is represented by green color, same as the busses color.

Then there are other minor routes, such as:

e) Troncal lines that connect the terminals with the city center and are typified by yellow-coloured busses.

f) Yellow busses that are used also by the conventional line (convencionais), which links various districts to the city center, but unlike the Troncal, they do not stop in the terminals.

g) The circular center line (Circular centro), which operates with micro-busses and connects only different stops located exclusively in the city center, hence having a different ticketing system.

There are also special lines, like inter-hospital that connect the principal clinics and hospitals, the tourism line that, as the name suggests, has a tourist function (and runs on alcohol), scholar line and “sites” line, which is a line reserved for people with disabilities.

In Table 3 the different busses with numbers relative to the system are presented.

	Line	Capacity	Operating fleet	N° of lines
	Circular Centro/Micro	30	09	01
	Conventional/Micro-Micro Special	40/70	280	89
	Conventional-Troncal/Common	80	115	19
	Troncal / Articulated	160	24	19
	Feeder /Common-Micro Special	80/70	670	212
	Feeder / Articulated	160	75	212
	Inter-district / Padron	110	35	06
	Inter-district / Articulated	160	90	06
	Direct / Padron	110	385	18
	Express / Bi-articulated	270	165	06

Table 12. Curitiba’s system: Lines, busses, capacity, fleet. Source: URBS, 2008

Today the RIT has the following characteristics, with some of the data presented by Mr. Ceneviva - between parenthesis the number relates to the city itself without metropolitan integration: 390 (285) lines, 29 (22) terminals, 351 (332) tube stations, in a total 7,000 bus stops, 72 km of reserved lanes, 270 km of feeder lines and 185 km of inter-district lines. During a working day, on the 390 (285) lines 21.000 trips are taken, for

483.000 driven km; there are 2,260,000 (1,810,000) passengers transported, and 1,045,000 (850,000) paying passengers daily – discrepancy between passengers transported and payers due to the opportunity to catch two or more different rides with the same ticket (URBS, 2008).

5 Future plans of the city

The municipality is moving forward so as to give better accessibility and service to its citizens. The City Hall is investing more than R\$300 millions in infrastructures regarding transport system (Curitiba in English, 2008) and in particular the maintenance, enlargement and upgrading of terminals and tube stations because some of them have already reached their saturation and increasing the accessibility for persons with mobility problems. The main projects for the “ligeirao” and “linha verde”- green line (URBS, 2007) and the renovation of the fleet – use private capital, although under established conditions of URBS, but as Ms Soares emphasized it is invoiced to the politicians as if they were paying the costs.

5.1 Ligeirao

The “ligeirao”, that is the augmentation of the “ligeirinho”(the direct line bus), will run on the same reserved lanes of the express routes, but the “ligeirao” will be accessible only at the terminals thus serving people that do not need to stop at intermediate stations; it will overtake the bi-articulated busses while they are boarding. To solve the problem regarding overtaking the bi-articulated, some of the tube stations will be relocated a few meters before or after, because the actual dislocation (one in front of the other) would not enable overtaking if two biarticulated busses from opposite directions stop at the same time. This suggestion was also proposed by Mr. Lerner during his interview, but with the idea of letting one bi-articulated bus which should have a stop every four tubes (2,000 meters), overtakes the normal bi-articulated that stops every 500 meters, so as to solve problems regarding carrying capacity in the long term.

The work will start this year (2008) with the Boqueirao axes first - diminishing the travel time in the axes from 33 to 18 minutes (URBS, 2008), and the axes North-South after.

While restructuring the reserved lanes a new 22 km cycling lane will be created, flowing in both directions; it is not going to be an isolated case because along the Green line a 10 Km cycling lane will also be created (ibid.). The perplexity regarding the real connection to jobs accessibility and bike lanes expressed before in the paper finds the same scepticism here, as the two lanes will be structured on the same line as the biking lanes constructed before – basically connecting parks (URBS, 2007); however the city will implement a 15 km bike lane at CIC, in a project negotiated with the Interamerican Bank for Development, thus starting to give to workers the opportunity to use bikes as a real alternative mean of transport when commuting (ibid.). The financial resources in order to implement those projects came from different sources; R\$105 million from the “French Development Agency”, R\$67 million from the Interamerican Bank for Development and the Municipality of Curitiba jointly, R\$8 million from the Municipality by itself, R\$8,5 million from the

“Urban Mobility Program of Ministry of Cities” and R\$ 14,5 million from the World Bank together with the Municipality for the two bike lanes – the last is a grant to stimulate environmental preservation and non-motorized transportation (ibid.).

5.2 Green line

Considered as the infrastructure with the higher impact on the social and economical development of the city since the establishment of the CIC during the 70s (URBS, 2008), the Green Line created by the conversion of highway BR116, became the sixth axis of Curitiba, allowing the running of new public lines.

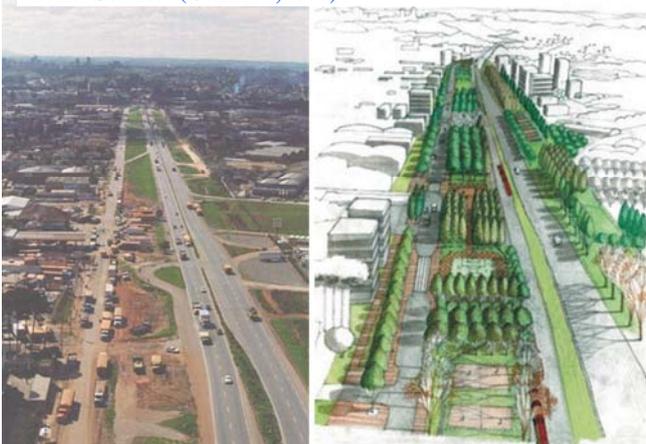
This project is a consequence of the city growth, with a higher number of inhabitants moving east and south of the BR116 due to the lower cost of land and houses; the highway, once built to unite, is now cutting the city in half, having the opposite role it was built for (Linha Verde,2008).

The new axes, which as mentioned before will replace the BR116 that now has a transit of 45.000 vehicles per day, will pass through 23 areas of the city with a total population of 287.000 inhabitants as Almeida said. Ms. Daher remarked how this conversion was possible only after Mr. Lerner, while Governor of Paraná, pushed for a transfer of the administrative concession of the highway from a federal level to a local level.

The Green Line will be finished in the second half of 2008. There will be three express lines – jointly with feeder lines – that will cover the axes 18 km long with a width from 60 to 80 meters. Features of the line will be 21.000 m² of parks, 13 bus stops (8 in the north sector and 5 in the south) in which the users can switch from the feeder to the express line or vice versa without paying extra tickets; bus stops that will be located at

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Picture 19. Sector south of the green line. Past, future. Source: (Curitiba,2008)



a longer distance compared to a normal express line so as to speed up the trips.

And again, three terminals, four main crossings, 10 parallel lanes (of which 3+1 on each flow direction and two reserved for busses), busses that as Mr. Costa underlined will run on a 100% bio fuel .

The first new line (Pic.19) will connect the south part of the city, from the terminal Pinheirinho (south line) to the center, and will be used by 18 articulated busses (URBS, 2007). Mr. Almeida claimed that one of its aims is to decongest the South line, which is transporting 260,000 users

daily; around 35,000 passengers, which is 30% of the users who transit in the Pinheirinho, needs to go directly from the terminal to the center, thus they will be attracted by a 17% time reduction compared to the south line trip (Linha Verde, 2008).

The articulated busses will be replaced over time by bi-articulated ones; also is matter of study how to let the people switch from one direction flow to another, a transfer that is now possible only in the terminals. The idea of implementing the green lines has three major reasons as noticed by Mr. Almeida; to decongest the south axes, to increase the economy of the area so as it develops better, and the fact that since 2002 a ring road has been under construction that will encircle the city so as to create a fast transport from the north to the south that does not cross Curitiba, so the BR116 is no longer needed. Ms. Daher said that houses will be constructed as well along the corridors, so as to subsidize the system that otherwise would be working only for workers during the peak hours, but not with the same population density of the other axes; as stressed by Mr. Almeida there will be bigger buildings next to the bus stops, and smaller ones along the line. For Ms. Daher improving the south area will mean less need to travel for the people, who live there, and Ms. Soares declared that to the south end of the line garages and workshops will be created for the transport system. Beto Richa, Mayor of Curitiba, commented that the new structural corridor is called “green” not randomly, but it is the outcome of the deep role the environment had in the planning of the axes (URBS, 2007). The green line will cost R\$121 million and is financed jointly by the Interamerican Bank for Development and the municipality of the city.

5.3 Metro

The city is studying also the possibility of implementing a Metro line, and the study project is financed with R\$2 million by the “Companhia Brasileira de Trens Urbanos”(ibid.).

As stated by Mr. Almeida contrary to a real underground metro, the system that is being studied, called “cut and cover”, will not necessitate a deeper digging in the soil, but a more superficial one (6,5 m depth; 8,5 m width), thus an average dig will cost 10 times less than in a normal tunnel; when it is needed to create/enlarge a metro system, in Curitiba it will cost only US\$40-50 million instead of US\$100-120 that cities like Sao Paulo invested.

It will replace 22 km of North-South line, with 22 stops, and in the beginning it is expected a 20% increase in users - more than 400,000 per day (URBS, 2008).

Mr. Almeida claimed that it is true that the costs are cheaper with busses, especially because they have less structural costs as the infrastructure already exists, but the metro line will provide more supply for the users; the municipality will get back some money with the elimination of the previous lines who served the area, in fact bi-articulated or *ligeirinhos* will not run anymore on the surface, but biking lanes, parks and pedestrian roads, a carfree zone that will give much more value to the area will be created. The metro system will be also be 50% cheaper than it should cost, as it will be created under the already existing axes, will not need land expropriation and it will use funding from Banco Federal and Interamerican Bank for Development (IPPUC, 2008b). The total project is estimated to cost R\$ 700 million (PSDB-PR, 2007)

As pointed out by Mr. Almeida, the prices of the busses are now three times less than that of trains, so if the bi-articulated costs R\$1 million and works for 12 years, trains that last three times longer have to be

purchased, so to amortize the costs. Mr. Almeida remarked how today the bus system is financing itself with the single ticket that allows the more costly lines covered by the cheaper ones, but in the new metro idea the users will pay R\$2.1 instead of R\$1.9; users will not pay the physical cost of the new line, but the service, because the structural costs are paid by the municipality.

Other advantages of the metro is that might attract many current drivers,, as emerged by the interviews, thus a future smaller use of cars; less private vehicles on the streets will lead to an higher safety levels for the citizens, both due to less accidents and for their health (URBS,2008).

Mr. Almeida asserted that Curitiba, as with the BRT, will be the first city in doing this, but not totally exclusive because a similar system is already present in Madrid. However, for Mr.Ceneviva, this project is not indispensable, but is more a dream; what is certain is that what is needed is an alternative to cars, but the priority can still be given to busses.

6 Theoretical framework

6.1 Defining sustainable transport

There are many definitions of a sustainable transport system in the literature – as with the definition of sustainability itself; between academics there is a vast disagreement resulting in several different ways to indicate sustainable transport, therefore there is no complete agreement on the connotation of the expression (Black, 2000).

For many researchers it has a predominant environmental nature, as for the OECD that defines it directly as “environmentally sustainable transport”, but for others it is more about offering to next generations at least the same choices as we have (ibid.). Black (2000:141) defined sustainable transport as “the satisfaction of current transport needs without jeopardizing the ability of future generations to meet their needs”, definition that is recalling the more famous Brundtland (1987) definition on sustainable development as “the development that meets the needs of the present without compromising the ability of future generations to meet their own needs”.

As a result, the features of a sustainable transport system according to Black are: running on a fuel that will have sufficient stock for the future, emitting the least pollution possible from the usage of that fuel, cause the lowesy number of accidents with fatalities and injuries, and lead to controllable congestion (Black, 2000).

Perman et al (1999) classified the various definitions into six main categories attributable to the different point of view of sustainability they focus on, but here more confined definitions will be used.

In the opinion of Mr. Ceneviva – President of IPPUC when RIT was implemented, and former President of URBS as well – when discussing the urban transport system in Curitiba, the sustainability of the system itself was seen as “a transport system that can economically sustain itself, without recurring investments, minimizing the environmental impact and to be accessible for everyone”. Actually he specified how the concept of sustainability was not developed at that time as it is now, but the general idea was already spreading around as it can be seen by the system’s principles.

A common feature to almost all the range of definitions is that sustainable transport should integrate, through planning, various aims such as long-term economic efficiency, equity, environmental and social development (Litman, 1999); hence it can be said that a sustainable transport system should not only base itself on the resources it uses, but the social and the economical aspects are also part of it.

As mentioned before, equity and accessibility are integral parts of a sustainable transportation system, so it should focus on accessibility, serving at the same time different classes of the population, such as women, men, children, people with disabilities, pregnant women, elderly, poor, etc.; to reach all the population of the area, giving to the people who live in a district the same opportunities as the people living in other districts for reaching jobs, homes and amenities, also promote integration of every area, as peripheral zones, in the city, thus avoiding possible risks of marginalization (Vivier,1999).

A sustainable transport system should also consider intermodal transport, encouraging alternative ways of transportation such as biking or walking, generating well-balanced systems that make use of each mode “for what it does best” (Litman et al.: 335).

From the literature reviewed, this paper has developed its own definition for a sustainable transport system; as one that, through the implementation of a plan that integrates land use and public transport, should be physically and economically accessible to everyone giving to all the citizens the same opportunities, guarantee an adequate carrying capacity, be self-sustaining, effective, reduce the number of accident, encourage the use of intermodal non-motorized transport instead of private motorized vehicles, run on fuel that will have sufficient stock for the future and emitting less pollutants in the entire phase of its usage.

The implementation of a sustainable transport system requires a well-planned process of policy making.

There are two considerable distinctions when developing a policy: it can be done by taking into consideration the circumstances at the present time or considering future aims. In the first case are made predictions from the current situation, so to know if the actual trend may be rectified; in the second, once the goals to achieve are set, the policy makers start to work backwards from those aims to the present and start developing policies in order to achieve the targets (OECD,2002). The main difference between the two approaches is that with the first one what is necessary is done in order to avoid a “unwanted future”, and with the second one what is needed is done in order to reach a ”wanted future” (ibid.). They can also be used together, but often the transport policy-makers give more importance to the present situation than achieving the long-term goals (ibid.), and basing their policies exclusively on short-term solutions. A clear example is the building of wider roads in order to solve congestion issues: with the under pricing of car-driving, it is not a solution as it induces the future car drivers to fill any additional space in time (Litman, 1999).

In order to move from an unsustainable to a more sustainable system changes in short (so to have immediate results to show) medium and long-term policies are needed (Colvile et al.,2004), changes regarding the energy used, the modes of transport used and other features that will be discuss after in the paper.

6.2 The case of Curitiba

Curitiba is cited in many articles and books by several authors; its public transport has been abundantly described, as well as its land use and recycling policies and so on. When it comes to its sustainability the data available on its economic, social and environmental impacts are much more limited.

Garrick et al. (2006) assessed the sustainability through the five tenants of smart transportation: using broadly defined goals; planning for desired outcomes; developing solutions for maximum accessibility; giving priority to cleaner, cheaper, and efficient modes of travel; diversity of modes for different needs. But the analysis takes place inside a bigger discourse about the total sustainability of the city.

Rabinovitch (1995) pointed out the innovative approach to transportation that the city had, giving particular relevance to the policies adopted and suggesting some principles that come out from his analysis as possible guidelines for reproducibility. Blaviss (2004) used Curitiba and Bogotá as perfect models of how to make a transport system more sustainable, identifying the successful criteria of these two cities; thus she gave a set of Latin American cities that are more and less prepared to adopt those guidelines in order to replicate their success. Campbell (2006) discussed only its structure as a relevant feature in order to achieve sustainability in the city. This paper analyzes the sustainability of the public system by reprocessing and extending the Adielsson & Friberg (2001) case study about the sustainability of the Curitiba transport system, that was referred to by the UN Habitat guidelines, as the author of the this paper thought it include a set of indicators that best suited the data collected by him.

6.3 Habitat II United Nations Conference

This paper uses, as the main reference for a sustainable public transport system, the guidelines developed in the UN Habitat Agenda, drafted during the Habitat II United Nation Conference in Istanbul, Turkey, June 1996; during the conference the city of Curitiba and its public transport system were represented with its bi-articulated busses. In the 4th chapter of the Istanbul Declaration on Human Settlements, section c, 7th paragraph, recommendations for sustainable transport and communications systems are considered. These recommendations take a broader perspective on transport in general; this paper applied the relevant criteria from the recommendations and applied it to public transport systems. As came out form the document, the transport sector represents a major concern to the United Nation Human Settlements Program because it is heavily based on fossil fuels, it makes a large use of a considerable amount of energy and land, creates externalities such as traffic, accidents and pollution; nonetheless the increase in the accessibility, safety, affordability and efficiency of a public transport system can reduce the problems of many unprivileged social class as poor, elderly, disabled people, woman, children and youth (UN, 1996).

At subsection 151 of the 7th paragraph seven main principles were reported that the municipalities which want to reach a sustainable public transportation should accomplish through working jointly with all stakeholders.

Those main features are considered in the following subsections; the text of the Habitat Agenda is presented and analyzed against the extent to which the city of Curitiba applied the seven points in its policies.

7 Analysis and Discussion

In this section will be analyzed the sustainability of the present public transport system in Curitiba: in order to achieve the paper's definition of sustainability, the UN Habitat Agenda's recommendations will be used to measure and discuss to what extent Curitiba matches the criteria. In the second subsection the author will also discuss and highlight what he considers the main features in order to move toward a sustainable urban public transport system.

7.1 Habitat II United Nation Conference framework applied to Curitiba

7.1.1 Support an integrated policy approach

Support an integrated transport policy approach that explores the full array of technical and management options and pays due attention to the needs of all population groups, especially those whose mobility is constrained because of disability, age, poverty or any other factor.

As described earlier, Curitiba since the second half of the 60s, integrated transport policy successfully in its urban decisions; the execution of the master plan with the creation of the structural corridors, directly connected with the implementation of a new mass transit system, clearly shows that the municipality supported the integration of the transport policy in the decision-making process.

The poorer classes of the population, that normally in Curitiba live in the peripheral areas, are definitely considered by the municipality with the implementation of the single fare in the entire metropolitan area, (IPPUC, 2008b). The single fare allows to switch lines without buying extra tickets, thus the inhabitants, regardless of where they live, can reach the same location with the same cost (Rabinovitch et al., 1995); it can be said that they are indirectly subsidized by the system (IPPUC, 2008b) as they are paying the same price for travelling longer distances than the wealthier classes that live in more central areas and presumably travel shorter distances. This gives to all citizens the same accessibility opportunity to the entire city area. Thus regarding same services and benefits; this is certainly a positive point regarding the sustainability of the Curitiba public transport system.

There are several classes that are exempt from paying the bus tickets, such as people older than 65 years or people with disabilities (ibid.). Also, the municipality gives the possibility to use public transportation even to the low income classes that cannot afford it, as it can be seen by the implementation of several policies regarding waste management; for example the city exchanged the recycled waste collected by people with food, books and bus tickets (Garrick et al., 2006). The Curitiba bus system and the policies implemented by the city stimulate a higher sense of community; during observations the author saw a person begging for money on the bus, and when he was stepping out of the bus this person saw a screw in the upper part of the door that was loose, and so he started screwing it in with a coin. This shows that even the poor feel a sense of commitment and responsibility to help take care of the public transport system.

The municipality really cares about paying attention to the entire population. In many tubes and busses there is a recorded voice message which advises users that elderly, people with disabilities and pregnant women must always be privileged while sitting on the busses or in the boarding/exiting procedures, and a great majority of the users respect this requirement.

The tube stations make for more comfortable and much faster access for people in wheelchairs or with mobility problems than other bus systems commonly in use all around the world, mainly because the platform is on the same level, easily reached by elevators in the tubes (Pic.16); also Mr. Ceneviva emphasized as 90% of routes in Curitiba use the tube stations, people with disabilities almost have total accessibility to the system. There are also special busses serving people with disabilities, but for the normal busses that do not board in tubes, the problems are those common to many busses worldwide; mainly the high entrance stairs.

However a potential problem can be the narrow tube entrances and this can create some operational problems and avoidable delays. When the tubes are crowded it is hard to see the people respecting the “right of way” mentioned above. The very last day the author spent in Curitiba, on the way to the airport, he was in a really crowded tube station with hand luggage and a regular suitcase and the boarding process resulted to be really difficult; from entering the narrowed entrance of the tube with the luggage (the author had to enter from the turnstiles while having to literally “push” the baggage amongst the crowd from the entrance reserved for people with disabilities) to reach the boarding doors in order to take the bus. There were many people waiting for other lines, because it was an ordinary (10x3meters tube) serving more lines, and some of the services were late that morning. It is hard to imagine what a pregnant woman, elderly or people with kinetic difficulties could have done in this case. This problem could be easily solved by enlarging the entrances.

One thing that clearly emerges from riding a bus in Curitiba is the way of driving (actually in the same line as other cities as Rio de Janeiro or Sao Paulo); slamming on the brakes and quick acceleration are, many times, ordinary components of the ride.

More than once the author witnessed incredible scenes coming from these issues. Once a young man in a wheelchair was riding in the reserved seat-free area of the bus (those areas sometimes featured by pull-out seats) when a pregnant woman entered with another kid in her arms; in the meanwhile she was (already struggling) pulling out the seat, the driver made an extremely rough acceleration, so that the pregnant girl with her kid fell right over the man in the wheelchair.

In another occasion, due to violent braking, an old man that was standing on the corridor completely lost his balance, and the author grabbed him before falling on the floor; for sure he would have been seriously hurt from hitting the ground with such force on his back side.

Normally the reactions of the users to these episodes are simple mumbles or just a laugh, because they are seen as normal *modus operandi* of the busses and their bus drivers. For many of the interviewees and the people which the author talked to, this did not represent an issue worth mentioning; many times the people comments were, “Did you ever ride a bus in Rio? They are the crazy ones!”, not being aware that it is in their rights to receive a better service. It is certainly an attitude that should be changed.

The author has been told by users that there are persons among them which complain to the drivers, but they are frequently vigorously scolded by the drivers: the drivers blame URBS for the impossibility of matching the timetables given to them, thus arising the necessity to speed. The URBS was questioned through Ms Soares about this issue and the possibility of more flexible timetables for the companies, but she replied that the timetables are feasible enough to not make them speed. Users should have the right to participate in these decisions, to show their opinions as they are also stakeholders; this would increase the sustainability of the system.

Conclusion

It can be said that the public transport system in Curitiba fits the first criterion proposed by the UN, particularly paying attention to the needs of its citizens and its more disadvantaged class.

Although problems regarding the quality of drivers emerged, and this could be addressed with educational seminars, better driving training and integrating the users in the achievement of an agreement on more flexible timetables between the private bus companies and URBS.

7.1.2 Coordinate land use and transport planning

Coordinate land use and transport planning in order to encourage spatial settlement patterns that facilitate access to such basic necessities as workplaces, schools, health care, places of worship, goods and services, and leisure, thereby reducing the need to travel;

The city of Curitiba, since the 60s-70s has aimed at coordinating land-use, road system and transport planning while developing its policies; the Curitiba Master Plan that addressed the city to a linear model of growth (IPPUC, 2008), represented a key moment under this viewpoint (Rabinovitch et al., 1995). The city center should not be the only area in which develop the main services; the conception of the five structural corridors had as its main reason to lead the settlement patterns of the city, in order to concentrate the daily activities, services and necessities of its population along the five main avenues – in this way houses, public transportation, commerce, schools, hospitals, workplaces, gyms and various amenities are decentralized and well spread all over the city, thus limiting the need of people to travel and giving them also better accessibility to any service (ibid.). Citizens of Curitiba have increased their access to work, housing, recreation and services thanking to the development of the transport system (ibid.) and almost 70% of inhabitants go to work by bus (Goodman et al.,2007), remarking the sustainability of the public transport under the accessibility aspect.

The idea of the structural corridors went side by side with the implementation of a zoning scheme. The peculiarities of the zoning laws was to decrease the housing density as the distance from the main arteries

was getting longer, and increase it next to the axes (Macedo, 2004). In between 1970 and 1978, Curitiba's population grew by 73%, but by 120% in proximity of the structural corridors (Demery, 2004); in 1992 around 40% of the citizens lived not farther than three blocks away from the five main corridors (FTA, 1998). In 1995, 75% of inhabitants were living on 41% of the city's land (Rabinovitch, 2005).

As Mr. Almeida stated, today almost 10% (Pic.13, 14) of the city's population is living in four of the five structural corridors, in this way divided: 40,000 in the north corridor, 30,000 in the west, and 100,000 in the southeast. In this data the 5th corridor "Boqueirao" is not considered; the data only takes into account the people who actually live on the main corridors and not even one block away from them.

The series of laws on land use, that allows a defined proportion between ground space and plot size, and the proportion must decrease with the decrease to accessibility to public transportation (Rabinovitch et al., 1995) show clearly the willingness to achieve the coordination among land use and transport system. Also ground and first floors of the buildings located on the corridors are reserved to services, economic and financial activities (IPPUC, 2008). Combining high density with presence of services and accessibility to the public transport system improves the sustainability of the Curitiba public transport.

When interviewing Mr. Lerner, he told me that one of the five points in order to achieve a sustainable city, is to "live closer to your work, or bring your work closer to your home", so as to reduce the necessity of commuting. One of the guidelines his team was following while planning the city (and trying to make it sustainable) was to make the people use their cars less and to let the city be an "integrated structure for living and working" – *uma estrutura de vida e trabalho junto*: "as long as there are these two conditions the transport system can go to infinity".

Many of the people interviewed did not think that in order to have a higher quality life they needed to leave their district, to go to the city center or other areas, because they have almost everything they need or want next to where they live (many times nightlife activities were an exception).

One of the keywords of the IPPUC for the future, as declared by Ms. Vallicelli, is "re-adensamento", which does not have any direct translation but means to re-increase population density; municipalities such as *Colombo* or *San Jose Pinhais*, situated respectively in the northeast and southeast conurbation of the city, are increasingly getting bigger. Mr. Almeida commented that the growing rate of the metropolitan area is higher than in the city, because the people who arrive in Curitiba live in the surrounding municipalities as the city extension is already limited and there is not so much available space, so the prices in the city are higher; for Ms Vallicelli if 20,000 new low-income families move to Curitiba every year, the municipality will have serious trouble in finding them homes. Thus in the last decades people are commuting more in order to work; living in peripheral areas and working in the CIC it is a very common situation among many families in Curitiba – CIC generates one fifth of the jobs in the city (Rabinovitch, 1995) – and the outcome is that the south axis (the one that goes to the CIC) is the axis which results to have the more crowded lines, sometimes

overshooting its carrying capacity in the peak hours – by this it is meant that users cannot get on the bus anymore and must wait for the next one.

Conclusion

The coordination of land use and transport system is the cornerstone of the cities good public transport and the policy they implemented the best. The implementation of the Master Plan, with the development of the five axis and the zoning laws gave its citizens the possibility to better access to their daily services and needs, fitting entirely the criterion fixed by the UN Habitat. Although the metropolitan area is getting bigger and it might encourage the need for travel creating a threat to the system for the long-term, it is in the municipality's agenda to increase services in the areas which need them the most. The green line represents an example of re-increase population density in the city.

7.1.3 Encourage the combination of modes of transport

Encourage the use of an optimal combination of modes of transport, including walking, cycling and private and public means of transportation, through appropriate pricing, spatial settlement policies and regulatory measures;

The physical outline of the city with its corridors encourage naturally an intermodal transport system; above all walking because of the high density next to the axis and the pedestrian area in the city center, sites which almost all the main public lines are accessible. During the last years the municipality began to give people better opportunities to ride bicycles inside the city, creating a net of 120 km of bike (bicycle) roads (IPPUC, 2008); however, no particular signs of the municipality encouraging the use of alternative modes of transport, like bikes, were observed. The author actually saw very few people riding bikes in Curitiba; the bike lanes connect principally the parks of the city (Adielsson & Friberg, 2001), while not many cycling roads are placed along the major streets and routes covered by the people. The bike lanes hardly give people the opportunity to use them to reach jobs, but just to use them for personal pleasure.

A negative impact on the spreading of cycling might depend also on the big distances in the city, but this cannot explain the lack of biking; bicycles can always be used as integration to the bus system, seeing them as “feeder” of the system (the same function as the busses), becoming a complementary part of the public transport system. Very few bicycle-parking lots were observed next the bus stops or terminals to facilitate this intermodal system. However, considering the way of driving of the Curitibaños, bicycling on roads can be really dangerous; for those citizens who would like to bike more this might have a negative impact as well as the long distances. The lack of reserved bike lanes along the main roads covered by work-commuters bring to the use the bus reserved lanes by many bikers, with all the subsequent safety issues and with a possible slow-down of the bus system. The encouragement of intermodal transport should really be improved in order to achieve a sustainable system, especially promoting more environmentally friendly modes such as walking and cycling.

After spending three months in Curitiba and talking to many people, the author has the opinion that it will not be easy for the Curitibaños to understand bicycles as a normal, alternative mean of transportation instead of a simple hobby for the weekend. It was also understood that the bus fare is considered fair enough for the

services they received; people who live in the peripheral areas (in Brazil are normally the classes that should have bigger economic concerns) are happy with it because they think that, at the end of the day, they are advantaged by the single fare policy, having the opportunity to reach almost every part of the city and its conurbation only paying once. Though they have some problems in comprehending that the single fare is indirectly subsidizing them, they fully understand that they receive an advantage, and this is a strong point for the sustainability of the system.

Mr. Almeida stressed that the population is growing; the users are both getting richer so as to buy and use a car, and getting poorer so as not to afford the public system anymore; the municipality cannot and would not lose the low-income users, so pays notable attention to the economical accessibility of the tickets.

In Table 4 are the prices of fares in R¹\$(Brazilian Reais) among the most important Brazilian cities.

São Paulo	Brasilia	Rio de Janeiro	Belo Horizonte	Salvador
2,3 R\$ - 1,88 €	2,00 R\$ - 0,77 €	2,00 R\$ - 0,77 €	2,00 R\$ - 0,77 €	2,00 R\$ - 0,77 €
Porto Alegre	Florianópolis	Curitiba	Fortaleza	Recife
2,00 R\$ - 0,77 €	1,90 R\$ - 0,73 €	1,90 R\$ - 0,73 €	1,60 R\$ - 0,61 €	1,60 R\$ - 0,61 €

Table 13. Fares in the most important Brazilians capitals. Source: URBS, 2008

The fare composition in Curitiba consists: 70% consisting in operational costs, mainly costs of personnel (57%), fuel (28%), accessories and pieces (11%); 13% by capital costs (39% remuneration and 61% depreciation of the capital invested); 8% for administration costs; 5% for the tributaries costs; 4% for the costs of the managerial fund (URBS, 2008). The fares entirely sustain the system and match with its economic sustainability.

There are no regulatory measures that normalize the use of private vehicles, and also no car parking was observed next to the bus terminals, both in central and more peripheral areas, so as to promote an intermodal transport. Lack of regulatory measures for private vehicles such as tolls for entering in determined areas of the city or restrictions to the use of cars during certain hours of the day time, seems to be the weak aspect of the transport policies of Curitiba. Also some people the author talked to resulted not to be particularly aware or worried about the issues linked with the overuse of cars. For the long-term sustainability this lack of regulatory measures and awareness definitely cannot be seen as a positive aspect.

Conclusions

The affordable fares appropriate to the service offered and the spatial settlement of the city naturally encourages the presence of intermodal transport strengthening the sustainability of the system, but the municipality is not doing enough to support it. Although bike lanes are increasing they are not planned so as to encourage the combination of modes of transport; promotion of intermodal transport that is lacking thus jeopardizing the long term sustainability.

7.1.4 Promote disincentive measures that discourage private motorized traffic

Promote and implement disincentive measures that discourage the increasing growth of private motorized traffic and reduce congestion, which is damaging environmentally, economically and socially, and to human health and safety, through pricing, traffic regulation, parking and land-use planning and traffic abatement

¹ R\$ 1 = €0,38 (exchange rate 2008, May 25th, <http://finance.yahoo.com>)

methods, and by providing or encouraging effective alternative transport methods, particularly to the most congested areas;

Integrating land use with transport system had as one of the main aims to guide the city development along the five corridors, decentralizing all the services, thus avoiding congesting the central area (IPPUC, 2008); at the same time it created both an attractive alternative mode of transport and avoided the formation of jam-packed areas - the public transport system can be considered in all effects as an alternative transport method to the private motorized traffic.

The average speed of the public transport is 20 km/h for the biarticulated, 30 km/h for direct lines and 18 km/h for conventional lines, that makes the system quite effective alternative mode of transport compared to the Metropolitan Transportation Authority subway system of New York, which average speed is around 32 km/h, or other cities in Brazil which busses at peak hours have an average speed of 10 km/h (Friberg, 2000). But, in order to discourage the increasing growth of the private motorized transport, alternative means of transport are not encouraged as they should, and for the author it can not be considered a sustainable system that promotes as the only alternative an option based on fossil fuels.

The high prices of the public parking spaces are a disincentive measure for the private motorization. It is not common to see municipally owned parking lots in the central area (Goodman et al,2007); most of the time the parking available is only found on streets next to the sidewalks, and is not located on every street – it has to be said that structures as universities or shopping malls have their own parking lots. The municipal pay-parking lots and spaces (they have a plate with “*estar*” wrote on it) cost R\$1 per hour all over the city during the day time (Bus ticket is R\$1, 90), and for free during the night – but in the peripheral areas the number of “*estars*” are lower than the central areas. The parking is cheaper than many other cities as Belo Horizonte (R\$ 2, 30) or São Paulo (R\$ 1, 80) (URBS, 2008).

However, if the lack of municipal parking spaces in the city center can represent a disincentive for the people who want to reach there with private cars, it is not really effective, because there is a high number of private parking lots, which are also expensive: they can cost normally from R\$2 to R\$7 during the night.

The fact is that, due to the high level of criminality, it is always advisable to leave private vehicles in places with surveillance, in particular during the night-time; even in free public lots, car drivers prudently pay people that abusively do surveillance in the area, especially at night. For the author it cannot be said that the rich presence of private car-parks diminish the municipality’s efforts because they can be regulated by the municipality itself, so to let the disincentive measure be more effective, thus getting a better sustainability.

If in the past strong measures in order to discourage private traffic and congestion were implemented – as closing down streets like Rua XV de Novembro – today it is not seen as a feasible solution by the current policy makers. Apparently the city did not learn its own lesson regarding their previous strong policies adopted. The economy is growing, there is going to be always more cars because the people today work to

buy themselves a car, as Mr. Almeida claimed. There are many car industries in greater Curitiba [there is the second biggest and more modern car industry centre of Brazil, with the presence of companies such as Volvo, Audi, Fiat, Volkswagen, Nissan or Renault (CidadesdoBrasil, 2008)], and it actually can be thought that the city, which is promoting its industrial area and always attracting more industries, might receive lobbying in order not to disincentive the use of cars or simply do not have willingness to do it. To add more value to this theory, also the city itself would have problems to face an increase of users in some of the lines; there are routes during the peak hours that are already overshooting their carrying capacity, so will not be able to afford a further increase of passengers. Asked about the lack of strong disincentive measures regarding private transportation Mr. Almeida said that today it is not possible anymore to shut a street down, to stop the transit, because it will be a very strong attitude by the municipality. For Almeida, this is something that cannot be stopped, the municipality cannot let the people not to buy or use cars: “those strong measures are going to be a solution only when no other solutions are available”. So it is explained the reluctance to implement private traffic regulations or traffic abatement methods. This situation is also worsened by the general knowledge that almost all drivers will badly react to a congestion price, except if the revenues were redistributed to them in some way (Greene et al., 1997).

However, due to the high use of public transport, the city results to be 25% less congested than other comparable Brazilian cities (Garrick et al., 2006), although the general impression of the Curitibaños is that the situation is getting worse. The transport system in the city attracts more than any other city in Brazil (Rabinovitch et al., 1995); the presence of alternatives to private motorization made the people change their travelling habits: 28% of the express bus users are former car drivers, thus saving around the 25% of oil consumption in Curitiba (Roseland et al., 1998), estimated to be 27 million litres of fuel per year (Rabinovitch et al., 1995). The consumption of oil per capita, due to the high use of public transport while the car ownership is quite high compared with neighbouring cities, is lower; gasoline consumption per capita in the city is 25% less than other 8 comparable cities in Brazil (WorldBank,2000).

Disincentive measures regarding the use of private motorization would also reduce the already low number of accidents, having a positive impact on the health and safety of the citizens.

Table 5 shows how Curitiba has a lower number of fatal accidents for every 100,000 cars yearly between the major Brazilian cities, and that it managed to be the third both in the total of accidents without fatalities and in the accidents occurred without injuries reported – as mentioned before this table might not have scientific validity, but can help to understand how, even with the highest number of cars per inhabitants, the numbers of accidents are actually lower than many other cities, probably due to the public transport.

	Inhabitants	total cars/inh.	accidents deaths/100,000 cars	with accidents deaths/ 100,000 cars	with no accidents injured/ 100,000 cars
CURITIBA	1 797 408	0,44	11,59	1049,12	839,40
FLORIANOPOLIS	396 723	0,39	Na	na	Na
SAO PAULO	10 886 518	0,37	36,97	844,18	679,55
PORTO ALEGRE	1 420 667	0,32	35,42	1584,07	1247,36
BELO HORIZONTE	2 412 937	0,31	23,77	2260,47	1825,72
BRASILIA	2 455 903	0,31	58,11	1631,39	1230,51
RIO DE JANEIRO	6 093 472	0,23	57,92	1168,22	789,46

RECIFE	1 533 580	0,18	31,37	899,13	684,65
FORTALEZA	2 431 415	0,15	97,54	1945,41	1711,20
SALVADOR	2 892 625	0,13	55,12	1647,34	1338,73

Table 14. Accidents per cars. Data elaborated by the author. Source: data from Denatran, 2008.

Conclusion

In Curitiba land use planning discourages private motorized traffic, thus adding strength to the public transport sustainability. However it can be said that regulatory measures for private motorization are almost absent; the main disincentive as high-priced/lack of parking is not really effective due to the presence of private areas. The increase of the car market over time can bring an increase of private motorized traffic, and the city is trying to disincentive their use, and this might compromise the sustainability of the system in the future. Traffic regulation policies are simply missing. The only valid alternative to private motorization is represented by busses, which are still a motorized mode of transport based on fossil fuels, so far from being sustainable.

7.1.5 *Promote public transport*

Provide or promote an effective, affordable, physically accessible and environmentally sound public transport and communication system, giving priority to collective means of transport with adequate carrying capacity and frequency that support basic needs and the main traffic flows;

When the RIT was implemented in November 1980, the municipality published on every newspaper maps of the new integrated network in order to promote the use of busses, saying to the citizens that the public transport system was the right, more comfortable, cheap and fast mean of transportation in the city, and that RIT was the opportunity to show to Brazil how to economize 230,000 liters of fuel per day in a period of world oil crisis (IPPUC, 2000).

Campaigns were implemented such as “*È com esse que eu vou*” (“I’m going with the bus”), which had as its main purpose to entice the use of busses leaving the car at home, cutting back the fuel consumption (ibid.).

The public transport system is well spread around the city. There is a law which imposes on the municipality that everyone must live at a maximum distance of 500 meters from a bus stop, but as Ms Soares pointed out, URBS was able to reduce this distance to a maximum of 400 meters; almost the entire area of the city is reached by the RIT, that actually covers 92% of the passengers demand and 73% in the metropolitan area (Demery, 2004). The system is undoubtedly physically accessible for people with mobility problems due to the elevators in the tubes (Pic.16); considering that 90% of the demand in Curitiba uses the tubes, as stated by Mr Ceneviva, it is possible to say that the system provides good accessibility. The busses serving the tubes [padron (type of bus) and bi-articulate of the direct and express routes] normally have seat-free spaces reserved for wheelchairs. Thus the system has a good physical accessibility, both in terms of coverage and accessibility for disadvantaged classes. However, the entrances in the tubes are narrow, and as mentioned before this can present problems, especially during peak hours. In other routes served by different busses there are the same problems common to many other bus systems, such as high steps while boarding.

Acquisition of new fleet with wider entrance and lower steps and floor, or the presence of an elevator would solve this issue, as a re-styling of the interior.

The system has busses that run on alcohol, but are used only for the tourist line, maybe in order to show the tourists a more sustainable image of the system; all the other busses run on diesel, and it is definitely a major negative aspect of the public system, compromising heavily its sustainability.

Fares are set by URBS, which takes into account both the cover of its costs and the economical accessibility of the low income users, as normally transport costs only 10% of their average salary (Garrick et al., 2006). The ticket is considered fair by the people, both for the low price and for the single fare policy. The price of the ticket on Sunday is almost half price, R\$1, so as to stimulate the use of public transport by families and people when going for a walk or reaching the city's mall structures (always including cinemas, shops, restaurant, etc.) instead of using their private vehicles (IPPUC,2000). To implant the corridor "Boqueirao", US\$20 million was needed, but the city had only US\$4 million; the North-South axes needed US\$40 million for the new line construction (tubes, terminals, platforms, etc.), but the city had only US\$10 from the public money (IPPUC, 2000.). How was the city able to develop such ambitious infrastructures then? The bigger share of the investment was done by the private bus companies that were operating in the city (ibid.).

Considering Table 6 below, the RIT has the highest average of rides per person/yearly(r/p/y) among the Brazilian cities – it has to be considered that the RIT consists of metropolitan journeys as well (29% of the total). In 1991, Curitiba had 230 rides per person yearly (not considering the transfers that are estimated by URBS to be 1.4 times the tickets paid) thus making it (in proportion) the most used transport system in Brazil at that time (Demery, 2004). The level of users' satisfaction is 89% (Curitiba, 2008).

	Population	Tot.Rides/year	R/p/y		Population	Tot.Rides/year	R/p/y
CURITIBA	1.797.408	490.000.000	273	SALVADOR	2.892.625	451.019.839	156
SAO PAULO	10.886.518	2.661.110.194	244	RIO DE JANEIRO	6.093.472	755.260.476	124
PORTO ALEGRE	1.420.667	315.387.657	222	FORTALEZA	2.431.415	286.481.946	118
BELO HORIZONTE	2.412.937	422.301.637	175	BRASILIA	2.455.903	189.206.076	77
FLORIANOPOLIS	396.723	64.923.817	164	RECIFE	1.533.580	n.a.	n.a.

Table 15. General data from 2006, Rio's data from 2005. Source: Ministry of Cities, 2008

The system was extremely flexible and thus always prepared to face the increasing number of users over time assuring an adequate carrying capacity as claimed by Ms. Soares, adopting constantly new solutions, while proceeding side by side with the revisions of the Master Plan of the city that had the same flexibility. An example is the implementation on the express route of "padron" busses first, articulated busses and now bi-articulated, as the number of people riding along the structural corridors were increasing.

The graph below (Pic.19) shows the total number of paying users; in the last 10 years the total number of users decreased and, as highlighted by Mr. Almeida only a cut in the fare in January 2004 (from R\$1,90 to R\$1,65, but now back to R\$1,90) reversed the downward trend.

In the last decade, some busses started becoming packed, especially during the peak hours; the situation did not collapse because of the absence of increase in users in the last years, as it is showed by Fig.1.

There are lines that received massive pressure, as the case of North – South axis for example; as stated by Mr. Almeida this line had 416,931 passengers transported per day in 2007. Almeida said that it can be affirmed that the axis North-South of Curitiba receives the biggest pressure of the country: in normal conditions there is a public vehicle every 50 seconds – express of direct bus; the system can find itself in



crisis when it rains, but now it is difficult to give the users a higher frequency; it is going to suffer when it will face 500,000 users per day. In order to enlarge the carrying capacity of the system there will be implemented solution in this year (2008) as the *ligeirao* and the *green line*.

Figure 2. Urban transport passengers. Source: URBS, 2008

The environmental soundness of the system can be argued, depending if it is seen in terms of overall reduction of fuel consumption or the fact that it runs on fossil fuel. As already claimed by the author, it can be defined sustainable a system that runs on a highly pollutant non-renewable resource.

Conclusions

The bus system in Curitiba provides an effective, affordable and physically accessible public transport. The municipality gave the priority to public transportation while planning the city. The frequency of the busses is good but the system is reaching its carrying capacity. Under those aspects it can be said that the system reached a good sustainability level, and future implementations as the *ligeirao* or the *green line* might solve the carrying capacity issue. It can be questioned whether a system which runs on fossil fuels can be called environmentally sound system, even if can be argued that reduce the use of fuel comparing with a car based system, but the author believes the system should rely on an alternative to diesel fuel.

7.1.6 Promote use of efficient and low polluting technologies

Promote, regulate and enforce quiet, use-efficient and low-polluting technologies, including fuel-efficient engine and emissions controls and fuel with a low level of polluting emissions and impact on the atmosphere and other alternative forms of energy;

Technological innovation plays a big role in achieving this recommendation, thus the reality of the Brazilian situation has to be considered while discussing this proposal, with the not so consistent financial resources available and the contemporary presence of several other significant problems. Nonetheless, the city stated that busses older than 8, 10 or 12 years – depending on the different type of busses – have to be replaced by new ones, in order to keep the pollution levels as little as possible. The bus companies can sell the old busses to other cities or directly to the city of Curitiba itself, which uses them as itinerant libraries for the poor areas of the city, or as markets and schools in which people can learn job skills or receive an education. All the busses run on standard-diesel fuel, while the tourism line runs on alcohol. Measures were taken in order to make the engines more fuel efficient; in 2005 the preventive maintenance and the correct tuning of the

vehicles made the emissions of the pollutants decrease by 11, 2% from the previous year (URBS,2008). Curitiba has both a minor use of oil per capita due to its public transport system, and also is working on solutions. It was the first city in Brazil to use less polluting fuels for its vehicle. As stated by Ms. Soares, URBS is always conducting research on busses that run on biodiesel, checking their feasibility regarding resistance and potency. A fuel composed by a combination of 89.4% of diesel, 8% of alcohol and 2.6% of soybean additive was tested, having as a result of a cut back by 43% of particles emitted in the air (UNEP, 2008). Using alternative fuels, such as alcohol, stimulates the production in the rural areas, which brings economic and social paybacks as well, as a billion liters of alcohol generates approximately 50,000 new jobs (ibid.). But still needs to be questioned the overall impact on the society and the environment when producing biofuels; in the author's opinion, switching from fossil fuels to biofuels cannot certainly mean a switch to a more sustainable system, just because of the lower level of pollutant emitted at the end of fuel use; it should be included the entire process of producing biofuel.

In fact biofuels are a risky subject, as they are under criticism right now; the Time cover of the 7th of April 2008 is dedicated to them, with its correspondent article, written by Grunwald (2008), that links the use of biofuels with the shortage of food and its higher costs – due to the fact that always more corn is destined for the production of ethanol diminishing the quantity of crop – with the destruction (in order to create plantation of corn, or soybean) of forests, wetlands and grassland; land that also stores a great amount of carbon, that once released in the atmosphere actually increases global warming. However, biofuels can be produced from many different sources that have different impacts.

Friedman, in his article, specifies that the sugar ethanol produced in Brazil - a large share of cars in Brazil run on ethanol (Gudmundsson et al., 1995) – provides 8 times more energy than the energy used (from fossil fuel) to make it, instead this ratio for the American corn ethanol is 1.3 times; sugar cane ethanol produce less greenhouse gasses than corn ethanol, and it can be produce also in poor tropical country alleviating their poverty, but the production must be planned so to avoid environmental damages as deforestation (Friedman, 2008) and assure good conditions for the workers.

In Brazil, without special authorizations it can be mixed in the diesel only 2% organic components, as for example soy derivates, due to the law 11.097/2005 (URBS, 2007). Élcio Karas from URBS declared that the city would like to use a higher mixture (ibid.).

Although much more could be done in order to implement technological solutions that reduce the emission of pollutants in the air, the different bus lines that use diverse busses depending on the population density of the area they serve – with a higher volume of busses matching higher volume areas and vice versa (Rabinovitch et al.,2005) – brings to a more efficient use of fuel; less empty busses, fewer fuel used to transport a set number of users, less waste of environmental and economical resources (ibid.), thus a reduction on the impact on environment, health and economy.

In 1979 Volvo and the municipality showed data regarding the implementation of articulated busses in the north axis; there was a cut back in oil consumption by 46% per passenger transported and a probability of reduction in the fleet by 43% (IPPUC, 2000). Impacts on the atmosphere are actually being reduced. Due to the low use of cars, Curitiba achieved one of the lowest rates of air pollution in Brazil (FTA, 1998).

In the table below (Tab.6) there are data relative to vehicles and cars per inhabitants in some of the major Brazilian cities and data relative to deaths for every 100,000 inhabitants due to diseases that can be connected somehow to the use of motor vehicles.

Even if the following data might not have scientific relevance due to missing information regarding the pathologies and to what extent they are connected to the use of private vehicles, it is interesting to see how Curitiba, with the highest number of total vehicles and cars per inhabitant, has a low number of deaths; these might depend on the high usage of public transportation despite the total number of cars.

City	Total vehicles/ inh.	Total cars/in h.	Deaths due to cancer /100,000 inh.	Deaths due to circulatory system pathologies/100,000 inh.	Deaths due to respiratory pathologies/100,000 inh.
CURITIBA	0,60	0,44	39,22	34,10	30,66
FLORIANOPOLIS	0,54	0,39	48,40	43,10	33,78
SAO PAULO	0,50	0,37	27,06	56,41	48,68
PORTO ALEGRE	0,43	0,32	46,39	69,54	78,48
BELO HORIZONTE	0,43	0,31	37,05	48,28	37,75
BRASILIA	0,41	0,31	22,07	36,44	30,05
RIO DE JANEIRO	0,29	0,23	42,29	47,36	42,52
RECIFE	0,26	0,18	26,15	64,42	57,12
FORTALEZA	0,23	0,15	22,46	39,57	31,92
SALVADOR	0,18	0,13	23,78	32,88	23,68

Table 16. Index of deaths and cars per inhabitants. Data elaborated by the author. Source: data from IPPUC, 2008

A study conducted by Marcilio and Gouveia (2007) on the impact of air pollution on the Brazilian population showed that among Belo Horizonte, Fortaleza, Porto Alegre, Rio de Janeiro, Sao Paulo, Curitiba and Vitoria, Curitiba has a low index of PM₁₀ in the atmosphere, with 23.3 µg/m³ on annual mean. It was also shown that Curitiba always resulted in below average levels of air pollution and the city with the second lowest indices in relation to how many children less than 5 years of age and elderly over 65 were admitted to hospital or died due to respiratory causes attributable to PM₁₀ (*ibid.*).

City	PM ₁₀ (µg/m ³) index	% deaths >65	% deaths <5	% admissions >65	% admissions <5
Belo Horizonte	20,7	2,2	2,5	2,6	4,1
Curitiba	23,3	2,5	2,8	2,9	4,7
Fortaleza	49,5	5,3	6,0	6,3	10,2
Porto Alegre	27,8	2,9	3,3	3,5	5,6
Rio de Janeiro	55,5	5,9	6,8	7,0	11,5
Sao Paulo	49,8	5,3	6,1	6,3	10,3
Vitoria	27,3	2,9	3,3	3,4	5,5
average	36,3	4,9	5,5	5,2	8,3

Table 17. PM10 in some Brazilian cities, and attributable percentage in deaths and hospital admissions. Source: (Marcilio & Gouveia,2007).

Particulate matter is a good indicator of sources of air pollution (Kunzli et al.,2000) – source as burning of fossil fuel, thus use of vehicular motorization as for example in the US the 95% of the energy used for transportation are fuels derived from oil (Greene et al.,1997).

It can come into mind why it was not implemented a different system as light rail or metro that run on electricity –but here we have the same problem regarding how electricity is produced. If for Mr. Lerner and

Ceneviva – the previous managerial class – implementing a different system never represented a necessity, for the newer managerial class it's not being done mainly due to economical issues, as claimed by Almeida. However, in the past alternative electrical solutions as trolleys were considered. In 1976 Mr. Ficinski said that in the next 5 years electrical busses will not be implemented due to economical impracticability, because of the costs relative to the import of the infrastructures (IPPUC, 2000:83), albeit the idea of implementing an electrical system was there.

In 1979, Mayor Lerner and Mr. Ficinski – at that time President of IPPUC – did not discard the possibility of implementing electrical trolleys in Curitiba (ibid), and the new Mayor Fruet in 1983 presented his project to the Federal Government for the adoption of electrical trolleybus so as to reduce the consumption of diesel fuel (mainly responsible for the high operational costs) with a less pollutant technology (ibid.). But as the demand was always increasing, other, faster solutions as the *ligeirinhos* were implemented. In reality, the city wanted to put into practice a tram system instead of *ligeirinhos* and it was not done because of its economical feasibility again, as stated by Ms. Soares. Although it was studied a project about a light rail system, in 1995 the City Hall decided to implement the biarticulated busses, even if the financial resources for the trolleys were guaranteed by World Bank loans (IPPUC, 2000). Mr. Ceneviva, at that time President of URBS, claimed that working with busses was cheaper, and the implementation was easier; in particular the bi-articulated with boarding on level, pre-paid system guaranteed by the tube stations, 270 users per trip, were able to accomplish the users demand, and were able to be implemented in only 7 months (ibid.).

It was in perfect symbiosis with the city's philosophy: always achieve simple, cheap and rapid solutions. The implementation revealed to be 7 times cheaper than the US\$280 million estimated for the implementation of electrical trolleys on the same line, with a capacity of only 300 users per trip, almost as the biarticulated (ibid.) – presumably due to the length of the stations platform.

For Mr. Almeida, the struggle of a transport system as the one in Curitiba consists in the fact that it is not possible to implement new solutions counting on subsidies; at the state of things, an increase in the revenues represents the most practicable manner in order to invest in the system. As already mentioned, the system is self-sustaining (Garrick et al., 2006), working without subsidies and generating profits both for the private companies, even with vehicles replacement costs, both for the municipality, as highlighted by Mr. Lerner;

Conclusions

The situation of Curitiba is better than many other cities of Brazil and other cities around the world. The city has a lower use of oil compared to other cities, thus it means that it is used more efficiently having a high bus rider-ship. New low-polluting fuels are currently being researched and more efficient engines, but the presence of a single line (tourism) with busses that run on alcohol while the entire system is still depending on fossil fuels is confusing to the author. A system based on a resource that will have its peak (IEA, 2005) in a couple of decades cannot be considered sustainable. Other alternative energies must be considered in order

to achieve sustainability of the system, but in this paper the author cannot address the issue related to the use of biofuels because the focus is at a higher level.

7.1.7 Promote electronic information services

Encourage and promote public access to electronic information services.

Public access to electronic information services is being developed in Curitiba during the last years. Mr. Almeida asserted that sixty-nine multimedia “totems” (internet points) were established all over the city in order to give the possibility to citizens to check different information, such as bus timetables, bus routes or other information regarding the city; in 2007 3,573,699 accesses were registered (URBS, 2008). Under this aspect the situation in Curitiba is surprisingly good considering the reality of the city, for example comparing this service with other cities in Brazil, or taking into account generally the situation of Brazil itself.

Conclusions

The city is putting a lot of efforts into achieving this criterion and it can be said that the actual situation fits the UN recommendation, with an increase in public access area to electronic information services and their use.

In order to be a sustainable system, it must include all the relevant criteria to urban public transport listed in the UN Habitat framework, the analysis of the Curitiba system has shown that it achieves many of these criteria, however the analysis has also shown that it does not meet some criteria. Therefore while the Curitiba system is on the path towards sustainability it cannot be termed as sustainable given the framework utilised in this paper.

7.2 Main features to move towards a sustainable public transport system

In this subsection are presented what, according to the author, are the main features in order to move towards a sustainable a public transport system, using the Curitiba experience as a basis for this discussion, and the UN Habitat framework as a guide. The different elements are grouped under four different areas: environment, society, economy and institutions. It should be noted that many of them have overlapping impacts.

7.2.1 Environment

7.2.1.1 Reduce the impact on the atmosphere

There is a strong correlation between traffic and air pollution; in a study on traffic related air pollution conducted in France, Switzerland and Austria, half of the deaths due to air pollution were connected to motorized traffic (Kunzli et al, 2000). Transport, especially road vehicles, is a main source of pollutants as oxides of nitrogen or volatile organic compounds (Greene et al, 1997); it emits 1/6 of global anthropogenic

carbon dioxide discharged and motor vehicles release respectively in Europe and the USA 47% and 45% of oxides of nitrogen, 39% and 37% of volatile organic compound and 66% and 78% of the total carbon monoxide emissions generated (ibid.). Therefore, to have a sustainable public transport should be implemented means of transport that *reduce the impacts* on the atmosphere, but *considering the entire phase of production* of less pollutant fuels as ethanol, and not considering only the pollutants emitted in its phase of use.

7.2.1.2 Energy used

One of the first things that come into people's minds when thinking about a sustainable transport system regards the energy it relies on; as in the case of Curitiba it can be questioned if it is possible to say that the system is sustainable while running on diesel fuel, even if it matches many economic and social aspects.

Greene et al. (1997) stated that the concept of sustainability does not necessarily mean that the transport system must stop running on oil right now, but it has to improve the efficiency in using it, finding alternatives which have a minor impact for the environment and for the human health, so to give to the next generation mobility and healthy environment. However, for the author of this paper, energy used represents a cornerstone on which base the sustainability of a public transport system.

In relation with environmental impact regarding pollutants emitted, a LRT or a metro are definitely as a cleaner system than busses; the thermal efficiency of a bus which runs on diesel is around 20%, while fossil fuels power plants that generate electricity is 45%, and 55% for combined cycle plants (Avrenli, 2007), thus implementing an electric system brings less emission produced, not even considering the possibilities to run an electricity power plants with renewable resources. Busses can always use low pollutant fuels as the mixtures Curitiba is testing, but as already mentioned in the paper the entire process of using biofuels can actually increase the environmental impact of the system (see section 7.1.6) or use electrical engines. An *assessment on the biofuels and electricity used* is required while planning a public transport system, together with an overall cost-benefit analysis regarding the implementation of the two energies, but *fossil fuels* should *surely be avoided* if it is aimed to achieve sustainability.

7.2.2 Society

7.2.2.1 Air pollution and health-related problems

Air pollution has several negative effects on the human health it can lead to death or hospitalization due to respiratory and cardiovascular diseases, reduces physical activity, decrease the quality of life, increase the demand for medication, thus create school and work absenteeism (Marcilio & Gouveia, 2007). Pollutants as PM₁₀ (Particulate matter), sulfur dioxide or carbon monoxide were connected with diseases and death associated with air pollution (Stieb et al, 2002). Long-term exposure to PM increases mortality from respiratory and circulatory diseases and lung cancer (Hoek et al, 2002). A public transport system *cannot* be based on fuels that *increment the release* in the atmosphere of *these pollutants*. The implementation of a sustainable transport system *shouldn't limit itself on the energy used* by its means of transport, but go side by

side with measures as *emission control*, *tolls* to enter the city with private motorized vehicles and *area restricted* to their use, making the vehicles and engines more efficient, *encouraging intermodal* means of transport as cycling and walking.

7.2.2.2 Accidents

Traffic accidents do not bring only physical outcomes, but can also cause psychological problems such as anxiety, depression and post-traumatic stress disorder, resulting in a decrease of the quality of life (Wang CH, 2005). Transport accidents are considered by the World Bank to jeopardize the human health having impact on the economy and health of the society, thus affecting two pillars of sustainability (Greene et al., 1997). So, the presence of a good public transport system should *encourages intermodal* transportation that *reduce* the use of *private vehicles* and thus it lowers the risks and occurrence of accidents, giving the citizens a safer and healthier environment.

7.2.2.3 Accessibility and priority to alternative to private motorization

A sustainable transport system, instead of supporting only a greater movement at higher speeds, should give importance to accessibility, providing to all the citizens in an equal, impartial, economically affordable and with low impacts on health and environment, the access to services, goods or houses (Litman, 1999).

It should be given *higher priority to public transit, or other means of non-motorized transport that are available to almost all the citizens* (ibid.), as Curitiba did being the first in Brazil implementing pedestrian roads and prioritizing the public transport integrated with land use. As the world trend of possessing and using cars is always growing, if the transport system does not want to lose users, must *be attractive*, must represent always a *good alternative* to cars, as explained by Mr. Ceneviva. He also commented: “it’s needed to reach new areas, create new reserved lanes, new stations, because if it does not happen the system will lose quality, thus users, starting a trend that hardly will be inverted: the public system must be considered the priority system of mobility”. Prioritize public transport through *disincentive private motorization*, implementing *higher taxes on registrations, fuels, discourage* their use through *unavailability of parking areas* and high *park-fees*.

A sustainable system must be *accessible to all the population*, especially to *disadvantaged* class that have already problems with mobility; they should have the same opportunities as the other users of the system.

Boarding on level, low floor busses with their *interior especially designed* for people with disabilities, presence of *lifts* to help the boarding, *employees trained* to handle these situations, are essential conditions for a sustainable transport system.

The creation of the *single fare* increase the accessibility of the citizens, gives to all of them the same opportunities in reaching, at the same price, the entire area of the city and part of its greater area: should be implemented a system that allows its users to switch lines without paying extra fees.

The accessibility must not be only physical but also economical; the system must be *affordable* for the low class. The municipality should provide free transfers when are needed, and also subsidized the class of

population that cannot afford the fares with special programs that stimulate a higher sense of community, as showed by the Curitiba's case with the programs where garbage is exchanged with tickets.

7.2.2.4 *Safety and comfortableness*

The system should be *safe* for its users, both regarding the rides themselves and the presence of criminality. From the interviews and conversation with the users in Curitiba emerged how criminality on busses, stops and terminals, especially when it is dark can affect the use of public transportation. A more active presence of police is required. The *rides* must be *safe* and *comfortable*, especially for elderly, pregnant women or people with disabilities. *Seminars* should be held for the employees of the public system on this theme, along with more education of the users as well, as proposed by an interviewee after he testified a common situation of finding the sector of the bus next to the door crowded, while there were sectors on the same bus with a much lower passenger density. In case of presence of reserved lanes people should be aware also about the risks of crossing them, as it can be a matter of violent brakes.

It was noticed, and confirmed by Mr. Almeida, that only a small share of users are the middle-upper class, and they should be involved more.

7.2.2.5 *Improving the infrastructures*

Infrastructures for intermodal transport as *bike lanes* needs to be improved, especially giving the bikers the opportunity to go to work by bike and not giving to bikes only a recreational connotation. *Exchange areas to encourage intermodal transport* are needed; it is not possible to pretend that people from the metropolitan area will not drive through the city with their own cars if are not provided parking lots next to public transport access in the outskirts of the city, so to park the car and catch the public transport.

Stops, busses, trains, terminals should always be *cleaned, repaired and improved*. They must be supplied with city *maps* and route maps, so to make the user more confident with the system. In the case of Curitiba, it should be said that if you are not from the city or not a customary user of the system it can be hard to get information on where to go.

Creation of *reserved lanes* is definitely improving the quality of the system. Features as *signal priority* for public transport, *pre-boarding fare* collection, *boarding on level, free transfers between lines, overlapping systems* of services (FTA, 1998) increase the quality of the system.

Means of transport should always receive an accurate *maintenance* so as to be always efficient and not generating waste.

Making the system attractive, will be one of the key for its future good functioning, thus restricting the number of private vehicles used in the city.

7.2.2.6 *Public participation*

In the case study emerged from the interviews and informal conversation that public participation in the decision is considered inadequate or almost totally absent; it was a nearly total agreement on the fact that when politicians adopt solutions they don't leave the citizens the opportunity to in the process.

Ms. Vallicelli claimed that IPPUC first suggest, then discuss with the population and then adopt the decisions, and the public are asked to suggest as well, that is a form of public participation.

The citizens must have the *opportunity to take part* in the *decision* that might affect their health, economic and social life, through seminars, meeting, referendum, attending presentation or forums.

7.2.3 Economy

7.2.3.1 Traffic

Traffic has heavy consequences on the economy (as it could be seen from Tab.9), society, human health, safeness and the environment (Vivier, 1999). Has showed by the case study, the integration of public transport with land use can reduce the need to travel, thus the need to use motorized transportation. Decentralization of main services and recreational activities instead of centralized everything in some areas of the city is needed.

Measures that *reduce the use* of private vehicles on the roads as car-free day or afternoon should be implemented.

7.2.3.2 Match transit capacity with feasible solutions

MR. Almeida claimed that generally, as it does not require high investments in infrastructures because it basically runs on normal roads, the execution of a bus system is more cost-effective compared with other solutions as metro or light rail. A study conducted by Kühn(2002) in different US cities shows that differences in capital costs when implementing the different systems are significant: from US\$21 million for LRT to a BRT range from US\$ 8 to 0.42 million per km depending on the type of street the BRT is implemented on – mainly due to higher prices of vehicles, rails, infrastructures for the electricity unless there is already an existing rail track, while the operating and maintenance costs resulted generally to be lower in BRT, mainly due to the higher number of staff required (ibid.). The costs regarding a metro system are much higher, US\$50-100 million per km (Adielsson & Friberg, 2001), and as Mr. Lerner said the vantage of a surface metro is that actually citizens know their city better and feel more part of it, thus caring more about it. The normally acknowledge theory that LRT has higher capacity than BRT is not always applicable (Kühn, 2002), as showed also before regarding the Curitiba's North-South axis capacity.

Avrenli (2007) states that, in presence of *high level of rider ship*, *light rail is the best economical solution*, because it is true that the implementation costs are higher per km, but they can be lower per user, while –due to its lower costs and better adaptability to changes – bus rapid transit is a more efficient system if

Table 18. External Cost of transport. Source: Vivier, 1999
(assessment in € per thousand passengers x km)

External cost category	Car	Bus	Metro and train
Noise (1)	10 to 25 depending on the density	2 to 3	2 to 3
Local air pollution (1)	6 to 12 depending on the density	< 1	< 1
Air pollution including greenhouse effect	10 to 50 (2)	About 3 times less than the cost for the car	4 to 10 times less than the cost for the car (3)
Accidents (cost not covered by insurance)	5 (1) 5 to 25 (2)	< 1 (1)	< 1 (1)
Congestion	10 to 70 (2) 50 (4)	< 10 (4)	0
Urban space use (traffic and parking)	50 to 250 depending on the density	3 to 20 depending on the density and the mode of operation	< 5

implemented in low-medium density populated areas. Also in his study, Kühn (2002) claimed that in a city with a population of *around 1 million*, a *BRT is an excellent solution*, but in the long run, if the number of users increase and if there are available funds, a light rail system might represent a better solution, especially if the change to the LRT happens gradually over time – as adopting from the beginning roadway that can be more easily converted in rail thus at smaller costs. The author always recommends the use of non fossils fuels. There is also the icon that the different system represent; for the users LRT is more attractive than busses (Kühn, 2002), and almost all the people interviewed in the case study by the author were fascinated by the image of metro system, also declaring to be more than favorable to its implementation in Curitiba. A BRT has a faster implementation at affordable costs, facing the demand more easily (ibid.) in the short term and is more flexible. In the case study is totally subsidized by the fares; do not need additional many as subsidies from the State to work.

Thus when implementing a public transport system it should be *taken into account the carrying capacity* required and at the same time the economic feasibility of its solutions.

7.2.4 Institution

7.2.4.1 Political willingness

The case study showed how the development of the city along the structural corridors, *integrating land use and transport system* and improving continuously its plan while *prioritizing public transportation*, resulted to be crucial for Curitiba progress, as crucial as the political willingness of its administrators. Curitiba was advantaged by a common political view regarding its choices, as from 1971 it is administrated by the same political faction (regularly run by another political group in the term '83-'88), thus giving the city the continuity it needed in order to implement its plan. However this should not mean that in order to achieve a sustainable system it is needed the same party to rule, as the policies must be implemented with the coordination of *local, autarchic and technical institutions*, as the case of URBS and IPPUC in Curitiba.

The positive results of the case study are frequently seen as the result of political willingness in planning (Macedo, 2004). Interviewing Mr. Jaime Lerner I asked him if the fact that he was appointed by the regime for his first term, affected his way to do politics, not concerning about the willingness to be re-elected in the following term so capable to implement strong, unpopular policies, but he answered that this one was not the key issue. According to Mr. Lerner the key issue is starting, *planning* does *not* have to take a *long time*, and *showing to the people the scenario* before taking a decision will help them *to understand* and thus let them see the strong policy with less concern; basically what affects the implementation of a strong policy is not enough willingness, complexity sellers (for those people which see everything more complex than it really is, and also sell this complex image) and lobbies.

Strong leadership and *political willingness* are fundamental requisites.

7.2.4.2 *Importance of small steps achievable in short time*

A more sustainable approach to transport is to *implement low-priced strategies and projects* instead of setting high-priced plans all at once (Litman, 1999), and in the case presented there was a continuous improvement and expansion of the transport system that brought a high quality service at small capital costs – as the system is financed by the users (Rabinovitch et al.,1995), demonstrating that coordinated land use with transport system bring greater benefits for the long-term than in the short-term (Kühn, 2002). This must go side by side with *fastness* in implementing the *solutions*, as claimed by Mr. Lerner: “it is needed to show to the stakeholders as users, normal citizens and private companies what is going on and how things will be in the end, show them the scenario proposing them better and valid alternatives, and show rapidity in taking decisions and adopting solutions”. The “Rua XV de Novembro”, the pedestrian street was created in 48 hours in the city studied, represents a perfect example.

7.2.4.3 *Presence of a urban plan, institutions and economical viability*

The presence of an *urban plan* is determinant in achieving the sustainability of the public transport system; for Mr. Ceneviva having a team with a good vision of what it is going to be in the future and implementing a well thought plan is fundamental, as well as the economical viability – the system should be *self-sustaining*. In the case study, as pointed out by Ms Soares, the main difference between the city and the other Brazilian cities consisted in the implementation of a good Master Plan. *Land use integrated to the transport system* should be the key of the plan, *decentralizing the services* needed for daily activities. *Encourage* a linear development with *high density* areas and provide them a *higher access* to the transport system. The *presence of local institutions* such as IPPUC and URBS that plan, guide the implementation and the revisions of the planning process is vital. Interdisciplinary institutions as those are needed in order to address in a better way the different issues related to transport, not focusing only about public transportation or parking (Bleviss, 2004). It is important to rely on local institutions, because they know better the problems of their city and the public transportation needed. Also they should have a strong *autarchic character*, so to not totally depend on the political party that rules the city at a given time.

7.2.4.4 *Equation of co-responsibility*

As strongly recommended by Mr. Lerner, always try to create an equation of co-responsibility between the stakeholders. In this way in the case study, where solved many possible issues as the presence of abusive private companies as in the other Brazilians cities, and also it was possible to implement an ambitious infrastructure otherwise impossible to execute. Call together all the stakeholders when planning a solution, let tem all take part to the process make them understand that thing that can be seen such as a negative trade off now can turn to be positive in the long term. Implementing an equation of co-responsibility reinforce the sense of community amongst the stakeholder.

7.2.4.5 *Public participation*

There is a dispute regarding the public participation at decisions, and to what extent people should be involved in taking decisions for the sustainability itself: many times the only voices that speak up representing the communities are “local professional elite” or “activist representing special interest” (Litman et al, 2006: 340), thus not representing the real interest of the communities. Municipalities must *include citizens* in the *implementation of decision* that might affect their lives.

8 Further research

A further suggested research topic could be to analyse the impacts on the economical, social, health and environmental features regarding the future implementation in Curitiba of a light rail system, a metro system or a bus system which runs on biofuels. To study the impacts that would have been produced by biodiesel fuel or electricity, not only in the phase of use but also in the phase of production, or their carrying capacity and their possibility to generate higher incomes for the city, but it would be interesting to study whether it is better and possible just to increase the frequency of the busses running on renewable resources or implementing another system as light rail or metro, or maybe the two options together.

Future research should study other age structures, as the author focused on younger generation, taking into consideration that most of the older generation users need to be shown a formal identification card from the municipality in order to be interviewed.

9 Conclusion

The cities will increase their role in the future due to the growth of their dwellers, side by side with the increase of their urban issues. Many problems today have their foundation or its bigger share in the cities, thus the cities must be seen as the solutions to these problems. The case presented showed how the political willingness in adopting an urban plan which integrates land use, road hierarchy and transport system can represent the alleviation to many of the city problems, as the transportation issues.

The RIT, analysed under the criteria presented, resulted to be a very effective system, mixing very positive indicators such as physical and economic accessibility, economical viability, coordination of land use and transport system, giving electronic access to the information and being more efficient in use of resources. Although there are indicators that cannot let the author say that the system is sustainable, as the encouragement of effective intermodal transportation, the presence of disincentives for private motorization traffic and the use of diesel fuel. In the future the city is already implementing new solutions, some of them based on biofuels, but regarding the future sustainability of these choices further researches needs to be done. The overall impression is still very positive and after all the system in Curitiba is better than many other systems implemented in other cities worldwide; overall the system is on the path to be sustainable, but it can be not until a change in those (unsustainable) indicators discussed above are addressed.

This paper has concluded, what for the author are the key criteria, in implementing a sustainable public transport system, highlighting the importance of the presence of good planning, political willingness, accessibility and use of renewable resources.

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IPPUC, Instituto de Pesquisa e Planejamento Urbano de Curitiba, presentation attended on 21-01-2008(b)

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All the data and article used in the paper are contained in a compact disk supplied with the paper.

Appendix 1

Question asked during the interviews, translate in English as they were made in Portuguese

Date: 2008, February, 20th

Respondent: Almeida Clever, Engineer, IPPUC.

After an average ten year period time the busses can be part of the system anymore. What happens after that?

Is it easily possible to access the information on public transport online? Are there any free internet points in the streets?

Who decide the routes, fares, who are going to be excluded to paying fares?

How many people live next to the structural corridors?

What are the predictions regarding the population for the future? How many people? How many cars?

What about the users of the public system? What is the trend?

I had the impression that the middle-upper class doesn't use public transportation that much. Is that true?

Do you have any data about accidents?

Can you tell which the main features of the Green Line are?

And the metro project?

Date: 2008, March, 11th (a)

Respondent: Almeida Clever, Engineer, IPPUC.

Who is responsible for the public transport in the metropolitan area, URBS or COMEC?

Do you always apply an environmental impact assessment to your projects?

How much is going to be invested in the green line?

Who is paying that money?

What do you think are the area that needs a better development?

Is the city thinking about any disincentive measures for private cars in the future?

Date: 2008, February, 28th

Respondent: Ceneviva Carlos Eduardo former President of IPPUC and former president of URBS

What was important for the implementation of the Curitiba's system?
What is for you a sustainable transport system? Is Curitiba's system sustainable?
Is the system covering effectively the entire city? Do you see any correlation between poor areas and lack of transportation? Between favelas and lack of transportation?
What you think must be done in order to improve the present situation? Alternative solutions are needed? Which ones?
What you think about the metro project?

Date: 2008, May, 14th

Respondent: Costa Daniel, Engineer, URBS

In many sources I read that the city is investing in new fuel-efficient fleets, but wasn't it a prerogative of the private bus companies?
Why the tourism line is the only line running on alcohol?
How it comes that in Curitiba there isn't the presence of private vans working as public transport but without the authorization of the municipality, as in Rio or Sao Paulo?

Date: 2008, March, 14th

Respondent: Daher Ariadne, Architect, Jaime Lerner Arquitetos Associados

What is the function of the Jaime Lerner institute?
Can you give me a background of the Curitiba Transport system, history, planning, etc?
What about the abusive private bus companies?
Do you know why the tourism line is the only one running on alcohol?
Can you tell me the main features of the green line?
The municipality has complete authority on its territory?
Do you see any relationship between criminality and lack of public transport? And between the favelas and the lack of public transport?
What is the future of the public system?

Date: 2008, February, 28th

Respondent: Ficinski Lubomir Dunin, former president of IPPUC

What happened with land use in Curitiba?
How the public transport is connected to poor areas?

Date: 2008, January, 21st

Respondent: Jaime Lerner, former Mayor of Curitiba and Governor of Paraná, former President of IPPUC

Can you give me an introduction to what for you is a sustainable city?
Do you think that the public transport system in Curitiba is sustainable?
Where you appointed for the first term or elected?
Did it play an important role in the boldness of your choices? And the facts that for the Brazilian law you cant get elected twice in a row?
What was the reaction of the people to your policies?
There were problems while creating the system? Corridors, lanes, tubs?
The city is attracting people, would this be a problem in the long run?
Why the other cities do not implement system similar to the one in Curitiba?

Date: 2008, March, 12th

Respondent: Soares Anive, Architect, URBS

Can you tell me something about the history of the public transport?
What are its future developments?
What was the Curitiba secret?
How the URBS started?
Which are the main URBS's functions?
What URBS is doing in order to diminish its environmental impacts?
There is the level of public participation in your decision?

Date: 2008, January, 23rd

Respondent: Vallicelli Liana, Foreign Affairs Advisor, IPPUC

Which one are the IPPUC's functions?
How do you judge the public participation here in Curitiba?
Which are the bureaucratic issues that IPPUC normally faces?
What are the future development of Curitiba?

Appendix 2

Question asked during the interviews, translate in English as they were made in Portuguese

Since how long are you living in Curitiba?

Where?

What is your profession?

Do you use the public transport system? Why? How many times per week? Which lines?

What image do you relate to the transport system?

Do have access to a car in your household? Do you own a car?

How many times do you use it? Why? When you don't use your car is because you think that transport system is a good alternative?

Would you like to buy yourself a car?

If you could use your car everyday, would you use it? Why it is needed a car in Curitiba?

What do you think are the main problems in the public system in Curitiba that should be improved?

Do you feel comfortable in the public transport?

How much is influent the presence on the political programs of improves in transport planning in your political choice when voting for a Mayor?

What are the average waiting times of the busses? Are they usually late?

What you think about the integrate network the busses have? There are the areas that should be improved?

Do you think there is an important difference in accessibility to services between who live in the center, who live on the corridor and who live in peripheral areas? It is possible to have the same quality of life?

Is the ticket fair?

What do you think about the single fare?

What do you think about the green line? And the metro?

Do you think public participation is present in Curitiba?

Are you happy about Curitiba? Do you like to live in another city?