Technische Universität Dresden
Fakultät für Verkehrswissenschaften „Friedrich List”
Institut für Verkehrsplanung und Straßenverkehr
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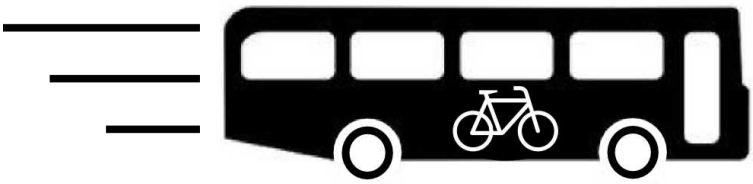
DIPLOMARBEIT

Sustainable urban transport approaches for Brazilian megacities – the examples of Rio de Janeiro and Curitiba



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EXECUTIVE SUMMARY

In Brazil, the use of private motorized vehicles has dramatically increased in recent decades, while public transportation is marked by a weak performance, and pedestrians and cyclists cope with a poor infrastructure design. Thus, suitable approaches are required to tackle current transport problems of Brazilian megacities. In view of the World Cup 2014 and the Olympic Games 2016, the megacity Rio de Janeiro is undergoing significant changes which offers a unique opportunity to ease the current situation and achieve an integrated sustainable urban transport concept.

Therefore, this Diploma thesis creates an overview on the current transport situation in large Brazilian cities, in particular for Rio de Janeiro; provides integrated and sustainable approaches to tackle transport problems of Rio de Janeiro; analyzes the transferability of infrastructure measures between Curitiba and Rio de Janeiro; and examines the impact of the upcoming sports events.

First, a literature review focuses on the transport situation in Brazil and Rio de Janeiro and explains Curitiba's unique approaches. Second, an audio-based qualitative content analysis of seven expert interviews with stakeholders in urban- and transportation planning gives a concise insight into the current transport situation. Third, a synthesis of both the literature review and the output of the expert interviews provide recommendations for decision makers, researchers and international organizations.

In order to initiate a sustainable development of the megacity Rio de Janeiro, urban- and transportation planning must be interconnected with each other, a transport association has to be created to design and manage a metropolitan public transport network, and it is imperative to reorganize the local bus system. Furthermore, non-motorized transportation modes should be promoted by designing streets based on sidewalk policies and building a bicycle network in regard to the local demands. In addition, Curitiba's most important lesson for Rio de Janeiro is the interconnection of high density areas with mobility corridors. However, the megacity will not be able to achieve an integrated sustainable urban transport concept by the sports events.

In conclusion, future transport measures have to focus on the middle class, while ensuring a needs-oriented mobility for all social classes. Decision makers should concentrate on the three "I's“ – Information, Integration and Inclusion – to enable real transport mode choices, facilitate sound and seamless travel, and attract more people towards ecomobile transportation modes. Eventually, a paradigm shift towards ecomobility is needed in order to enable a sustainable urban transportation concept for today's and future generations.

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LIST OF ABBREVIATIONS

ANTP	Associação Nacional de Transportes Públicos National Association of Public Transport
ASBEA-RJ	Associação Brasileira de Escritórios de Arquitetura Rio de Janeiro Brazilian Association of Architecture Rio de Janeiro
AZIA	Audiobasierte Zusammenfassende Inhalts-Analyse Audio-Based Content Analysis
BRS	Bus Rapid System
BRT	Bus Rapid Transit
CBD	Central Business District
CET-RIO	Companhia de Engenharia de Tráfego do Rio de Janeiro Traffic Engineering Company of Rio de Janeiro
CNG	Compressed Natural Gas
COMEC	Coordenação da Região Metropolitana de Curitiba Coordination of the Metropolitan Region of Curitiba
COPPE	Instituto Alberto Luiz Coimbra de Pós-Graduação e Pesquisa de Engenharia Alberto Luiz Institute - Graduate School and Research in Engineering
CPTM	Companhia Paulista de Trens Metropolitanos Paulista Company of Metropolitan Trains
CTBA	Curitiba
DET	Departamento de Engenharia de Transportes (UFRJ) Department of Transportation Engineering (UFRJ)
FAU	Faculdade de Arquitetura e Urbanismo (UFRJ) Faculty of Architecture and Urbanism (UFRJ)
FETRANSPOR	Federação das Empresas de Transportes de Passageiros do Estado do Rio de Janeiro Federation of Passenger Transport Companies of the State of Rio de Janeiro
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH German Agency for International Cooperation
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit German Agency for International Cooperation
INVERDE	Instituto de Pesquisas em Infraestrutura Verde e Ecologia Urbana Research Institute for Green Infrastructure and Urban Ecology
IPP	Instituto Pereira Passos Pereira Passos Institute
IPPUC	Instituto de Pesquisa e Planejamento Urbano de Curitiba Institute for Urban Research and Planning of Curitiba
ITDP	Institute for Transport and Development Policy
Logitrans	An acronym that refers to the consulting firm Logística, Engenharia e Transporte.
LRT	Light Rail Transit
NMT	Non-Motorized Transportation
OECD	Organization for Economic Co-operation and Development

PDTNM	Plano Diretor de Transporte Não-Motorizado Master Plan of Non-Motorized Transportation
PDTU	Plano Diretor de Transporte Urbano Master Plan of Urban Transportation
PlanMob	Plano de Mobilidade Transport and Mobility Master Plan
PNMU	Política Nacional de Mobilidade Urbana National Policy on Urban Mobility
PR	Paraná
PT	Public Transportation
RIT	Rede Integrada de Transporte Integrated Transport Network
RJ	Rio de Janeiro
RMRJ	Região Metropolitana do Rio de Janeiro Metropolitan Area of Rio de Janeiro
ROLAC	Regional Office for Latin America and the Caribbean (UN-HABITAT)
SAMBA	An acronym that refers to the public bicycle system of Rio de Janeiro.
SECTRAN	Secretaria Municipal de Transporte da Cidade do Rio de Janeiro Municipal Secretariat of Transportation of the City of Rio de Janeiro
SETRANS	Secretaria de Estado de Transportes do Rio de Janeiro State Secretariat for Transport of Rio de Janeiro
SMTR	Secretaria Municipal de Transporte Municipal Secretariat for Transport
SP	Sâo Paulo
SUPERVIA	An acronym that refers to the private concessionaire in charge of operations and maintenance of the Rio de Janeiro suburban rail.
SUV	Sports Utility Vehicle
TA	An acronym that refers to Transporte Ativo (Brazilian Transport NGO) which is an active civil society organization, focusing on the quality of life through the use of human-powered transport modes.
TC URBES	An acronym that refers to the consulting firm specialized in the preparation of studies, plans and projects on mobility, accessibility and redevelopment of urban public space.
UCT	Universidade Cooperativo do Transporte Cooperative University of Transport
UFPR	Universidade Federal do Paraná Federal University of Paraná
UFRJ	Universidade Federal do Rio de Janeiro Federal University of Rio de Janeiro
UN-HABITAT	United Nations Human Settlements Programme
URBS	An acronym that refers to Urbanização de Curitiba S/A which is a mixed economy company that controls the public transportation system in Curitiba.
USP	Universidade de São Paulo University of São Paulo

1 INTRODUCTION

The goal of any sustainable urban transport concept is a high share of ecomobile transport modes. In contrast to this stands Brazil's growing middle class, which is rapidly buying cars and motorcycles, supported by a strong car-culture trend. Thus, the use of private motorized transportation has dramatically increased in recent decades, while public transportation is marked by a weak performance and pedestrians as well as cyclists cope with a poor infrastructure design. In consequence, the transportation system of large Brazilian cities suffer severe problems which resulted in a mobility crises with extreme effects for the every day life of all citizens.

Hence, suitable and creative approaches are required to tackle current transport problems. In view of the World Cup in 2014 and the Olympic Games in 2016, the megacity Rio de Janeiro is going through an important change which offers a unique opportunity for decision makers in order to ease the current situation and achieve an integrated sustainable urban transport concept.

Curitiba, a model city for urban- and transportation planning and mother of the *Bus Rapid Transit* (BRT)-system, has successfully established an affordable solution to deal with its transport problems within the past 40 years. Although it has one of the highest car-ownership rates in the country, its fast, cheap, and reliable transportation system shifts the modal share towards public transportation, using this system as a key tool to direct the growth of the city.

Meanwhile, the megacity Rio de Janeiro struggles with massive transportation problems. Currently, the city's public transportation system is undergoing major changes, but this infrastructure upgrade mainly derives from the external force of the sports events and is not an immediate response to its transportation problems. This indicates that the city requires adequate approaches to develop a sustainable urban transport concept, supported by the lessons drawn from the Curitiban experience.

Therefore, the objectives of this thesis are to create an overview on the current transport situation in large Brazilian cities, in particular for Rio de Janeiro; to provide integrated and sustainable approaches in order to tackle current transport problems of Rio de Janeiro, focusing on the reformation of the public transportation system and the promotion of non-motorized transportation; and to analyze the transferability of infrastructure measures between Curitiba and Rio de Janeiro.

First, a comprehensive, international literature review gives an overview of Brazil's general characteristics and its transport structure, explains transport related institutional issues, analyzes sustainable urban transportation within the context of Brazil, and identifies key transport problems of large Brazilian cities. Furthermore, it provides information on relevant transportation and future mobility issues of Rio de Janeiro as well as on Curitiba's unique approaches. Research is presented in a top-down process, starting with the national perspective of Brazil, followed by Rio de Janeiro's state and municipal point of view, and eventually focusing on the Curitibian experience. This section provides the necessary background for the understanding of the expert interviews.

Second, the audio-based qualitative content analysis of seven expert interviews with relevant stakeholders in urban- and transportation planning of Rio de Janeiro, Sâo Paulo, and Curitiba gives a concise insight into the current transport situation. The output of these interviews present information on transportation problems of Brazilian megacities, approaches to tackle the transport problems of Rio de Janeiro, and the transferability of infrastructure measures between Curitiba and Rio de Janeiro. In addition, it examines the impact of the upcoming sports events in Rio de Janeiro as well as future challenges for the Brazilian urban transportation sector.

Third, recommendations provide a concise synthesis of the literature review and the expert interviews for decision makers, researchers and international organizations, such as the *Deutsche Gesellschaft für internationale Zusammenarbeit (GIZ) GmbH* (GIZ), the *Institute for Transportation & Development Policy* (ITDP) or the *United Nations Human Settlements Programme* (UN-HABITAT).

2 LITERATURE REVIEW

2.1 BRAZIL

2.1.1 GENERAL STRUCTURE

Brazil is the biggest country in Latin America and the fifth largest country in the world in terms of territory and population. It spreads out north to the equator line and south to the Tropic of Capricorn. As a consequence of its vast territory and geographical location, it is marked by many differences. [SILVA, SILVA COSTA, MACEDO 2008, P. 351]

In 2010 the country's population reached approximately 190 million inhabitants. The annual population growth rate between 2000 and 2010 was 1.17 % [IBGE 2011a] and is expected to be 0.8 % between 2010 and 2015 [UNDP 2011, P. 163].

The Federative Republic of Brazil consists of 27 states and differs in five geo-political regions (South, Southeast, Center-West, North, Northeast), each one marked by several economic and social contrasts [SILVA, SILVA COSTA, MACEDO 2008, P. 351]. The states located in the southern and southeastern region are among the most affluent in the nation [MACEDO 2004, P. 539]. Brazil has 13 cities with a population over one million people[1] [IBGE 2011a]. Most of them are located at the coast, demonstrating an uneven distribution of the population throughout the country (see Figure 1/2).

The metropolitan areas of São Paulo and Rio de Janeiro represent a mega-region[2], with a population of more than 43 million people [UN-HABITAT 2010, P. 8]. More than Ten million people live in each agglomeration. Thus, both are considered to be mega-cities[3][IBGE 2011a]. In addition, the city of São Paulo will reach the status of a meta-city[4] by 2020 when it surpasses the 20 million threshold [UN-HABITAT 2006, P. 1].

1 São Paulo, Rio de Janeiro, Salvador, Brasilia, Fortaleza, Belo Horizonte, Manaus, Curitiba, Recife, Porto Alegre, Belém, Goiâna, Guarulhos.

2 Mega-regions are natural economic units that result from the growth, convergence, and spatial spread of geographically linked metropolitan areas, accumulating even larger populations than any mega- or meta-city. [UN-HABITAT 2010, P. 8]

3 A megacity is a high-density metropolis of more than 10 million inhabitants. [UN-HABITAT 2006, P. 1]

4 A meta-city is a city with a total population in excess of 20 million people. [UN-HABITAT 2010, P. 8]

Figure 1: Map of Brazil;
Source: [WIKIPÉDIA 2004]

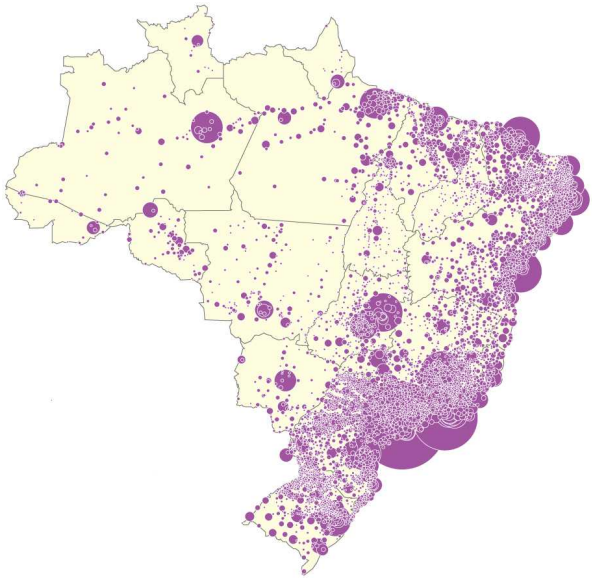

Figure 2: Distribution of the population in 2000;
Source: [THÉRY, ARCHELA 2008]

Brazil is the 10th largest economy in the world and belongs to the BRIC-countries[5] whose economic growth development exceeds the world's leading industrialized nations [Biggemann, Fam 2011, P. 5]. Furthermore, Brazil can be classified as a newly industrialized country because it has undergone profound structural changes in its economy under conditions of a fast growth rate since the mid-1960s [BOŻYK 2006, P. 164]. The annual changes of its Gross Domestic Product (GDP) development demonstrate its vibrant economy (see Figure 3). In 2007, São Paulo, Rio de Janeiro, Brasília, Belo Horizonte, and Curitiba had the highest municipal GDP's of all cities, in total accounting for almost a quarter of the Brazilian economy [IBGE].

Nevertheless, Brazil is one of the most unequal countries in the world, considering its GINI coefficient[6] of 0.566 [UN-HABITAT 2010, P. 86]. According to the World Bank, the inequality concerning income and wealth is high. In 2009, the income of the top tenth of all Brazilian households was 40 times larger than the income of the lowest tenth (see Figure 4). [AICHINGER 2010, P. 68]

5 A grouping acronym that refers to the countries of Brazil, Russia, India and China.

6 "The Gini index is the most widely used summary measure of inequality. It measures the distribution of either income or household consumption expenditures as a ratio between 0 and 1, where 0 indicates perfect equality (a proportional distribution of resources), and 1 indicates perfect inequality (where one individual has all of the income or other resources and no one else has any). [UN-HABITAT 2010, P. 62]"

The Human Development Index (HDI)[7] ranks Brazil among the countries with “high human development“ on 84th position with a value of 0.718, closely followed by countries such as Colombia or Iran. [UNDP 2011, P. 128] Regarding the inequality-adjusted HDI, Brazil's situation evidently deteriorates, being the second lowest of all countries with high human development [UNDP 2011, P. 136].

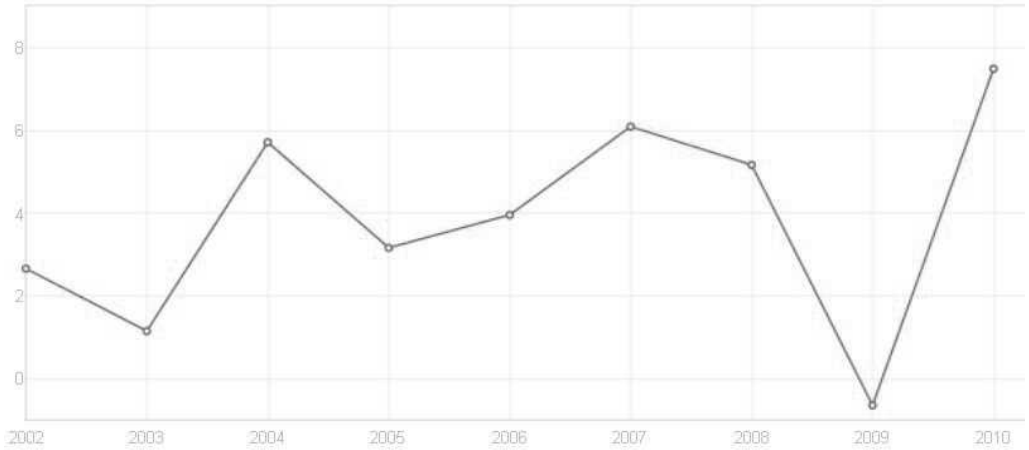

Figure 3: Brazil's GDP growth (annual %); Source: [World Bank 2012]

However, decreases in income inequality in Brazil have been reported. Overall urban Gini values fell from 0.63 in 1999 to 0.58 in 2007. [UN-HABITAT 2010, P. 77] Over the past decade, millions of Brazilians were able to rise from extreme poverty to higher income groups which resulted in a growing middle class [AICHINGER 2010, P. 68 – 69].

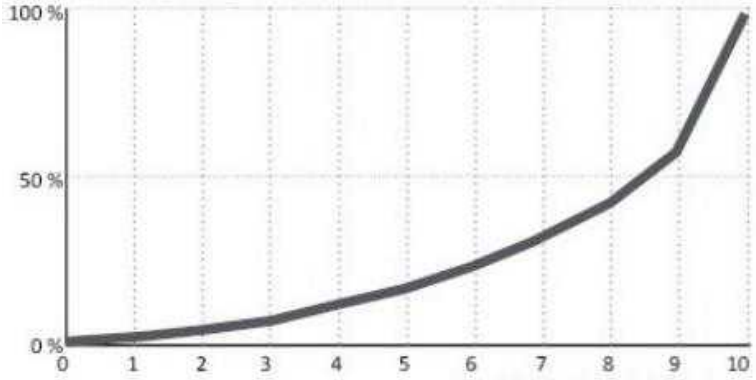

Figure 4: Cumulative distribution of income to households by deciles (i.e. tenth); Source: [AICHINGER 2010, P. 69]

7 The HDI ranks countries by level of human development, measuring the average achievements in a country in three basic dimensions of human development: long and healthy, access to knowledge, and standard of living. [UNDP 2011, P. 168]

2.1.2 INSTITUTIONAL ISSUES

Institutional responsibility for transport in Brazil is divided into federal, state and city level of government. Depending on infrastructure and transport modes each level has its specific area of responsibility as it is defined in the Brazilian Constitution.

The federal government is responsible for airports and ports, the federal railway system, the federal highway system, and controls the bus and interstate train system. It is exclusively responsible for defining traffic regulations and fuel quality and furthermore is responsible for establishing service contracts, approving technological innovations of vehicles, and the use of new types of fuel.

Responsibilities of the state government are state highways and railways, intercity and long-distance bus systems, and intercity transport.

City governments are in charge of public transportation[8] and traffic within the city's geographical limits. Local mayors are legitimate authorities with the power to conduct traffic planning, operations and inspections which include administrative policing regulations. Most municipal authorities have contracted private operators to manage the bus system and provide public services.

Transport issues are handled by technical departments, in state or city transport departments. Vehicle licenses and driver’s licenses are the state government's responsibility, while local authorities are responsible for planning, signaling, and operating the urban traffic. This distribution of responsibilities was defined by the Brazilian Traffic Code[9], enforced in January 1998.

Since 2003, the Ministry of Cities has incorporated all activities connected with public transport, transit, housing and urban development. It created the National Secretariat for Mobility and Urban Transport and reorganized the National Traffic Department (DENATRAN). Environmental issues are under the responsibility of the Ministry of the Environment and – if available – the State Departments of the Environment. The main federal government environment regulatory agency is the National Council for the Environment (CONAMA). Few cities have their own environmental departments.

Community engagement with transport issues is still weak, but over the last decade the relationship between government and civil society improved in this area. This can

8 Public transportation is a shared passenger transportation service. Transportation modes include trains, metro, trams, buses, ferries, taxis and other modes of transportation (e.g.: the cable car).

9 Port.: Código de Trânsito Brasileiro, regulates the public use of the road system. [ANTP 2003, P. 14]

be explained by the society concerns due to the deterioration of the urban environment and the strengthening of Brazilian democracy which succeeded in the inclusion of new social groups in formal discussions regarding policy decisions. Recently, a large number of government agencies engaged with civil society, remarkably in projects with significant environmental impacts which usually require environmental impact studies prior to the project approval. [WBCSD 2009, P. 23–29]

The 1988 Constitution incorporates a chapter about urban policies and defines the service of public transportation as an essential public service of municipal responsibility [SILVA, SILVA COSTA, MACEDO 2008, P. 352]. It empowers the federal government to draft the guidelines for a National Policy for Urban Development – including city transportation (Article 21, clause 20) [WBCSD 2009, P. 28]. The City Statute[10], enforced in 2001, is a groundbreaking body of legislation that redefines the concept of land ownership, as it expresses the social value of urban land [UN-HABITAT 2010, P. 124]. Furthermore, it enforces municipalities with more than 500,000 inhabitants to make integrated transportation plans, so called *Plano de Mobilidade* (PlanMob). [SILVA, SILVA COSTA, MACEDO 2008, P. 352].

On January 3rd of 2012, the new *Política Nacional de Mobilidade Urbana* (PNMU)[11] was enacted. It will become effective within April 2012. It establishes guidelines and principles for municipalities to plan urban development and the improvement of services and infrastructure to ensure the mobility of people and goods in urban territories. The PNMU prioritizes public transportation and non-motorized transportation[12], and financially encourages municipalities, with a population over 20,000 inhabitants, to develop a mobility plan within three years in order to receive further funding for urban mobility. It will be the new legislative instrument on urban development and mobility issues in the country. [EMBARQ BRASIL 2012]

2.1.3 SUSTAINABLE URBAN TRANSPORT

The term “sustainable development” was introduced in 1980 and popularized in 1987 by the Brundtland Commission. The achievement of sustainability in all sectors

10 Estatuto da Cidade, Law number: 10.257/2001, regulates the articles 182 and 183 of the Federal Constitution.

11 Política Nacional de Mobilidade Urbana, Law number: 12.587/2012.

12 *Non-motorized transportation* (NMT) is any form of transportation powered by human energy. For example walking, cycling, wheelchair, skateboard, skates, etc. This type of transport is an aspect of the day-to-day life of people as they walk to the bus stop, go by bike to work or study, or for leisure activities with the family. [SETRANS c]

of human activity, including transport, became a global mission after the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in 1992.[OECD 2002, P. 15]

Unfortunately, there are various definitions of the term “sustainability”. Likewise, the understanding of what can be a “sustainable transport system” varies, too. Academics define sustainable transport in several different ways which results in a vast disagreement. Therefore, there is no complete agreement in defining this expression. [BLACK 2000, P. 141]

According to the Brundtland Commission, sustainable development "meets the needs of the present without compromising the ability of future generations to meet their own needs“ [BRUNDTLAND 1989, P. 8]. Such ‘needs’ include goals related to economic development, social and human development, and environmental and ecological health [GOLDMAN, GORHAM 2006, P. 262]. Transport is an integral element of social development. In this context, “sustainable mobility” means to establish transport systems, which attend the worldwide growing demand for mobility and enable the development of dynamic economies. Likewise, it must help to overcome poverty and has to assure the overall goals of sustainable development. [BMZ 2003, P. 14]

One of the first concepts of sustainable urban mobility, created by the *Organization for Economic Co-operation and Development* (OECD) and later complemented by the *European Commission Group of Specialists in Transport and Environment*, defines “sustainable transport” within social, economic, and environmental dimensions as a type of transportation which:

- “Allows the satisfaction of the basic accessibility and mobility needs of people, companies and society, so that it can be compatible with human health and the equilibrium of the ecosystem, promoting intra- and inter generational equality.
- Has acceptable costs, functions efficiently, offers the possibility to choose transport modes and supports a dynamic economy and regional development.
- Limits emissions and residues according to the earth’s capacity to absorb them, utilizes non-renewable resources at a rate below or equal to the development of renewable substitutes and reduces land use and sound emissions to the minimum level possible.” [SILVA, SILVA COSTA, MACEDO 2008, P. 350]

Furthermore, the OECD defines an environmentally sustainable transport as one where: “Transport does not endanger public health or ecosystems and meets the needs to access consistent with a) use of renewable resources below their rates of regeneration, and b) use of non-renewable resources below the rates of development of renewable substitutes.” [OECD 2002, P. 16]

However, in spite of these internationally accepted definitions, the mobility concept strongly depends on the context. In order to reflect the priorities and approaches of different regions and areas, every country has to work at several levels. Transportation systems are complex because of structural differences in terms of infrastructure and vehicles as well as differences among technicians and organizations involved in their planning and management. Additionally, different modes and services, regulatory rules, financing agencies, technologies, land use patterns and aspects of the human behavior contribute to make them even more complex. [RICHARDSON 2005]

In Brazil, traditional urban mobility planning concepts, implemented from 1960 to 1990, focused on: traffic management (strategies to reduce congestion), transportation services (provision of public transportation), and transportation infrastructure (expansion of the urban road networks). The results of this process are the supply of infrastructure for road transport through multi-lane roadways and expressways, the prioritization of individual transport to the detriment of the public transport, the disregard of the non-motorized transportation modes, and the separation of urban and transport planning. Those uncoordinated actions have resulted in the loss of financial resources, the lack of social control, and the disregard of environmental questions in the planning of urban transport in Brazil. [SILVA, SILVA COSTA, MACEDO 2008, P. 352]

The new concept of urban mobility has its basis in the 1998 Federal Constitution, but the debate about sustainable urban transport has started only after the *City Statute* and the following creation of the *Ministry of Cities* in 2003. The new mobility concept introduces social, environmental, and equity issues into the planning process. [SILVA, SILVA COSTA, MACEDO 2008, P. 352] The *Ministry of Cities* describes “sustainable urban mobility” as the product of policies which provide broad and democratic access to urban space, prioritizes non-motorized and public transportation modes, eliminates or reduces spatial segregation, contributes to social inclusion, and encourages environmental sustainability [MINISTÉRIO DAS CIDADES 2007, P. 42].

However, a country like Brazil is characterized by economic, social, and structural differences between the mobility systems of the various municipalities. Each region and city has particular characteristics that limit the elaboration of one unique solution for all mobility problems. Thus, the sustainable urban transport concept has to be adapted to the social context and the needs and potentials of the specific location. [SILVA, SILVA COSTA, MACEDO 2008, P. 352]

2.1.4 TRANSPORT STRUCTURE

Brazil is undergoing major demographic, social and economic changes which are modifying the characteristics of its cities and the mobility of its people. Thus, data on mobility is limited and unreliable. The most comprehensive survey is done by the *Associação Nacional de Transportes Públicos* (ANTP)[13]. [MALUF ET AL. 2011, P. 3]

In the 2010 report, the analyzed amount of trips totals 59.5 billion trips per year (see Table 1). With 40.5 % of all trips, non-motorized transportation is the dominant urban transport mode in Brazil – this reveals that most trips were made on foot. Public transport almost equals the share of motorized transport. Local buses are the dominant technology within the public transport share. The ecomobility[14] modes of transport represent almost 70 % of the total urban transport system.

Modal distribution differs according to the size of the city. Non-motorized transportation (56 %) prevails in cities up to 250,000 inhabitants, while public transport (36 %) dominates in cities with more than one million inhabitants, closely followed by walking (33 %) and the automobile (28 %). The share of cycling is extremely low in these cities (1 %). [ANTP 2011, P. 35]

The “Sistema de Indicadores de Percepção Social” (SIPS)[15] provides a different modal share for Brazil's urban mobility. According to the 2011 report, most of the people prefer to use public transportation (44 %) which is followed by the automobile (24 %) and the motorcycle (13 %). Only 12 % walk, 7 % use their bicycle.

13 The *Sistema de Informações da Mobilidade Urbana* (eng.: mobility data system) encompasses 438 cities and represents about 60 % of the country’s urban population and 60 % of the vehicle fleet, which demonstrates that it covers the majority of urban trips in Brazil. [ANTP 2006]

14 Ecomobility is an integrated form of environmentally sustainable mobility, which refers to the use of non-motorized modes of transportation and / or the public transportation to allow people to move in their local environments without utilizing privately owned motor vehicles.

15 SIPS intends to serve as a framework for data about the perception of the population. The research serves both as an indicator for the public sector to structure their actions, and as a method to understand civil society. [IPEA 2011, P. 2]

Analyzing Brazil's regions separately (see Figure 5), it differs from the national average. Public transportation has the highest share in all regions. But in the North and Northeastern region people tend to walk and cycle more than in the South, while people in the Center-West, South and Southeastern regions prefer the car. Evidently, people seem to use more non-motorized transportation in the poorer North than in the richer South (see Chapter 2.1.1). [IPEA 2011, P. 4]

Table 1: Trips per year by main mode of transport (2010); Cities with 60,000 inhabitants or more; Source: [ANTP 2011, P. 31–32]

MODE OF TRANSPORT	TRIPS	
	(millions of trips / year)	(%)
Total public motorized transport	**17,333**	**29.1**
Local bus	12,263	20.6
Metropolitan bus[16]	2,862	4.8
Track	2,208	3.7
Total private motorized transport	**18,061**	**30.4**
Automobile	16,140	27.1
Motorcycle	1,921	3.2
Total private non-motorized transport	**24,100**	**40.5**
Walking	22,171	37.3
Cycling	1,929	3.2
TOTAL	**59,494**	**100.0**

In Brazil, non-motorized transportation is still a very new aspect in urban mobility and, in a broader perspective, refers to any form of transportation powered by human energy, such as walking and cycling. Unfortunately, both modes of transportation have to cope with a dangerous environment in large Brazilian cities (see Chapter 2.1.5). The conditions for pedestrians are in stark contrast to the current modal share. Badly maintained infrastructure characterized by narrow, potholed and unpaved sidewalks are a very common sight in Brazilian cities. Investments appear to be superfluous because walking has always been considered second-class mobility. [MALUF ET AL. 2011, P. 16–17].

Approximately, there are over 60 million bicycles in Brazil (see Table 2), making it the most prevalent mode of transport in terms of availability. The bicycle has four distinct

16 Buses linking cities within metropolitan areas.

images: First, as an object of entertainment for all social classes, with wide use on weekends and holidays. Second, as an object for children, representing the first step in obtaining freedom. Third, as an object for sport, increasingly present within the middle class cyclists. Fourth, as a mode of transport of the low-income population, by far the strongest image prevalent in Brazilian society. [VALERI 2007, P. 65]

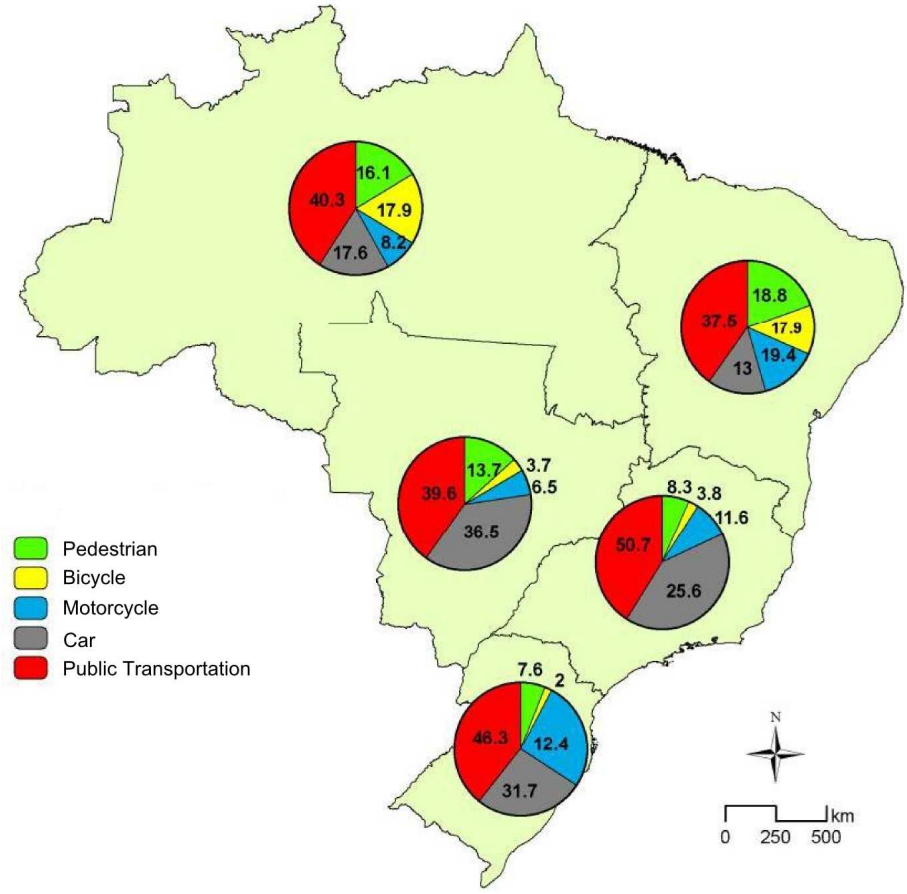

Figure 5: Usage of transport modes by region;
Source: [IPEA 2011, P. 4]

Public transportation is based on local buses, metropolitan buses, and rail systems. In all urban areas, local buses remain the predominant mode of transport, while metropolitan buses are provided in 20 areas. Eleven railway and subway systems are in operation, most of them located in large cities. [ANTP 2006] In total, the public transport system serves more than 17 billion passengers per year, whereas 71 % of the total demand is served by local buses. The vehicle fleet consists of 77,753 local buses, 25,318 metropolitan buses, and 3,034 railway and subway cars. [ANTP 2011, P. 99].

The country's bus system has become one of the largest in the world, due to a unique relationship between government authorities and private operators. However, the image of the public transport system is suffering decreasing importance, quality, efficiency and reliability, and today it is perceived as the "necessary evil" by those who cannot afford to buy themselves a car. [WBCSD 2009, P. 29–31] Informal activities exploded in the mid-nineties in response to the stagnation and structural changes [GOLUB ET AL. 2009, P. 603].

Table 2: Bicycle fleet in Brazil;
Source: [REVISTA BICICLETA 2010, P. 25]

REGION	QUANTITY	%
Southeast	28,800,000	44
Northeast	16,800,000	26
South	9,100,000	14
Center-West	5,200,000	8
North	5,200,000	8
TOTAL	**65,100,000**	**100**

The Brazilian vehicle fleet (see Table 3) consists primarily of automobiles, motorcycles, and mopeds (82 %). In 2010, about 3.5 million new automobiles, light commercial vehicles, buses, and trucks were registered [ANFAVEA 2011, P. 65]. The motorcycle industry produced a further 2.1 million vehicles [ABRACICLO 2011].

Table 3: Registered vehicle fleet – 01/2012;
Source: [DENATRAN 2012]

VEHICLE	QUANTITY	%
Automobiles	40,029,320	56
Motorcycles and mopeds	18,569,379	26
Light Commercial	6,878,363	10
Trucks and tow trucks	4,293,437	6
Buses and micro buses	788,457	1
Other	406,183	1
TOTAL	**70,965,139**	**100**

In 2010, 82 % of all new vehicles were flex-fuel-powered[17], 10 % were diesel-powered vehicles (only light commercial, trucks or buses), and 8 % were gasoline-powe-

17 The Brazilian "flex-fuel" technology enables cars to run on either gasoline, ethanol, or a mixture of both in any proportion.

red. Strictly ethanol-powered vehicles were no longer manufactured. Heavy duty vehicles were entirely diesel-powered. [ANFAVEA 2011, P. 67]

Between 2000 and 2011, the vehicle ownership increased dramatically, almost doubling the quantity of automobiles and more than quadrupling the number of motorcycles (see Figure 6). Currently, vehicle ownership rates are accounting for about 200 automobiles and almost 100 motorcycles and mopeds per 1,000 inhabitants. Between 2010 and 2015, the growth of automobile registrations is prognosticated to be 6.8 % [PTV 2011, P. 20].

In fact, the core problem is the intensive use of private motorized transportation. The "modal imbalance" is a reflection of the comfort of the car and the practicality of the door to door transport, all tempered by the strong automotive and fuel lobby [BRANCO 2011, P. 9]. Former public transport users are resolving their mobility problems by purchasing motorcycles or cars, often stimulated by the Federal Government [BOARETO 2003, P. 47]. For the high-income sector cars appear to be the only efficient mode of transportation available [WBCSD 2009, P. 30]. This longing, commonly known as *sonho do automóvel* (eng.: dream of a car), is the origin of the actual crisis and has serious implications for the efficiency and quality of life in Brazilian cities and it represents a continuing threat to public transportation. [ANTP 2003, P. 15]

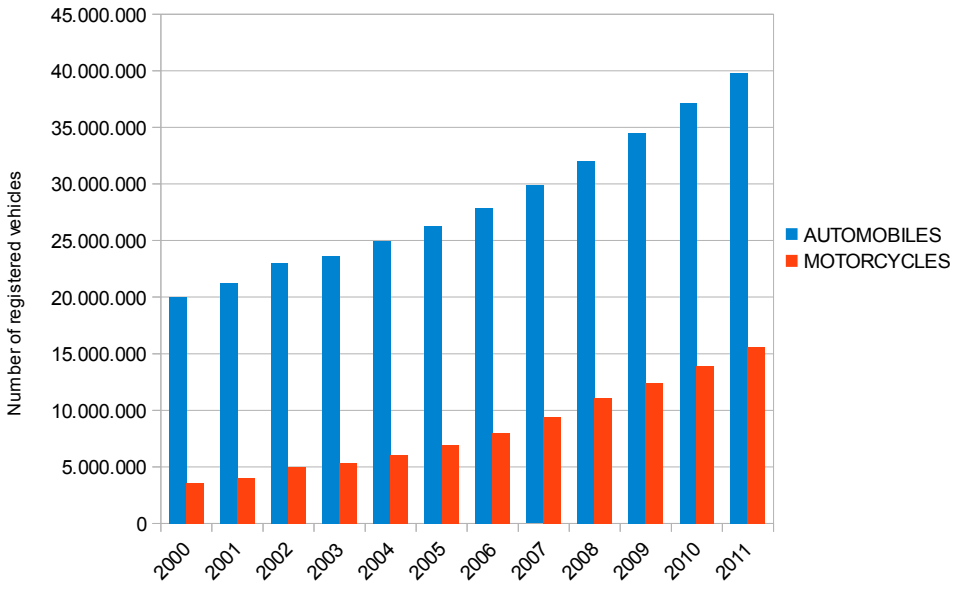

Figure 6: Development of registered vehicle fleet between 2000 and 2011; Source: [ANFAVEA 2011]

2.1.5 TRANSPORT PROBLEMS OF BRAZILIAN CITIES

As shown in Table 4 (P. 20), the urban transport crisis in developing countries has several dimensions and problems. Even though, Brazilian cities differ greatly in economic, social, and structural characteristics, most transport related processes are similar in all Brazilian cities [VASCONCELLOS 2005, P. 100].

“Poor transit supply, low accessibility, badly maintained vehicles, discomfort, congestion, pollution, and accidents are daily problems faced by most people living in large Brazilian cities“ [SILVA, SILVA COSTA, MACEDO 2008, P. 352].

Furthermore, structural, political, and economic conditions maintain social exclusion, poverty, and unemployment and limit the decision-making process to selected groups. Likewise, private transportation has often been favored, while public transportation and non-motorized transportation modes have been neglected. [SILVA, SILVA COSTA, MACEDO 2008, P. 352]

Key problems of the Brazilian urban transport system are [WBCSD 2009, P. 32–35]:

- Endemic congestion,
- Long travel times in public transportation system,
- Poor public transport supply,
- Increase of informal transportation services,
- Increase in number, severity, and distribution of traffic accidents,
- Air pollution,
- Conflicts among state and local public agencies in charge of urban transport and traffic issues,
- Geographic and social exclusion for large segments of the population,
- Violation of residential and collective use areas and destruction of historic and architectural landmarks, and
- Security problems.

Endemic congestion:

In the last decades, major Brazilian cities promoted the use of the automobile. This development occurred hand-in-hand with the growth in the number of cars (see Chapter 2.1.4). The road network has been constantly adapted and expanded at huge costs to meet the demands of the growing automobile use. Yet, the benefits are neutralized by massive traffic jams and gridlocks as the result of this development [WBCSD 2009, P. 30]. In São Paulo, for example, downtown weekday traffic speeds average only 15 km/h or less [GWILLIAM 2003, P. 198]. Such chronic traffic congestion causes a lengthening of travel times and a reduction in productivity of urban activities, already showing effects in medium-sized cities, too. The impact of such a restricted mobility and accessibility on the whole economy is enormous. According to a study conducted by the ANTP in 2007, it is estimated that in ten Brazilian metropolises 1.5 billion hours are being wasted each year in traffic jams. [WBCSD 2009, P. 32]

Long travel times in public transportation system:

Concurrently, public transport systems are not able to provide adequate services. Public transportation has become inefficient, overloaded, and slow [BRANCO 2011, P. 11]. The growing number of automobiles on the roads as well as the disproportional share of road space in favor of the car affects the performance of city buses. In many Brazilian cities, average bus speeds are well below 20 km/hour, and the time for daily commuting tends to be very long, about 50 minutes in each direction, including access time on foot and waiting times at bus stops and terminals. This has a direct impact on operational costs, system reliability, attractiveness of the system, and on the prices of fares paid by its users. [WBCSD 2009, P. 30–32]

Poor public transport supply:

Furthermore, a poor public transport supply is a striking characteristic of the Brazilian transport system. Transport networks have difficulties to follow the urban dynamics which generate new travel desires [BOARETO 2003, P. 47]. Private operators constantly adapted supply to ensure profitability, often at the expense of service frequency and accessibility of low-density areas. For the majority of the people who live in the outskirts and rely on buses, the average travel times have increased since the bus

system did not expand at a sufficient rate. Moreover, information to users is virtually non-existent. [VASCONCELLOS 2005, P. 96]

Increase of informal transportation services:

As a result, a poor bus system, characterized by service irregularity, unreliability, and discomfort as well as very limited interconnections, is facing growing competition from the informal sector [VASCONCELLOS 2005, P. 96]. Informal public transport supply, in particular using vans and minibuses, exploded during the past decade in dozens of cities across Brazil. The poor, already subjected to long commutes in crowded buses and trains, have largely embraced this alternative. [GOLUB ET AL. 2009, P. 601–602] Consequently, the number of passengers using public transport has decreased in Brazil's large and medium-sized cities [WBCSD 2009, P. 32].

Increase in number, severity, and distribution of traffic accidents:

Brazil has one of the highest traffic accident rates in the world. Traffic accident rates in large Brazilian cities can be up to 15 times higher than those in cities of industrialized countries. In 2004, more than 30,000 deaths due to traffic accidents and more than 260,000 casualties were recorded from the National Traffic Department. [WBCSD 2009, P. 32 – 33] For 2006, ANTP estimated that in large Brazilian metropolitan areas around 1,563,000 vehicles were involved in about 829,000 traffic accidents (from minor to fatal), causing 355,124 victims (fatal and non-fatal) [ANTP 2006]. In large Brazilian cities, the highest number of deaths are recorded among pedestrians, demonstrating the poor traffic conditions for non-motorized transportation. But these numbers should be taken as conservative, due to a large number of unreported events and the number of deaths which occur after the accidents. [WBCSD 2009, P. 32–33] Furthermore, only few cities included in the ANTP's mobility data system have sound statistics on traffic accidents [ANTP 2006]. Reasons for the high number of casualties are the poor quality of roads, driver behavior, large numbers of pedestrians, and inadequate road-safety education and inspection [WBCSD 2009, P. 32–33].

Air pollution:

Brazilian cities, such as São Paulo, are experiencing severe pollution problems due to its large vehicle fleet. The major problem are trucks which still use diesel with high levels of sulfur. Limitations of pollutant emissions for light vehicles did not exist in Brazil until 1986 when federal mandatory limits were defined to be applied to new automobiles (Proconve program). Truck and bus emissions were not controlled until the end of the 1990s. [Vasconcellos 2005, P. 99] Today, the environmental impact is considerable, and Brazilian environmental agencies are struggling to align with European and North American emission standards [WBCSD 2009, P. 29–30]. Since 2009, the Proconve L-5 phase limits the emissions for gasoline and ethanol powered automobiles to 2.00 g/km of CO, 0.30 g/km of HC and 0.12 g/km of No_x which will be reduced in 2014 [IBAMA 2012]. However, as part of the old fleet continues to run, the average gasoline car used in 2010 in the metropolitan area of São Paulo still emitted about 3.00 g/km of CO, 0.17 g/km of HC and 0.17 g/km of NO_x [CETESB 2011, P. 68]. The total yearly emissions – CO, NO_x, HC, PM, SO_x, CO_2 – for “Mobility Data System cities”[18] in 2010 are estimated to be 28.2 million tons, while private motorized transport modes were responsible for 65 % of the total amount. [ANTP 2011, P. 69]

Conflicts among state and local public agencies in charge of urban transport and traffic issues:

Decisions on land use, transport, and traffic are highly interdependent, but large Brazilian cities are examples of a permanent lack of coordination. Urban policy initiatives in the transport and traffic areas are rarely coordinated. “Most cities feature a transport, traffic or public roads department, but seldom an urban planning department. Urban development in Brazilian cities is determined by market laws, land-values and accessibility and tends to be devoid of regulation and control mechanisms. In medium-sized cities, public transport is usually managed directly by city mayors and their technical staff. However, these activities tend to be separated from traffic concerns and dealt with as part of wider transport-related concerns. In large cities, transport and traffic issues tend to be better coordinated although they still suffer from a lack of integration with road and urban planning departments.“ [WBCSD 2009, P. 27] In addition, there is a gap between metropolitan-scale transport actions and local

18 Meaning the cities included in the Mobility Data System of the ANTP survey.

transportation policies. Mayors tend to protect their legal power when deciding on local issues such as regional transportation infrastructure or services. [VASCONCELLOS 2005, P. 95] As a result, attempts to develop and manage urban transport networks in metropolitan regions rarely been successful. [WBCSD 2009, P. 28]

Geographic and social exclusion for large segments of the population:

In some Brazilian cities, socially marginalized groups are concentrated in slums where they suffer a lack of access to decent shelter and opportunities. Mostly poor city dwellers are marginalized in peripheral locations or inhospitable inner-city locations which results in a lack of access to transportation. For them, the only available transport modes are walking, cycling, and public transportation which are characterized by weak conditions, in particular the non-motorized transportation modes. When they live far away from the city, the long commutes penalize them in terms of cost and time. [UN-HABITAT 2010, P. 86], [GWILLIAM 2003, P. 201], [YAMASHITA, MAGALHAES 2006, P. 39]

Violation of residential and collective use areas and destruction of historic and architectural landmarks:

The construction of new roads, the reorganization of traffic to improve vehicle flow, and the abusive use of the city streets and avenues as traffic corridors has led to a severe destruction of city landmarks and publicly-owned lands. Moreover, it led to the degradation of urban areas and cultural heritage. [WBCSD 2009, P. 35], [YAMASHITA, MAGALHAES 2006, P. 41]

Security problems:

The security problem due to criminal behavior is a common characteristic of South American cities such as São Paulo. Insecurity particularly affects pedestrians and cyclists, but also people in cars and public transport vehicles. The perception of vulnerability influences people's travel patterns, diminishing trip rates as people avoid vulnerable modes and travel times. [GWILLIAM 2003, P. 199]

Table 4: The urban transport crisis in developing countries: Characteristics and problems; Source: [VASCONCELLOS 2000, P. 177–178]

DIMENSION	CHARACTERISTICS / PROBLEMS
Structural	➢ Unbalanced economic growth ➢ Frequent threat of economic or political crisis ➢ Widespread poverty ➢ Accumulation of income ➢ Unemployment or employment in informal activities ➢ Rapid and uncontrolled urban growth ➢ Increasing dependence on motorized transport ➢ Lack of urban infrastructure and modes of transport
Political	➢ Fragile democracy and citizenship ➢ Closed decision-making process ➢ Political representativeness differentiated between classes ➢ Strong links between the middle class and the state ➢ Strong links between the inner and outer lobbies and the State
Ideological	➢ Identification of the technocracy, the elite, and middle classes on mobility as a symbol of progress and support due to urban space adapted for car use ➢ Prejudice in relation to public transport as a social issue, seen as a problem of the market ➢ Vision of subsidies to public transportation as heresy and vision of the automobile as democratic and beneficial to society
Economical	➢ Fiscal crisis real or perceived as an impediment of public investment in infrastructure for public transport ➢ Investments in roads seen as democratic and equitable
Institutional	➢ Dominant sectors contrary to effective planning ➢ Cities do not organize their agencies, neither train their personnel ➢ Policies on urban, transport, and transit related issues are not coordinated and have conflicting agendas and goals
Technical	➢ The planning process renders a mere trend forecasting ➢ Traditional techniques are conservative and reproduce inequalities ➢ Traditional techniques use assumptions and values of other societies ➢ The traffic management pretends to be neutral and creates excluding spaces
Technological	➢ NMT modes are forgotten; space is hostile to pedestrians and cyclists ➢ Public transport is badly planned, implemented and monitored ➢ There is a commitment to the automotive model
Operational	➢ The provision of public transport is highly unstable ➢ The traffic management ignores public transport and its users
Social	➢ The physical and economic accessibility is unfair ➢ The appropriation of space by transport modes is highly inequitable
Environmental	➢ The space adapted for motorized transport destroys the space for the people ➢ Traffic accidents have become the most serious problem ➢ The security in traffic is highly unequal ➢ Major cities have serious problems of pollution ➢ The impacts of pollution are not distributed equally ➢ Externalities of transport are not collected or controlled

2.2 RIO DE JANEIRO

2.2.1 GENERAL STRUCTURE

As shown in Figure 7, the state of Rio de Janeiro is located in the Southeast of Brazil close to the Tropic of Capricorn. The area has a tropical savanna and monsoon climate with average minimum temperatures around 14°C and maximum up to 35°C [WIKIPÉDIA 2012a]. The city experiences 130 days of rain per year with the rain season from December to March [PREFEITURA DA CIDADE DO RIO DE JANEIRO 2011c].

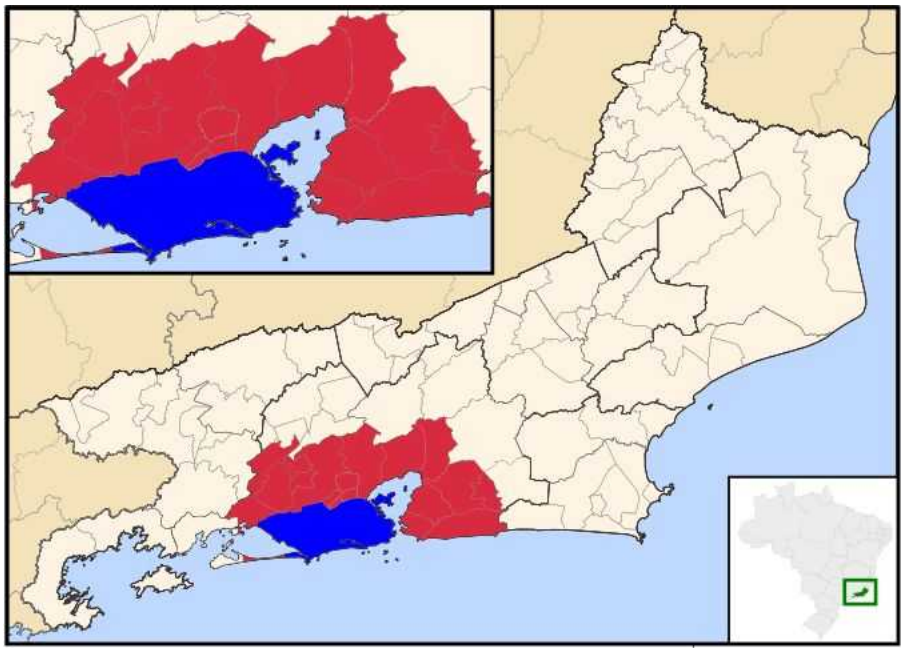

Figure 7: Rio de Janeiro state, metropolitan (red) and city area (blue); Source: Adapted from [OLIVEIRA JÚNIOR 2011] / [ABREU 2006]

The *Região Metropolitana do Rio de Janeiro* (RMRJ) is situated at the state's southern coastline and is separated by the *Guanabara Bay* (port.: Baía de Guanabara), spreading out to the North into the lowlands of the *Baixada Fluminense*. It is the second largest agglomeration of Brazil [IBGE 2011a], expanding about 140 km from East to West and 70 km from North to South, and it contains 19 municipalities[19] (see Appendices A.I).

19 The size of the RMRJ changed several times [WIKIPÉDIA 2012b]. Since 2009, the RMRJ consists of 19 municipalities, due to the Lei Complementar Nº 133, from 15.12. 2009. [CABRAL 2009]

The city of Rio de Janeiro is the capital of the state and consists of 33 administrative regions (see Appendices A.II). It is located next to the Guanabara Bay in the East and the Atlantic ocean on the Southern coastline. The city's expansion is about 70 km from East to West and 30 km from North to South. A lake system in the South and three mountain ranges that are as high as 1,000 m divide the city area, providing difficult conditions for non-motorized transportation modes. Its beauty and natural environment attracts tourists from all over the world, having its geographic setting as its most important asset and image. [ACIOLY JR. 2001, P. 510]

Spatially, the city area is divided into four distinctive zones (see Appendices A.III/ A.IV): the Center, South, North, and West. Most middle- and upper-income neighborhoods are located in the Central[20] and Southern zones. This is the part of the city with the best urban infrastructure, commerce, services, and various modes of transportation. But it is also characterized by *favelas* (eng.: informal settlements), which benefit from being near to the center of the city.

Low-income households and most *favelas* are concentrated in the Northern zone, where neighborhoods first emerged as the railroad system expanded from the city center towards the North (see Chapter 2.2.2). Middle-income households that are unable to afford the high costs of housing in the Southern zone tend to live in the Northern zone. The lack of developable land in the Central and Southern parts as well as high housing costs in central locations caused an urban sprawl towards the West. Poor settlements in this area are lacking paved streets as well as water and sewage systems and are located far away from the city center [PAMUK, CAVALLIERI 1998, P. 453].

Table 5 shows the population, land area, and density of the state, metropolitan and city area for the year 2010. The RMRJ had its highest growth rate of 4.36 % per year between 1950 and 1960. After this period, the rate declined, but between 1991 and 2000 it again experienced a slight growth of 1.14 % per year. The city of Rio de Janeiro shows a similar profile, but with lower rates than those recorded for the RMRJ. [PREFEITURA DA CIDADE DO RIO DE JANEIRO, P. 2-1] From 2000 to 2010 the annual growth rate of the RMRJ was 0.83 %, congruently the city experienced 0.76 % [IBGE 2011b].

20 The *Central Business District* (CDB) is located in the East of the city, next to the Guanabara Bay.

Rio de Janeiro ranks among the top 30 GDP cities of the world [UN-HABITAT 2010, P. 20] and constitutes the second largest economic area of Brazil, generating about 5 % of the national GDP in 2007 [IBGE].The city is home to numerous companies such as important oil and energy corporations (Petrobras and Eletrobrás), mining company (Vale) and the biggest steel mill in Latin America. [AICHINGER 2010, P. 18] It is also an important commercial and financial center with a well established service sector especially in the financial and technological areas, also offering a wide range of services in culture, leisure and tourism. Although Rio de Janeiro lost its status as capital of Brazil in 1960, it still hosts the headquarters of many central government agencies. [ACIOLY JR. 2001, P. 510] Furthermore, public institutions and international organizations such as the Brazilian Development Bank, the National Library or the Regional Office for Latin America from UN-HABITAT are located in Rio de Janeiro's city center. [AICHINGER 2010, P. 18] Undoubtedly, it is the most important cultural and tourist center of Brazil. [ACIOLY JR. 2001, P. 510]

Table 5: Population, land area, and density of the city, metropolitan, and state area of Rio de Janeiro in 2010; Source: [IBGE 2011a]

AREA Rio de Janeiro	**POPULATION**[21]	**LAND AREA**	**DENSITY**
		(km^2)	(inhab. / km^2)
State	15,989,929	43,780	365
Metropolitan	11,835,708	5,326	2,222
City	6,320,446	1,200	5.265

However, Rio de Janeiro “suffers the consequences of a fast population growth and of an exclusionary and unsustainable urban development“ [ROSSI, ALVES, VIDER 2008, P. 86]. The city is marked by vast inequality, due to an evident problem of distribution of wealth. 13 % of the city's population earns less than half of the minimum wage. This percentage differs greatly throughout the different administrative regions of the RMRJ, revealing that the prevailing part of the poor does not live within the city's boundaries. Informal settlements spread throughout the whole city, creating extreme differences in income (see Figure 8). [AICHINGER 2010, P. 94–95] Evidently, this results in feelings of fear, anxiety, and insecurity that contribute to partitioning Rio de Janeiro into safe and “no-go areas”. [UN-HABITAT 2010, P. 54] Nevertheless, Rio

21 Population numbers differ from source to source. This could be due to the usage of preliminary data of the 2010 census as the official data for the 2010 census will be published by the end of 2012. Preliminary results are available online at www.ibge.gov.br/.

de Janeiro experienced a significant decline (12 %) in its income Gini coefficient [UN-HABITAT 2010, P. 77] which demonstrates that inequality is on the decrease. The city's 2007 GINI coefficient was 0.53, making it less unequal than many other cities in Brazil [UN-HABITAT 2010, P. 193].

Figure 8: Income differences between formal and informal city in Rio de Janeiro (2000); Source: [AICHINGER 2010, P. 95]; Annotation: monthly average income of the head of household

2.2.2 TRANSPORT STRUCTURE

MODAL SHARE

The state and city of Rio de Janeiro has a comprehensive documentary system for mobility data as well as detailed information from each operator. Unfortunately, most of the times it is not documented how this data is obtained – a fact that establishes a lack of reliability. [AICHINGER 2010, P. 99] In 2003, the State of Rio de Janeiro made a *Plano Diretor de Transporte Urbano* (PDTU)[22] for the RMRJ by doing an intense research about origin-destination of trips, describing characteristics of supply and demand, making performance diagnosis, and analyzing the costs- and benefits of several alternatives of intervention. The plan makes suggestions to improve the urban public transportation system until 2013, and it provides tools to implement a PDTU as a permanent planning process. [ROSSI, ALVES, VIDER 2008, P. 87] Nevertheless, the study focuses on working and education trips, thus it may be assumed that it misses relevant aspects such as shopping or free time activities, which might underrepresent non-motorized transportation modes. Despite these limitations, the PDTU is the basis

22 PDTU - Plano Diretor de Transporte Urbano da Região Metropolitana do Rio de Janeiro; This master plan still includes the municpality of Mangaratiba, due to adjustements in the associated municipalities of the RMRJ at this time (see Chapter 2.2.1).

for the state government in order to plan the urban transportation system of the RMRJ. [AICHINGER 2010, P. 99] According to the main mode of transport[23], the distribution of trips in the RMRJ (see Table 6), shows that the ecomobility modes of transport sum up to 84 % of all trips. Public transportation has the highest share with 47 %, non-motorized modes of transportation reach 37 %, and private motorized transportation has the lowest share of only 16 %[24].

Table 6: Trips per day by main mode of transport in the RMRJ; Source: [GOVERNO DO ESTADO DO RIO DE JANEIRO 2005, P. 1–3]

MODE OF TRANSPORT	TRIPS	
	(trips / day)	(%)
Total public motorized transport	**9,429,749**	**47.34**
Local and inter-municipal buses	6,586,742	33.07
Alternative transport[25]	1,630,985	8.19
Metro	355,404	1.78
Train	303,578	1.52
Taxi	139,109	0.70
Water transport[26]	82,091	0.41
Tram	2,195	0.01
Others[27]	329,645	1.66
Total private motorized transport	**3,100,004**	**15.57**
Automobile	2,969,634	14.91
Motorcycle	100,922	0.51
Trucks	29,448	0.15
Total private non-motorized transport	**7,386,198**	**37.09**
Walking	6,740,688	33.85
Cycling	645,510	3.24
TOTAL	**19,915,951**	**100.00**

23 The main mode refers to the one in which the user spent most of the travel time. [GOVERNO DO ESTADO DO RIO DE JANEIRO 2005, P. 1–3]

24 It must be assumed that these numbers do not represent today's share, regarding the increase of registered automobiles and motorcycles in the past decade (see Chapter 2.1.4).

25 Alternative transport refers to transport with vans which are just partially regulated. [GOVERNO DO ESTADO DO RIO DE JANEIRO 2005, P. 2-2]

26 Ferry, hovercraft and catamaran.

27 Chartered transport, school and executive buses.

Walking (33 %) is the prime mode of transport, closely followed by local and inter-municipal buses (33 %) and the automobile (15 %). The alternative transport represents the second highest share of the entire public transportation system, thus bringing significant competition into the public transport sector. Metro and train services, on the contrast, do not seem to play a significant role within the metropolitan public transport network. Motorized individual transportation is primarily realized with the automobile. Cycling has a very low share of 3 %, but is still higher than for example the one of the metro or the local train system.

PRIVATE MOTORIZED TRANSPORTATION

The road network of the RMRJ (see Appendices A.V/A.VI) consist of local, state and federal roads which can be classified into express, arterial and collector roads. The density is higher in the city of Rio de Janeiro and in its surrounding municipalities, becoming lower within greater distances. The major metropolitan transport corridors run along express highways, but many proceed on secondary arterial roads, and some on collector roads. This applies in particular to the central area of the city of Rio de Janeiro where the road system is incompatible for the existing traffic flows. [GOVERNO DO ESTADO DO RIO DE JANEIRO 2005, P. 2–16]

The most intensely used express highways are *Avenida Brasil, Avenida das Américas, Linha Amarela,* and *Linha Vermelha* which are the backbone for private motorized transportation of the city of Rio de Janeiro[28]. The city's road network is also characterized by tunnels (port.:túnel) which cross the mountain terrain of the area. Apparently, there is only one bridge (*Ponte Presidente Costa e Silva*) between the East and the West side of the Guanabara Bay, causing a bottleneck for the RMRJ.

Private motorized transportation had a high political priority in recent decades. Large infrastructure projects, such as the construction of expensive highways in the central area of the city of Rio de Janeiro, were implemented to meet the increasing demand of individual motorized transportation. Some examples are the two level highway section of the *Linha Vermelha* between the center and the airport, numerous tunnels through the mountain ranges and the bypass of the central area with the artificially created *Aterro do Flamengo*. These approaches created a system in which traffic demand is constantly growing, causing high social and ecological costs. [AICHINGER 2010, P. 102] In 2010, automobile ownership rates added up to almost 300 ve-

28 During weekdays these roads serve up to 170.000 vehicles per day. [SMTR 2012]

hicles per 1,000 inhabitants for the city of Rio de Janeiro. This rate is likely to grow within the next decade (see Chapter 2.1.4) [DETRAN/RJ].

PUBLIC TRANSPORT SYSTEM

The public transportation network of the RMRJ consists of nine distinctive systems (see Appendices A.VII): 1) the local and inter-municipal buses, 2) the alternative transport 3) the metro 4) the train system, 5) the taxi, 6) water transportation, 7) the cable car, 8) the tram, and 9) other transport systems. Numerous private companies operate within the public transport system of the RMRJ. It is the municipalities' responsibility to grant concessions for local bus companies and taxi services, but the metro and train system, the ferries, and the cable car for example operate under the concession of the state government[29].

1) Local and inter-municipal buses:

Within the RMRJ about 130 bus companies are responsible for the regular passenger transport. The entire network consists of more than 1,200 bus lines and is served by over 16,000 buses, covering most parts of the RMRJ. Standard local buses have a capacity of about 40 seats and a standing room for another 40 passengers. The entire vehicle fleet of the state of Rio de Janeiro has an average age of 5.5 years [FETRANSPOR 2010a].

The *Federação das Empresas de Transportes de Passageiros do Estado do Rio de Janeiro* (FETRANSPOR) incorporates ten unions of bus companies, all responsible for urban and suburban passenger transport as well as tourism and charter transport. The incorporated bus companies of these unions represent 81 % of all regular public transportation in the state of Rio de Janeiro, making FETRANSPOR is the most important stakeholder for public transportation in the RMRJ.

In 2010, the city of Rio de Janeiro tendered its municipal bus routes. The bus companies gained the status of concessionaires, with legal obligations and subject to sanctions by the grantor in case of violating the rules. To facilitate operation and avoid competition between different operators in the city of Rio de Janeiro, these bus companies were grouped into five consortiums (port.: consórcios) [FETRANSPOR 2010b].

29 Responsible for Rio de Janeiro state is the *Secretaria de Estado de Transportes do Rio de Janeiro* (SETRANS) the *Secretaria Municipal de Transporte* (SMTR) for the city of Rio de Janeiro.

2) Alternative transport:

Regulated vans (port: “vans” or “kombis”) have a capacity of 10-15 passengers and function as an alternative mode of transportation in areas with difficult access for public transportation. Unregulated vans, however provide informal services in areas where the regular system fails to offer adequate supply or simply compete with the regular system. Informal transport serves the Northern suburbs and some wealthier neighborhoods in the South zone. These vans circulate through neighborhoods, collect people and then enter the main highways towards downtown, duplicating regular bus lines. The total regional ridership of the informal service is estimated with 150,000 trips per day on roughly 30 routes. [GOLUB ET AL. 2009, P. 606]. Moreover, there are special services by motorbikes (port.:mototaxis) which reach even the narrowest roads and steepest hills in the urban jungle of Rio de Janeiro. Thus, they are the number one choice for people living in *favelas*.

3) Metro:

MetrôRio manages, operates, and maintains two metro lines[30]. The network is located within the city limits, measuring about 48 km and containing 35 stations (see Appendices A.VIII). The most frequented stations are *Tijuca*, *Ipanema*, and *Pavuna* as well as *Central do Brasil*, *Carioca* and *Botafogo* [AICHINGER 2010, P. 101]. Physical integration between the metro and the train system occurs in four stations. In 2011, the 32 metro trains transported more than 600,000 passengers per day. In addition, the concessionaire operates various bus lines[31] within the city of Rio de Janeiro which serve as an integrated feeder system for the metro. The “surface metro” (port.: Metrô na Superfície) consists of two lines[32] with a network length of 22 km and 15 stations – it carries about 29,000 passengers per day. Moreover, the metro offers an integrated bike parking system (port.: bicicletários) at eleven stations and bicycles can be taken into the metro on weekends and holidays. [MELLO 2011, P. 1]

4) Train system:

The private concessionaire SUPERVIA is in charge of the management, operation, and maintenance for the suburban rail system. The rail network (see Appendices A.IX) is about 270 km long and includes 98 stations. From the downtown main

30 Line 1 (orange): Saens Peña – Ipanema/General Osório (Travel time: 31 min); Line 2 (green): Pavuna – Botafogo (Travel time: 54 min). [MELLO 2011, P. 1]
31 Barra Expresso (3 lines) / Integração Expressa (14 lines) / Integração Intermunicipál (4 lines).
32 Ipanema (General Osório – Gávea) / Botafogo – Gavea.

station *Central do Brasil* run eight lines to the Northern and Western suburbs. [SUPERVIA a] In 2010, the 160 trains (589 coaches) in operation carried about 136 million passengers per year [SUPERVIA b]. The rail system was successfully implemented in the 19th century, but fell into disrepair and mismanagement for years, suffering a huge loss[33] in ridership in the 1980s [GOLUB ET AL. 2009, P. 606]. Today, ridership numbers are increasing again, serving more than 500,000 passengers per day [SUPERVIA b].

5) Taxi:

The city of Rio de Janeiro grants concessions for taxi operators (individual drivers or companies). In total, there are 700 taxi stands with about 3,500 parking spaces, with a higher concentration in the city center. About 32,000 vehicles are offering regular and special taxi services 24 hours a day, making it one of the largest taxi fleets in the country. Almost 20 % of the fleet operates illegally. Analyzing the relation between the number of inhabitants and the number of taxis available, there are 198 inhabitants for each vehicle which represents a very high availability compared to other Brazilian cities. According to the city's master plan, the objective is to reduce the fleet dramatically in the next 30 years. It is important to mention that all taxis run on *Compressed Natural Gas* (CNG). Due to the cleaner characteristics of CNG, the taxi fleet can be regarded as a greener one compared to others in the country. [BALASSIANO, SANTOS, SILVA 2011, P. 23–25]

6) Water transportation:

The current public water transportation network consists of Four lines which connect the city center of Rio de Janeiro with Niterói and the islands of the Guanabara Bay. The system suffers strong competition from the bus system which caused a decrease of ridership. Daily passenger numbers dropped from more than 140,000 in 1970 to 40,000 in 2004. [ROSSI, ALVES, VIDER 2008, P. 91]

7) Cable car:

Since 2011, SUPERVIA operates the cable car which is the new innovation in public urban transportation in the city of Rio de Janeiro. The system encompasses one line with a length of 3.5 km and five stations, connecting the group of *favelas* called *Complexo do Alemão* with the suburban rail system at the train station *Bonsucesso*. Ten

33 Ridership numbers fell from over 1 million down to about 200.000 trips per day. [AICHINGER 2010, P. 101]

passengers fit into one of the 152 gondolas which are currently transporting about 10,000 passengers per day [MOBILIZE BRAZIL]. The system – representing a brand new aspect in urban mobility – will be expanded at other locations throughout the city.

8) Tram:

The city of Rio de Janeiro used to be full of streetcars [SANTOS 1934]. The tram system has its origin in the 19th century [DUNLOP 1973, P. 46], but after the 1950s it suffered a vast decline [SOUZA 2012, P. 2]. The current network consists of two lines (Carioca - Paula Mattos / Dois Irmãos) with a length of 8 km [SETRANS a]. The tram (port.: bonde) connects Santa Teresa with the city center, serving both local transport and touristic needs. The system is operated by the *Companhia Ferro-Carril de Santa Teresa* and carried about 1,500 passengers per day [GOVERNO DO ESTADO DO RIO DE JANEIRO 2010]. Due to several severe accidents in 2011, the tram system is currently not operating.

9) Other transport system:

The RMRJ includes various other transport systems, such as chartered transport services, school and executive buses, funiculars, elevators, and even horse-drawn carts. These modes of transport either supply local neighborhood transportation, specific tourism or business needs. Thus, they do not play a significant role in regard to an integrated metropolitan mass public transportation network.

NON-MOTORIZED TRANSPORTATION

Non-motorized transportation plays an important role within the RMRJ because it represents the second highest share within the distribution of trips realized by main mode of transport (see Table 6, P. 25). Analyzing the different municipalities of the RMRJ separately, this impression changes. Economically less structured municipalities appear to have a more significant participation of non-motorized trips than richer municipalities which, on the contrary, have a higher percentage of private motorized trips. Therefore, the Western parts of the city of Rio de Janeiro and the peripheral municipalities, such as São Gonçalo, Duque de Caxias, and Belford Roxo, experience a more intense usage of non-motorized transportation than, for example, the South zone of Rio de Janeiro or Niterói. [GOVERNO DO ESTADO DO RIO DE JANEIRO 2005, P. 1–6]

But there is a vast difference between walking and cycling (see Table 6, P. 25). Walking has the highest share of all modes of transportation in the RMRJ, but the conditions under which people walk seem to be quite difficult. Pedestrians, as the most vulnerable element in urban transportation, are paradoxically the most unassisted by transit policies. This mode of transport suffers the worst consequences from a false prioritization of the various actors of the traffic system (see Chapter 2.1.4). Laws that protect pedestrians are not enforced or disregarded by the urban administration. Several factors affect the safety of the pedestrian or diminish their quality of travel. Some examples are: inadequate sidewalks to suit the flow of pedestrians, bus stops with disproportional size in relation to the sidewalk or pavement which is inadequate or in poor condition. Thus, any walk inside the city of Rio de Janeiro becomes an obstacle course. [MIRANDA, CABRAL 2005]

Cycling seems to have an insignificant importance (see Table 6, P. 25) within the RMRJ. Even though, this fact corresponds with the national perspective (see Chapter 2.1.4), this assumption seems to be wrong. According to a study released by *Transporte Ativo* (TA)[34] in June 2010, bicycle usage in the South zone easily exceeded the recorded data of the PDTU for this area. In general, the quality of the available data is inadequate to measure the volume of cycling traffic or explain the reasons for mode choices. [AICHINGER 2010, P. 108–109].

The *Secretaria de Estado de Transportes do Rio de Janeiro* (SETRANS) is promoting cycling by means of the *Programa Rio-Estado da Bicicleta* (eng.: Program Rio-State of the Bicycle), which aims: 1) at encouraging the use of bicycles as a mode of transportation, 2) at supporting municipalities in the construction of bike lanes and racks, and 3) at integrating the bicycle with other modes of transport. [SETRANS b, P. 4]

The city of Rio de Janeiro implemented around 230 km of cycle tracks (see Appendices A.X) which makes it the second largest bicycle path network of South America. Within the program *Rio – Capital da Bicicleta* (eng.: Rio – Capital of the Bicycle), the city intends to upgrade its network until 2012 [SMAC]. Most of Rio's bicycle traffic is concentrated between the three South-zone districts, *Flamengo*, *Botafogo,* and *Copacabana*. There, the major cycle path runs along the beaches and is used every day – mostly for leisure activities – with a strong increase at weekends. In the Wes-

34 *Transporte Ativo* (TA) is an active civil society organization which focuses on the quality of life by means of human-powered transportation. Since 2003, TA has enabled dialogues between the government and the society to promote sustainable mobility and the quality of life in the city of Rio de Janeiro. More information available online at: http://www.ta.org.br/site/index.htm

tern parts of the city, people also use their bike intensely to go to work or in combination with the train, metro or bus system. [SIRKIS 2000, P. 90] Approximately, 3.5 million bicycles exist within city limits [SIRKIS, AINBINDER 2005, P. 158].

The public bike system SAMBA, is an initiative of the Municipality of Rio de Janeiro in partnership with the Itaú bank, being implemented and operated by SERTTEL. Since 2011, the project has grown quickly and will soon incorporate 60 stations and 600 bicycles, all located in the South and Central zone of the city of Rio de Janeiro. The stations are distributed at strategic points of the city, offering a sustainable and clean mobility choice to the people. [SAMBA]

Bicycle deliveries are a unique feature in the city of Rio de Janeiro. A survey carried out from TA, analyzes more than 11,000 bicycle deliveries per day in the Copacabana district. 95 % of all trips occur in a 3 km range, sometimes carrying more than 300 kg via bicycles, cargo bicycles, or trikes. A parallel survey from ITDP shows that hardly any serious accidents occurred, making it a safe and sustainable alternative for urban freight transportation. [TRANSPORTE ATIVO 2011a]

Currently, SETRANS is developing a *Plano Diretor de Transporte Não-Motorizado* (PDTNM*)* which will define a macro net for non-motorized transportation modes and will incorporate the concept of complete streets[35] [SETRANS b]. This plan has the following objectives:

- Increase of the walking and cycling modal split,
- Reduction of the number of pedestrian and cyclist accidents,
- Increase of participation of underrepresented groups of the population,
- Expansion of bicycle path network and pedestrian areas,
- Institutionalization of plans for the walking and cycling modes.

2.2.3 FUTURE MOBILITY ISSUES

In view of the World Cup in 2014 and the Olympic Games in 2016, the megacity Rio de Janeiro is going through an important change which offers a unique opportunity for decision makers in order to ease the current situation and achieve an integrated sustainable urban transport concept because mega events function as a “pacemaker“ for sustainable urban transport concepts [Maatz 2010]. Until 2016, the public

35 More information avalaibe online at: http://www.completestreets.org/

transportation system of the RMRJ will undergo significant changes (see Figure 9 and Appendices: A.XI/A.XII), due to the:

- Construction of a BRT-system, comprising four high capacity bus lanes (TransOeste, TransCarioca, TransOlímpica and TransBrasil), including new bus stations and articulated vehicles,
- Implementation of preferential bus lanes, called *Bus Rapid System* (BRS) in the South, Central, and North Zone,
- Improvement of the suburban railway network, including an upgrade of 120 new trains with air condition and several other measures,
- Extension of the metro system, connecting the city center with Barra da Tijuca (Line 4) and Niterói, São Gonçalo and Itaboraí (Line 3), and
- Construction of a *Light Rail Transit* (LRT)-system, included in the Porto Maravilha project in Rio de Janeiro's city center. [MOBILIZE BRAZIL 2011, P. 50– 54].

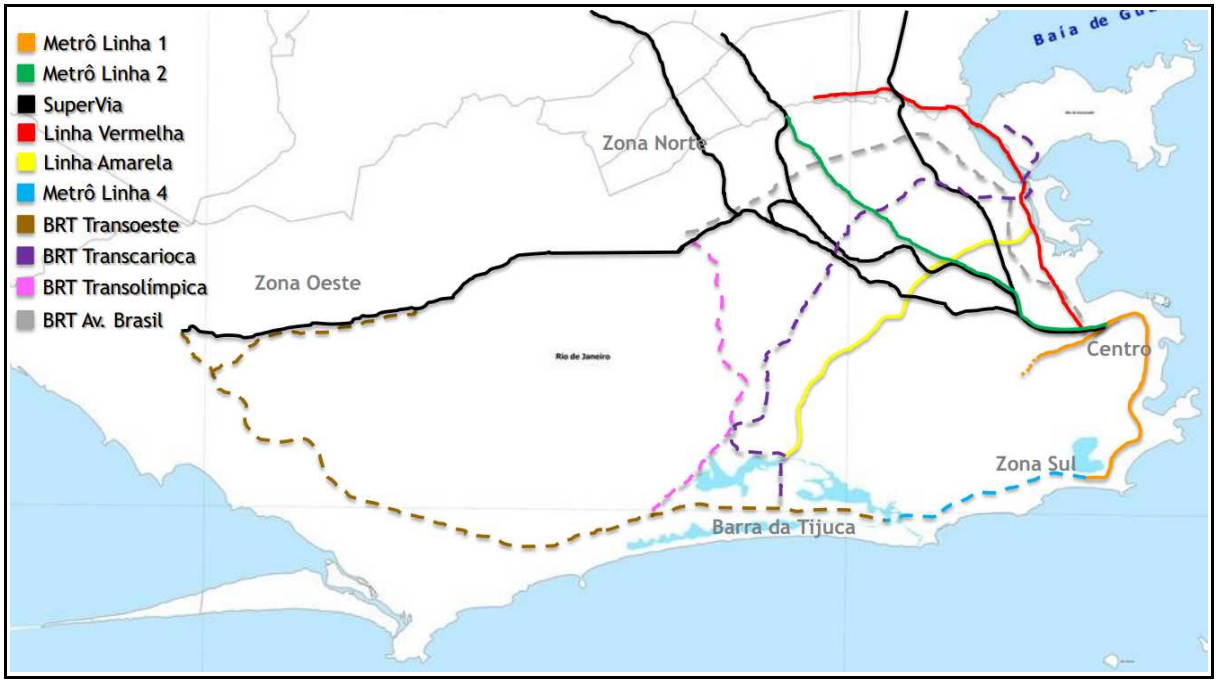

Figure 9: Future public transport network; Source: [OLIVEIRA 2011, P. 13]; Annotation: Solid lines represent the existing network, dotted lines the planned infrastructure

The construction of this new mass transport system will interconnect the West, North, and East zones of the city of Rio de Janeiro with the city center. More than ten million people, living in 20 municipalities, will benefit from this massive infrastructure invest-

ment and thus be enabled to take new mobility choices. Moreover, it will ensure the mobility needs for the upcoming events in 2014 and 2016 (see Chapter 2.2.1). [SOUZA 2012, P. 25]

BUS RAPID TRANSIT SYSTEM

The new high-performance BRT-system (see Appendices A.XIII) comprises about 130 km of exclusive bus lanes, numerous stations and terminals and almost 600 articulated vehicles with a capacity to carry up to 260 passengers (see Figures 10 / 11). According to government estimations, the first corridor being implemented will be the TransOeste in 2012 which will be followed by the TransCarioca in 2014, the TransOlímpica in 2015, and the TransBrasil in 2016. Once established, the entire BRT-system will replace local and inter-municipal bus lines with a high quality express bus transportation system, cut travel times, and serve over one million passengers per day. [PERES 2011, P. 12–15] Thus, it will generate economic, social, and environmental benefits [SOUZA 2012, P. 33].

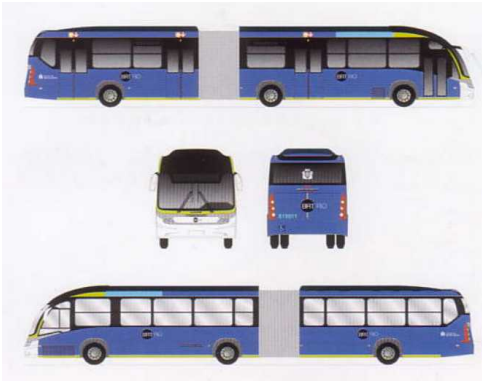

Figure 10: BRT-buses; Source: [PREFEITURA DA CIDADE DO RIO DE JANEIRO 2011a]

Figure 11: Station design; Source: [PREFEITURA DA CIDADE DO RIO DE JANEIRO 2011b]

The TransOeste, will start at *Jardim Oceânico* in *Barra da Tijuca* which will be an integrated station with the future Line 4 metro station. From there, will follow the *Avenida das Américas*, and will pass through viaducts and tunnels until it reaches the train station in *Santa Cruz*, or *Campo Grande*. The corridor of the TransOeste will mostly be separated from the general traffic. In addition, feeder lines will connect the surrounding suburbs with the BRT-system. Currently, the trip from *Santa Cruz* to *Barra da Tijuca* is approximately 50 km and can take up to two hours and 30 minutes during peak hour traffic. With the construction of the TransOeste, the travel time will be

less than one hour [SOUZA 2012, P. 30], for the benefit of about 200,000 passenger per day [PERES 2011, P. 12].

The TransCarioca will be 39 km long, comprising 45 stations between the terminal *Alvorada* in the southern part and the *Galeão International Airport* in the northeastern part of the city. Physical integration will be enabled with the TransOeste, the train system, the Metro Line 2, and conventional buses. The segregated bus lanes require the construction of new tunnels and viaducts. [SOUZA 2012, P. 28] According to government estimations, the TransCarioca will serve at least 400,000 people per day [PERES 2011, P. 12].

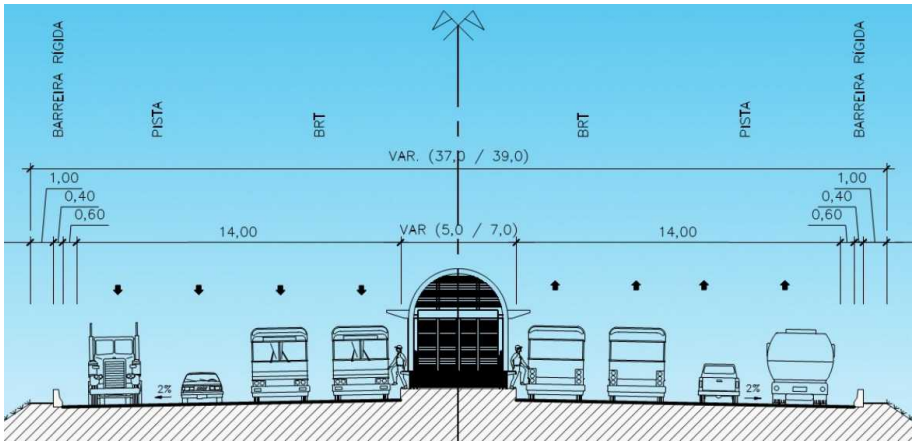

Figure 12: Standard profile of the TransOlímpica;
Source: [Barreto 2011, P. 29]

The TransOlímpica will encompass 26 km expressways, linking *Barra da Tijuca* with *Deodoro*. Approximately, 60 articulated buses will serve 18 stations, carrying over 100,000 passengers per day. The BRT-system will run on exclusive lanes, being accompanied by two to three lanes for individual motorized transportation (see Figure 12). The design of the TransOlímpica will include 30 km of bike paths on both sides of the road, including feeder bike lanes along the route. [SOUZA 2012, P. 30–31]

The TransBrasil will include five terminals with a total extension of 20 km and an estimated capacity of 40,000 passengers per hour during peak hour. This project will complete the high-performance transport network, linking Deodoro with the city center. [SOUZA 2012, P. 33] Figure 13 shows the profile of the future *Avenida Brasil*, demonstrating both the massive width of 70 m of this expressway and the approach to take away space from the car. About 325,000 passengers per day are estimated to use this corridor [PERES 2011, P. 12].

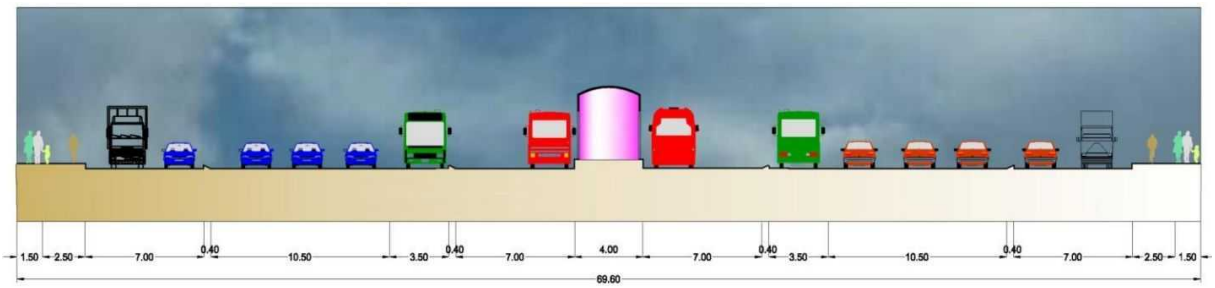

Figure 13: Profile of the Avenida Brasil (with future BRT system);
Source: [Peres 2011, P. 12]

BUS RAPID SYSTEM

The idea of the BRS is the reorganization of the traffic flow by prioritizing public transportation through separated bus lanes, reorganizing places and numbers of bus stops, and rationalizing the number of bus lines. The BRS-system has its origin in the tender procedure and the creation of the consortuims in 2010 (see Chapter 2.2.2). After an initial phase in Copacabana in the beginning of 2011, the system spreaded out rapidly throughout Ipanema and Leblon, reached the city center of Rio de Janeiro by the end of 2011, and is going to expand until the North zone.

Exclusive bus lanes (see Figure 14), implemented on the right side of the street, are separated from the regular traffic lanes through a continuous blue marking and reflective studs. Only buses and taxis (with passengers) are allowed to use the BRS-lanes, being controlled by traffic cameras in regular distances.

Figure 14: Exclusive bus lanes;
Source: [TAGNOZZI 2011, P. 6]

Figure 15: Bus stops with detailed information;
Source: [TAGNOZZI 2011, P. 6]

BRS-bus lines are divided into three groups (BRS 1, BRS 2, and BRS 3). BRS 1 are the radial lines from the Intersul consortium, which connect the South zone with the Central Zone. BRS 2 are the other lines from the Intersul consortium and BRS 3 are

the lines that pass through Copacabana and are operated by other consortuims. In front of each bus is a sticker with the corresponding BRS-symbol.

Buses are forced to stop in specific bus stops, according to their groups. The average distance between each stop of the group is about 500 meters. Detailed information about the available bus lines (see Figure 15) as well as useful overview maps which include points of interest and some touristic information are provided in all stops (see Figure 16). Moreover, it is planned to include variable message signs that will provide real time travel information.

Figure 16: Example of the maps at bus stops;
Source: [FETRANSPOR]

The system generates fluid traffic conditions and more convenience for the users, reducing travel times up to 40 % and increasing operational speeds from 13 km / h to 24 km / h. In addition, the optimization of the bus fleet will reduce greenhouse gas emissions and fuel consumption. [FETRANSPOR]

Despite the fact that the system improved the situation, it still suffers problems due to its design. It has a low range of the network, lacks physical integration with other modes, and the billing process – although it is largely electronic – is still deficient, causing a great loss of operational time during boarding.

Furthermore, the current bus fleet offers a low quality during the journey from the user perspective because low-floor buses are very rare. [SOUZA 2012, P. 23]

TRAIN SYSTEM

The train system is currently undergoing several improvements. Until 2016, SETRANS intends to purchase up to 120 new trains with air condition (see Figure 17/18). Within the same period, the government plans to completely remodel the existing fleet which will include new furniture and air condition. Moreover, a complete renovation of cross-ties and ballasts is promised to improve the quality of traffic and ensure higher train speeds.

Main stations which serve for the Olympic games will be remodeled and adapted to comply with international service and accessibility standards. The installation of escalators and elevators will be included in this renovation. Eventually, the control room and associated traffic signs will be modernized to reduce headways in order to make the train system as efficient as the metro. [SETRANS d]

Figure 17: New trains; Source: [GOVERNO DO RIO DE JANEIRO 2010]

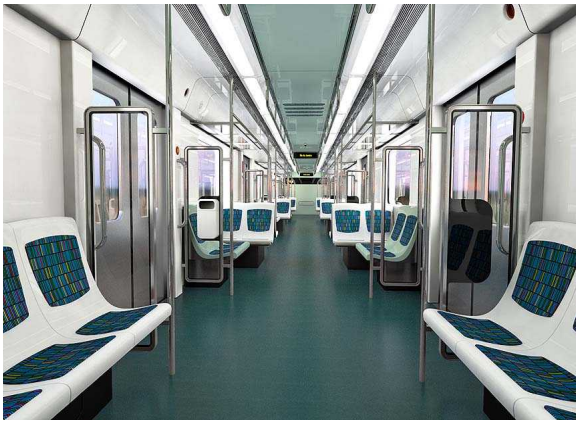

Figure 18: Interior views of new trains; Source: [GOVERNO DO RIO DE JANEIRO 2010]

METRO SYSTEM

By 2016 the network of the metro of Rio de Janeiro is proposed to be extended about 16 km. 240,000 passengers per day are expected to use the new Line 4 which will connect the South zone of the city at *General Osório* in *Ipanema* with the West zone at *Jardim Oceânico* in *Barra da Tijuca*, passing through *Ipanema*, *Leblon*, *Gávea* and *São Conrado*. [SETRANS 2011] The new connection will serve the fastest growing region in the city which receives dozens of new real estate developments and commercial centers each year [SETRANS d].

Furthermore, SETRANS intends to establish a new metro connection (Line 3) from the *Central Business District* (CDB) of the city of Rio de Janeiro, passing through the

center and North of Niterói to the municipalities of São Gonçalo and Itaboraí (see Figure 19). The first part of the Line 3 comprises 37 km, connecting the station *Araribóia* in the center of Niterói with *Guaxindiba* in São Gonçalo. The corridor Rio de Janeiro – São Gonçalo lacks a mass transportation system, even though there is a high demand of public and private transportation, especially between the city of Rio de Janeiro and Niterói. [SOUZA 2012, P. 25–26]

Figure 19: Execution phases of the Metro Line 3;
Source: [Souza 2012, P. 26]

LIGHT RAIL TRANSIT SYSTEM

The LRT-system will provide a new transportation system in the CBD of the city of Rio de Janeiro, based on modern trams[36]. The project is part of a major urban revitalization program of Rio de Janeiros city center called Porto Maravilha[37]. The total network will incorporate 26 km and 42 stations, serving the international bus station (*Rodoviária Novo Rio*), the central train station (*Central do Brasil*), the ferry passenger station at Praça XV (*Barcas*), several metro stations, and the *Santos Dumont Airport* (see Appendices A.XIV).

This infrastructure upgrade will increase the supply of medium-capacity public transportation in the center of Rio de Janeiro and will optimize the prevailing situation due to the high number of buses circulating in the downtown and harbor area. Featuring a new drive technology, the LRT-system will run without overhead wires by means of a third rail which powers the system at specific places and stations (see Figure 20). Power is also generated with each brake action and will be stored by a super-capacitor. The project is still in the study phase, though the city intends to complete it until 2016. [CDURP]

36 The existing tram will be completely isolated from this infrastructure measure, due to the different characteristics of both systems.
37 More information avalaibe online at: http://www.portomaravilha.com.br/

Figure 20: LRT-vehicle passes by the central station of Rio de Janeiro; Source: [CDURP]

2.3 THE BUS RAPID TRANSIT SYSTEM OF CURITIBA

Curitiba is the capital of the state of Paraná which is one of the southern states of the country. In 2010, the city had approximately 1.7 million inhabitants and incorporated a total area of 435 km^2 [IBGE 2011b]. Almost 1.2 million registered automobiles by the end of 2010 represent a comparatively high automobile ownership rate of about 680 vehicles per 1,000 inhabitants (see Chapter 2.1.4) [DETRAN/PR]. Thus, the city managed to maintain or even increase the public transport mode share, making its public transport system “known throughout the world as an example of a pragmatic, integrated, cost effective, and efficient transport system” [TCRP 2003, P. 2].

Curitiba’s bus system was developed as an integral part of an overall master plan (port.: plano diretor) which defined the city's radial expansion along structural axes. According to this plan urban planning is understood as an integrated land use, traffic system, and public transport planning process.

Since the opening of the first corridor in 1974, the city took many incremental decisions in order to improve public transportation service quick, pragmatic, and affordable. Today, the system is considered to be a model BRT-system, widely recognized for its innovative key features [TCRP 2003, P. 2], such as:

- Separated bus lanes along structural axes placed in the center of a “trinary” road system,
- High urban development density next to these corridors, getting lower with greater distances,

- Convenient fare-free transfer, due to trunk and feeder bus lines routed through terminals and stops, all included in the *Rede Integrada de Transporte* (RIT),
- Bi-articulated five-door buses and tube stations with off-vehicle fare collection and floor-level boarding facilitate passenger access, and
- Direct express service in the parallel one-way streets.

In total, 81 km of separated bus lanes [RAMOS 2011] form six structural axes, while each one is developed as a “trinary system”, consisting of three roads (see Figure 21). The central road is a two-way bus lane in the center of the road, surrounded by one or two traffic lanes in each direction for minor movements and service access to frontages. Approximately, one block from each side of the central bus lane, there is a one-way traffic road which has three or four lanes for private vehicles and direct express services with fewer stops and off-vehicle fare collection at tube stations. Between the central bus lane and the main traffic roads, high-density land use development is encouraged on either side. This land use approach creates a concentrated, high demand for transport services along a narrow corridor. [TCRP 2003, P. 2]

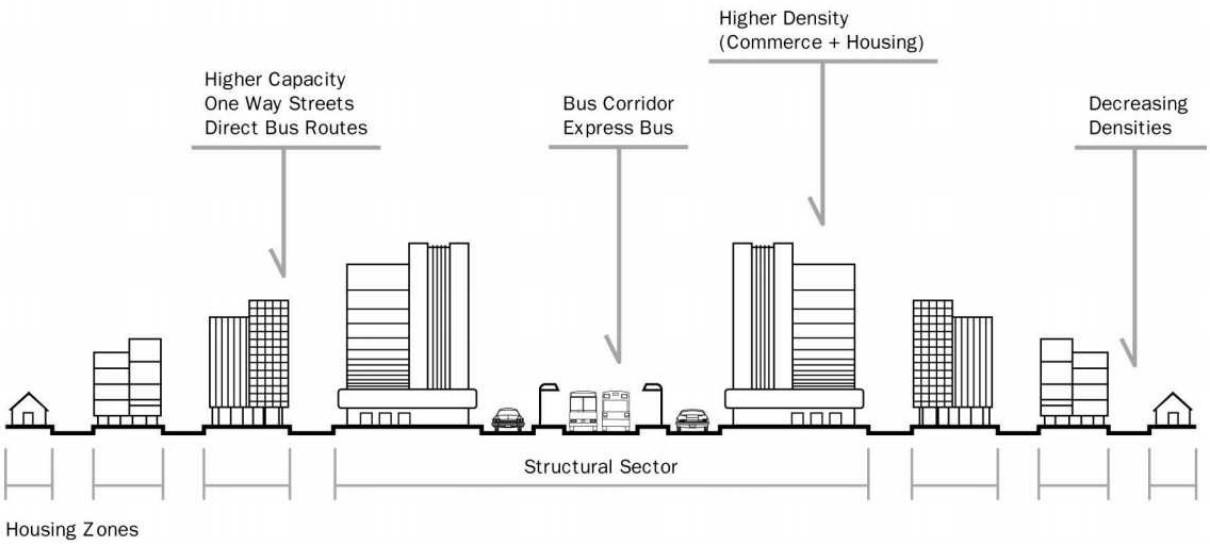

Figure 21: The trinary system of the structural axes;
Source: [TCRP 2003, P. 25]

The RIT incorporates 355 bus lines, all operating under one integrated fare system and a specific hierarchy of bus types which are color-coded according to their function in the network. Trunk and feeder bus services are routed through interchange terminals and on-street stops, where bus passengers can interchange between bus services without additional payment on the system (see Appendices B.I/B.II).

Curitiba's bus-based mass transportation system operates with a fleet of more than 1,900 buses, around 170 of them are bi-articulated vehicles. These buses have five passenger doors, a capacity of up to 250 passengers, and are designed for high-level boarding at Curitiba's unique tube stations (see Figure 22). [RAMOS 2011] These tube stations accelerate passenger handling and fare collection, serving up to three times more passengers per hour as a conventional bus stop. [TCRP 2003, P. 7] Bus average speeds reach 20 km/h on the separated bus lanes, while direct bus lines reach operational speeds of about 30 km/h. [TCRP 2003, P. 12–13]

Figure 22: Passenger boarding at tube stations;
Source: M.Kiepsch, 12/2011

The newest innovation of Curitiba's transport system is the Green Line (port.: Linha Verde) which is a transformation project of a former federal highway in a new axis of urban development (see Appendices B.III). Initiated in 2009, this axis forms the 6th corridor with exclusive lanes for public transportation, though with a different design. Increased operational speeds of 25 km/h reduce travel time and transfer the high demand of the south corridor towards the Green Line. The corridor improves air quality and encourages non-motorized transportation by means of new bi-articulated vehicles which run on biofuels and a linear park with a bicycle path. [RAMOS 2011]

The complete citywide system carries about two million people per workday [RAMOS 2011]. The most heavily loaded corridor is the north-south connection – it carries approximately 188,000 passengers per day. During peak hour, this corridor can carry up to 11,100 passengers per hour and direction, while higher capacities appear to be

possible. The key point is that the RIT has maintained commuter mode share at 70 % to 75 %, without remarkable decreases. [TCRP 2003, P. 12]

Moreover, a major role for the city's success played an effective institutional system. Public transport operation, planning and law enforcement are within the specific responsibility of one single municipal company *Urbanização de Curitiba S/A* (URBS). Furthermore, there is a close relationship between the short/medium term operational unit URBS and the strategic land use planning unit the *Instituto de Pesquisa e Planejamento Urbano de Curitiba* (IPPUC). [PIENAAR, KRYNAUW, PEROLD 2005]

Curitiba's bus system is cited as the birthplace of the BRT-system. But unlike other Brazilian cities, the bus system was a key tool in directing the growth of the city, rather than a response to immediate problems of traffic congestion. Thus, the most important lessons for other cities are:

- Prioritize public transportation in large cities and integrate public transport with community development.
- BRT-systems are capable of carrying high volumes of passengers at speeds equivalent to those of LRT-systems or trams.
- Passenger handling delays can be minimized and high levels of operational performance can be achieved by a good organization and appropriate design.
- The trinary system is unlikely to be replicable in other cities, except in transit corridors that are either new or in a process of a massive redevelopment.
- A good integration between trunk and feeder lines are able to overcome capacity issues, use buses efficiently, and optimize operation.
- The overall goal of any well-managed city has to be the integration of land use and transport planning processes.
- The public-private initiatives are able to implement efficient, high-quality bus services.
- Planning, design, procurement, and operation of the BRT-system should be treated in an integrated manner similar to an LRT-system.

2.4 SUMMARY

The previous chapter aimed at giving an overview of Brazil's general characteristics and its transport structure, explaining transport related institutional issues, analyzing sustainable urban transportation within the context of Brazil, and identifying key transport problems of large Brazilian cities. Furthermore, it provided information on relevant transportation and future mobility issues of Rio de Janeiro as well as Curitiba's unique approaches. This section provided the necessary background for the understanding of the expert interviews.

Summing up the in-depth literature review, it reveals that Brazil is undergoing significant changes which are characterized by a vibrant economy, social inequality issues, and tremendous transportation problems in large Brazilian cities. In the context of Brazil, a sustainable urban transport concept is enabled by enabling access to urban space, prioritizing public- and non-motorized transportation, and reducing urban sprawl, while this concept has to be in reconciliation with environmental issues.

The PNMU, as the new legislative instrument on urban development and mobility issues, demonstrates the efforts of Brazil’s federal government to bring forward new approaches to ease the prevalent situation. In view of the country’s dramatic evolution of registered new vehicles in combination with the strong car culture within Brazilian society, it is imperative to tackle key transport problems.

Currently, the megacity Rio de Janeiro is experiencing an intense, rapid urban development, supported by the pacemaker effect of the World Cup and the Olympic games. However, the city's road system is not capable anymore to serve current traffic flows, while the modal share determined in the PDTU proves the inefficiency of the existing mass transportation system. Previous approaches focused on the expansion of the road system and prioritized low-capacity local buses which created a system of constantly growing traffic demand, deceleration of the public transport system, and neglect of non-motorized transportation modes.

Recently, the city started to change its strategy mainly by developing a high-quality BRT-system and promoting walking and cycling as a mobility alternative. But it remains unclear if these approaches can provide a decent public transport system – not only – for the upcoming sports events, and thus maintain the current share of public and non-motorized modes of transportation.

Meanwhile, Curitiba developed a model BRT-system in the past 40 years which is known as an example of a pragmatic, integrated, cost effective, and efficient transport system. It functions as a key tool to direct the growth of the city and is not a response to immediate problems of traffic congestion. Based on innovative features, such as the integrated transport network, the trinary road system, bi-articulated five-door buses, and unique tube stations, Curitiba managed to maintain its public transport share in spite of growing automobile ownership rates. Thus, the most important lessons for other cities are the prioritization of public transportation and its integration into the urban planning process

3 EXPERT INTERVIEWS

3.1 METHODOLOGY

3.1.1 IMPLEMENTATION OF THE INTERVIEWS

At the beginning of this Diploma thesis, a general overview of accessible literature was implemented to identify key issues of the Brazilian urban transportation sector in order to prepare the conduction and analysis of semi-structured expert interviews. In this survey technique of qualitative social research, data is collected from the consultation of specialists, exploring their experiences, perceptions and reflections on a specific problem or topic by means of an interview guide [GUTJAHR 1985, P. 61–63].

The interview guide is based on the identified key issues as well as personal experiences deriving from exchange programs in Curitiba and Rio de Janeiro. It was assessed upon consultation with the *Chair of Transport Ecology of the Technische Universität Dresden* before the implementation of the interviews. Thus, the exploratory design of this problem-centered interview guide incorporates the following objectives:

- Identify current transportation problems of Brazilian megacities, especially for Rio de Janeiro,
- Determine adequate approaches to tackle current transport problems of Rio de Janeiro (rationalize the use of automobiles, reform the public transportation system and promote non-motorized modes of transportation),
- Analyze the transferability of infrastructure measures between Curitiba and Rio de Janeiro,
- Assess the impact of the sports events in Rio de Janeiro, and
- Collect information on future urban transportation challenges in Brazil.

Design and length of the interview guide were pre-tested during the first interview with Eva Vider, university professor at *Universidade Federal do Rio de Janeiro* (UFRJ), on 27th of October 2011. In consequence, the structure of the interview guide was fixed, without further adjustments. Consisting of various groups of questions, it comprises the following topics: Current Development, Sports Events, Transferability, Reformation of the Public Transport System, Promote Walking & Cycling (NMT), and Future Mobility Issues (see Appendices C.I).

From October to December 2011, 20 face-to-face interviews with stakeholders of urban- and transportation planning were conducted in Rio de Janeiro, São Paulo, and Curitiba (see Appendices C.II). The participants were chosen by means of knowledge deriving from literature research, individual evaluation of lecturers during the *18th Brazilian Transport and Traffic Congress* and several other workshops, as well as recommendations from the interviewed participants. Moreover, the selection process was done in regard to a balanced and wide perspective, enabled by the allocation of each participant to one of seven distinctive focus groups according to their current field of work or in case of retirement in regard to their former work experience (see Table 7).

Table 7: Focus groups, description, and number of interviewees per group

FOCUS GROUP	DESCRIPTION	NUMBER
Researchers	University professors	4
Government representatives	Representatives from the municipal or state government	3
Architects and engineers	Employees or owners of private companies	3
Public Transport representatives	Representatives from public transportation companies	3
International experts	Employees of an international organization	3
Bicycle specialists	Specialists on bicycle planning issues	3
Activists	Persons independently working on urban-or transportation planning issues	1
TOTAL NUMBER OF INTERVIEWEES		**20**

The interviews lasted up to 70 minutes and were implemented at various locations, such as offices, cafes, or other public places. All conversations were recorded, with the permission of the participants, to enable the audio-based qualitative data analysis (see Chapter 3.1.2). This procedure might have had an effect on the free expression of personal opinions [GUTJAHR 1985, P. 102].

In the beginning of each meeting, the participants were informed about the background of the interview [GUTJAHR 1985, P. 22]. Then, personal details on their current field of work as well as former work experience were collected to validate their status as experts. Within the framework of this Diploma thesis, participants were con-

sidered to be experts, if they had profound knowledge on the basis of research or professional experience with the:

- Urban- and transportation planning processes of Brazilian megacities, in particular for Rio de Janeiro or Curitiba,
- Planning and implementation processes of the current public transport infrastructure measures in Rio de Janeiro, or
- Promotion of non-motorized transportation within Brazilian society.

The questions were designed to give the interviewee an impulse for free narration, but also allowed the interviewer to guide the interview towards the main issues. Therefore, questions were divided into primary and secondary questions. Primary questions were always included, while secondary questions were used only if needed. This provided a rough structure and a certain minimum set of information [WITTKOWSKI 1994, P. 13]. Thus, the interview was conducted open and flexible, without fixed dimensions or categories [BOCHMANN, WARDANJAN 2000, P. 16]. Depending on the language skills of the interviewee, the interviews were held either in English or Portuguese, enabled by a trilingual interview guide (including German). Occasionally, misunderstandings occurred because of the German mother tongue of the interviewer, but this did not have a significant effect on the course of the interview.

After each meeting, a brief evaluation was implemented to facilitate further selection processes. These evaluations incorporated three features: an adequate course of the conversation, the exchange of relevant knowledge, and the quality of the recording. Thus, each interview could receive at most three points (xxx) if all features were fulfilled (see column “EV” in Appendices C.II).

Parallel to the interviews, a comprehensive literature research was implemented by analyzing local academic and gray literature, such as strategic- or design plans, public relation documents, and newspapers. The presentations at the *18th Brazilian Transport and Traffic Congress,* several other workshops, and literature from interviewees provided a perfect basis to collect relevant information. Moreover, the three month research period was constantly accompanied by user-perspective observations at various locations in Rio de Janeiro, São Paulo and Curitiba as well as field trips to current construction sites in Rio de Janeiro.

3.1.2 AUDIO-BASED QUALITATIVE CONTENT ANALYSIS

The field of qualitative data analysis incorporates numerous types of analysis methods, each suitable for specific research questions. The content analysis is the generic term for a variety of methods which systematically identify specific features of written or oral information [BERGMANN 2001, P. 51]. The overall goal is to describe its semantic content inter-subjectively [BOCHMANN, WARDANJAN 2000, P. 21].

Adapted from KNORR's *Audiobasierte Zusammenfassende Inhalts-Analyse* (AZIA) [KNORR, P. 170–188], this audio-based qualitative content analysis comprises five distinctive phases (see Figure 23):

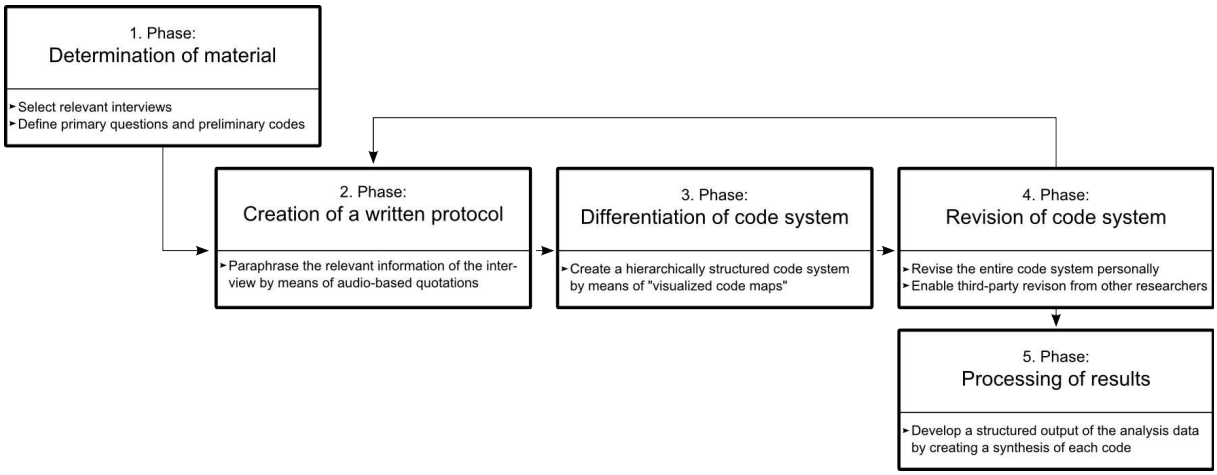

Figure 23: Five phases of the audio-based qualitative content analysis

1. Phase: Determination of material

To ensure a high quality information only the interviews with an evaluation of three points (xxx) were selected for further audio-based qualitative content analysis (see column “EV” in Appendices C.II). This includes the pre-test due to its equal implementation in comparison with the other interviews.

Although this limitation appears to be a great loss of information, the entire implementation of all interviews functioned as a comprehensive knowledge input for the understanding of the context and is reflected during the creation of the literature review. Without doubt, this spectrum of participants cannot provide a complete image on the current transport situation of Brazilian megacities, nor intended this survey to provide a statistically validated database. Nevertheless, it presents a concise insight into the current transport situation.

Primary research questions were chosen in consideration of the objectives of this exploratory research (see Chapter 3.1.1) and facilitated the development of a preliminary code system, both shown in Table 8.

Table 8: Primary questions and codes

PRIMARY QUESTION	PRELIMINARY CODE SYSTEM
What are the current transport problems in Brazilian megacities / Rio de Janeiro?	Transportation problems
What are suitable approaches for tackling current transport problems in Rio de Janeiro?	General approaches to tackle transport problems
How can the rising demand for motorized transportation be reduced in Rio de Janeiro?	Rationalize car usage
How can Rio de Janeiro reform its public transportation system, to reduce the rising demand for motorized transportation?	Reformation of public transportation system
How can non-motorized transport be promoted in Rio de Janeiro?	Promote walking & cycling
What strategies of Curitiba's urban planning and public transportation concept can be transferred to Rio de Janeiro?	Transferability of measures
What is the potential of Rio de Janeiro's new infrastructure measures, currently being built for the sports events?	Sports events
What are the main urban transportation challenges of Brazilian megacities within the next ten years?	Future challenges for urban transport in Brazil

2. Phase: Creation of a written protocol

Recorded verbal data of each individual interview was efficiently converted into a higher level of abstraction by means of an audio-based quotation process, enabled by the software ATLAS.ti (see Figure 24).

In this phase, the interpreter listens to the recorded raw material and simultaneously marks the beginning and end of a quotation. Then, this audio quotation can be easily repeated and the relevant information condensed into written English quotations, using paraphrasing techniques (Z1 / Z2-rules) [MAYRING 2008, P. 62].

In case of repetitive answers, only the new information was quoted, to accelerate the analysis procedure. Thus, this method abandons the idea of transcribing the entire interview and creates a concise, written protocol.

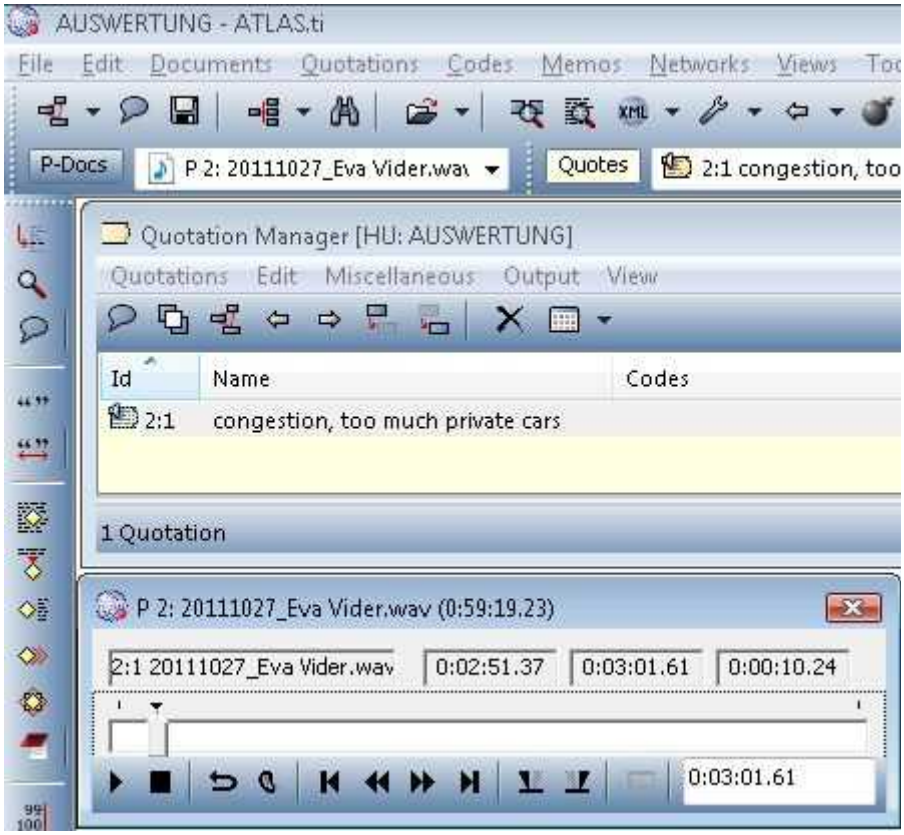

Figure 24: Creation of a written protocol

3. Phase: Differentiation of code system

The differentiation of the hierarchically structured code system, consisting of top-codes and sub-codes, was implemented in an inductive process. All interviews were encoded individually, while each quotation was assigned to a single code, according to their content. Starting with the preliminary code system, each code was assessed by means of “visualized code maps” (network views) to identify specific top-and sub-codes (see Figure 25).

As soon as one or more quotations represented an independently identifiable feature, in regard to similarities in content, a new sub-code was created. Occasionally, quotations were rearranged to other codes, if they did not comply with the desired content (see Quotation B in Figure 25).

The differentiation of the code system was a continuous and repetitive process. Thus, every implementation accelerated the encoding process of the next interview, due to a finer hierarchy of the code system. One specific example for an intermediate step can be assessed in Appendices C.III to support the understanding of the differentiation process.

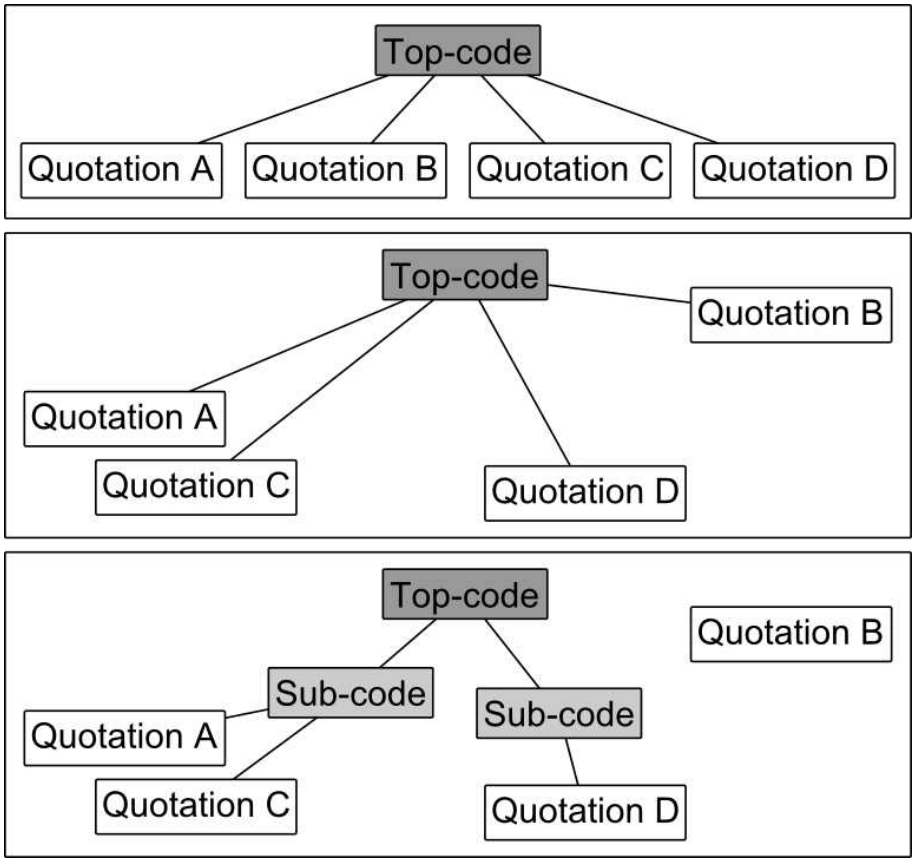

Figure 25: Differentiation of code system using "visualized code maps"

4. Phase: Revision of code system

The entire code system was revised after each interview by verifying each code and quotation. Moreover, a third-party revision with the developer of the AZIA was implemented after the first interview as well as an information exchange on further evaluation procedures. The final code system was reviewed upon consultation with the supervisor of this Diploma thesis. Although, this analysis does not ensure perfect inter-subjective results, due to the lack of assistance of several evaluators working independently of each other, it features a precise evaluation of the code system, implemented by specialist with different backgrounds.

5. Phase: Processing of results

In conclusion, a structured output of the entire analysis data was developed by creating a synthesis of each code using Z3 / Z4-rules [MAYRING 2008, P. 62]. A concise output of the relevant content of all selected interviews is provided by means of an overview on the code system and a comprehensive table of each code. Neither specific references of interview partners, nor the frequency of quotations was included, due to multiple responses of the participants.

3.2 OUTPUT

3.2.1 TRANSPORTATION PROBLEMS

This chapter contains detailed information on transportation problems of large Brazilian cities in general and in particular for Rio de Janeiro (RIO), Curitiba (CTBA), and São Paulo (SP). These abbreviations were used to mark the transportation problems of the specific city. Figure 26 shows the overview of the code system.

Figure 26: Overview of the code system of transportation problems

GENERAL MOBILITY CRISIS ISSUES
Congestion
High travel times
Lack of high quality public transport system
Informal transport competition
Modal shift
General dissatisfaction
Complex traffic management
Economic inefficiency

PUBLIC TRANSPORTATION ISSUES
Bad conditions of train stations
Complicated fare system
Unpredictable travel times
Road rage of bus drivers
Poor network design
Inadequate capacity
Lack of information

POLITICAL ISSUES
Prioritization of the automobile
Short time planning
Lack of guidance from the federal government
Weak performance of politicians
Power of PT operators

TECHNICAL ISSUES
Weak urban planning process
Chaotic implementation process
Poor NMT infrastructure design

SOCIAL ISSUES
Car Culture
Corruption
Security
Weak community engagement
Missing education
Lack of NMT mentality
Stress

ENVIRONMENTAL ISSUES
Environmental damage
Specific concerns

GENERAL MOBILITY CRISIS ISSUES	
Congestion	➢ Increasing congestion, too much private cars ➢ Megacities (> ten million people) suffer, but even smaller cities already experience small and local congestion's ➢ 1,000 new car licenses are distributed per day (SP)
High travel times	➢ People loose up to five hours per day in traffic (SP)
Lack of high quality public transport system	➢ Lack of high quality, comprehensive public transport system ➢ Poor and inadequate public transport supply
Informal transport competition	➢ In the 1990s there was an attack to PT by the informal market ➢ Informal transport fills the lack of the regulated PT system ➢ Some of the informal market structure was legalized and turned into legal bus operators ➢ Drug dealers and militia (police officers) control public transportation and politicians (RIO) ➢ Strong illegal control in the Western zone, but not so strong in the South zone (RIO)
Modal shift	➢ People, who take the public transport are willing to buy new cars or motorcycles (it is affordable and cheaper than PT) ➢ It is better to sit in your own car, then to be stuck in a crowded bus ➢ Molested woman are dreaming to leave the PT and get a car ➢ BRT-system is so crowded that people change back to the car (CTBA) ➢ Rich people use helicopters for their daily mobility (SP)
General dissatisfaction	➢ Dissatisfaction of the citizen with the transport system ➢ Today, we have a mobility crisis
Complex traffic management	➢ Traffic management is getting more and more difficult
Economic inefficiency	➢ Megacities concentrate economic incomes, but suffer from a great loss of efficiency due to mobility crisis ➢ Brazil looses huge amounts of money due to an inefficient transport system (loss in lifetime, elevated fuel consumption...)
PUBLIC TRANSPORTATION ISSUES	
Bad conditions of train stations	➢ Bad condition of train stations in combination with unpleasant surroundings (RIO)
Complicated fare system	➢ Complicating fare system (RIO) ➢ Rio has the highest number of "single tickets" in Brazil (RIO) ➢ Many fares hinder the process to establish cross-subsidies (RIO)
Unpredictable travel times	➢ High and unpredictable travel times (RIO) ➢ Buses do not comply with the timetables (RIO)
Road rage of bus drivers	➢ It is difficult to stop bus drivers, due to aggressive driving behavior (RIO)
Poor network design	➢ Weak integration of different modes of transportation (RIO) ➢ Small metro network and water transportation underused (RIO) ➢ People in the city center can choose between taxi, metro and thousands of bus lines which do not exist in Western parts of the city (RIO)

Inadequate capacity	➢ PT does not attend the demand adequately, ➢ No available seats in PT system during peak hour (RIO) ➢ High amount of bus lines (RIO) ➢ Empty buses in the city center / South Zone (RIO) ➢ Metro is very crowded (no available seats) (RIO) ➢ Train system needs an upgrade > more coaches and frequent services (RIO)
Lack of information	➢ Lack of information (website, route maps, time tables, ...) on PT (RIO) ➢ Not enough physical space to put information about bus lines and time-tables at bus stops (RIO) ➢ Identification of buses is difficult due to equal color of buses (RIO) ➢ Knowledge on bus lines has to be exchanged between users (RIO)
POLITICAL ISSUES	
Prioritization of the automobile	➢ Prioritization of the automobile (the root of the problem) by the political and technical class in all aspects of life ➢ Nationally strong automobile bias limits the understanding of possible solutions (default approach) ➢ Brazilian economy is based on the automotive industry since the 1950s and depends on it ➢ Brazil established national policies to stop the construction of track based transport systems and promoted bus- and automobile-based transportation ➢ Brazil is very far away from restricting the use of the car ➢ Tax induced incentives from the President to buy automobiles in 2008 as a reaction to the crisis ➢ Large cities promoted the use of cars by investing in infrastructure which eases access to goods and services for the automobile
Short time planning	➢ Lack of long time planning, due to discontinuity of politicians and public policy's is the most important problem in Brazil ➢ Short term political vision (elections / sports events) lacks a long term perspective ➢ Lack of a planning culture within Brazilian society in general
Lack of guidance from the federal government	➢ Insufficient funding from federal government and a bad relation of all three levels of government ➢ Weak collaboration within the Ministry of Cities departments ➢ Weak law enforcement: Cities with more than 500,000 inhabitants did not develop mobility plans so far ➢ Federal government financed only mass transportation systems, but never encouraged cities to make incremental benefits (Bus > BRT), so cities have high debts today ➢ Few politicians of the national level understand the importance of PT systems, sidewalks and bicycle infrastructure as well as the concept of mobility management
Weak performance of politicians	➢ Cities are falsifying "PT projects"which are actually road building projects and promote motorized transportation ➢ Projects are badly designed, so that they will not be implemented ➢ Politicians are not investing in efficient transportation although money is available ➢ Executives don't understand the PT system because they use cars ➢ We know what we need, we have the projects, but politicians do not want to do it (RIO)

Power of PT operators	➢ Lack of strong municipal and state transport government (RIO) ➢ PT is controlled by operators (RIO) ➢ Difficult negotiations between government and bus companies, PT operators do not want to lose power and money (RIO) ➢ FETRANSPOR is competent, has good technicians, and studies the city, but all under the aspect of a private operator (RIO) ➢ Isolated system thinking of operators (train, metro, bus) impedes integration (RIO)
TECHNICAL ISSUES	
Weak urban planning process	➢ Weak administration of urban space and institutions (RIO) ➢ Urban planning process does not combine urban- and transportation planning, it is rather dealing with micromanagement and looses the overall perspective (RIO) ➢ Urban density issues are not discussed in terms of diversity and integration (RIO) ➢ Bicycle and pedestrians were ignored / forgotten in the planning process of the past (RIO) ➢ Lack of vision towards an integrated public transport network of the municipal and state government (RIO) ➢ Isolated system thinking impedes the development towards an integrated transport system (RIO) ➢ Rios legal framework on land property is chaotic (RIO) ➢ Western and Northern parts require a lot of urbanism (RIO)
Chaotic implementation process	➢ Limited time to finish the implementation of infrastructure measures being built for the sports events ➢ Fast implementation process does not create good solutions (improvisations) ➢ Technicians do things without planning, based on macro plans, and constructions do not comply with plans (RIO) ➢ BRT-corridors do not take away space from the car (add-on to the existing road system) (RIO) ➢ Renouncement of concepts: Connection between the metro (Jardim Botanico) and the BRT-system (Alvorada) will not be built (RIO) ➢ Local communities suffer from the fast implementation process of the BRT-system (demolish schools, soccer grounds etc.) (RIO)
Poor NMT infrastructure design	➢ Cycling has a lot of political will, whereas pedestrians are mostly ignored politically (RIO) ➢ Local technicians have difficulties to take away space for the automobile, while implementing bike lanes (RIO) ➢ Sporadic and ineffective intentions to improve sidewalks, get cars and street vendors of the sidewalks (RIO) ➢ Sidewalks are poorly designed, maintained or do not exist (RIO) ➢ Poor pedestrian crossings at crossroads (RIO) ➢ BRT-corridor takes away space of sidewalks ➢ Bike lanes are full of obstacles (RIO)

SOCIAL ISSUES	
Car Culture	➢ High usage of the automobile, due to car-oriented society and the design of cities (e.g. Brasilia) ➢ Irrational use of cars for small distances for trips of 1 or 2 km ➢ Lack of mode choices between different modes of transportation ➢ The dream of a car: It is more important to have a car, then a house
Corruption	➢ Politicians participate in corruption: “Today, it seems that if you do not participate, it seems, that you are a fool” ➢ Population is trapped between two ways of thinking (disagreement or participation): “If everybody does it, I want my share as well” ➢ Insufficient confidence in politicians by the people, due to bad experiences in the past: “People believe that congestion charge would not be used to improve the situation, and they are right” ➢ Politicians sometimes don't implement good approaches because they don't “want” to, although it would be very easy to do
Security	➢ Chaotic traffic behavior of people, without laws (RIO) ➢ Insecurity in buses (assaults) (RIO) ➢ Women are molested in PT, when it is crowded (RIO) ➢ middle class is scared to walk or use PT because they are faced with a different reality (RIO) ➢ Robbery: People use a good bike and one for the thief (RIO) ➢ High speeds of electric bicycles on sidewalks (RIO)
Weak community engagement	➢ Weak community commitment (RIO) ➢ No connections between organized groups (RIO)
Missing education	➢ Professional bus and taxi drivers as well as pedestrian & cyclists do not have enough education to behave together on the streets
Lack of NMT mentality	➢ Lack of bike mentality (bicycle = leisure activity) ➢ People think that it is too hot for cycling (mental barrier) (RIO) ➢ People, who live in gated communities, will not walk to PT stations (RIO) ➢ Multimodal trips (NMT+ PT) are not very common (RIO)
Stress	➢ Psychological stress
ENVIRONMENTAL ISSUES	
Environmental damage	➢ Brazil is aware of the arising problems, but is not changing anything ➢ Environmental damage is high
Specific concerns	➢ Leaded batteries needed for e-mobility are allowed in Brazil, but cause high environmental pollution ➢ Environmental and social impacts of biofuels (sugar cane) are unknown

3.2.2 TACKLING TRANSPORT PROBLEMS

This chapter contains detailed information on the approaches to tackle transportation problems of Rio de Janeiro as well as suggestions for the national government. Thus, this output will be also useful for other large Brazilian cities. Figure 27 shows the overview of the code system.

Figure 27: Overview of the code system of tackling transport problems

ADAPT URBAN PLANNING PROCESSES
Decentralize
Interconnect urban- and transportation planning
Redesign urban transport infrastructure
Overcome short-term planning
Include all social classes
Innovate
Establish good relationships

RATIONALIZE CAR USAGE
Discourage the use of the car
Develop new policies
Reeducate decision makers and technicians
Encourage car-sharing and car-pooling
Educate citizens
Change culture

REFORM PT SYSTEM
Design an integrated network
Inform users about PT system
Invest in efficient mass transportation
Integrate the fare system
Reorganize bus system incrementally
Create exclusive bus lanes
Advertise the new system

PROMOTE WALKING & CYCLING
Improve planning processes
Integrate NMT with PT system
Change the image of cycling
Walking issues
Cycling issues

ADAPT URBAN PLANNING PROCESSES	
Decentralize	➢ Decentralize jobs, so that people don't have to travel enormous distances from their home to their jobs ➢ Review the distribution of city services, deconcentrate it towards a network of local access points, to promote walking distances ➢ Create sub-centers, every neighborhood should have a center with all urban facilities (recreation areas, schools, ...), so that people do not have to go to the center of the city ➢ Create BRT-stations with integrated public- and social services (kindergarten, hospital, shopping center), to revitalize the surrounding areas of BRT-system (similar to CTBA's terminals) ➢ Interconnect these centers with all modes of transportation ➢ Encourage that people live, work and study in the same area
Interconnect urban- and transportation planning	➢ Design the city first, then built the mobility system to serve the city ➢ Create a metropolitan agency which is responsible for integrated transport planning (define corridors, projects, focus on investments and urban development) ➢ Combine urban- and transportation planning, and connect high density areas with mobility corridors: Built metro either in high density areas or move high density areas towards the metro; When density reaches a certain amount, decrease the size of the buildings or start to build a metro
Redesign urban transport infrastructure	➢ Reorganize the city along with the current restructuring of the city: Create squares, recreation areas, cycle lanes along the BRT-system ➢ Do not built urban highways because it induces new traffic ➢ Take away space from the car or share available space with other modes of transportation
Overcome short-term planning	➢ Use the basis of 2016 to implement a long time planning process, but it has to grow independently of the upcoming sports events ➢ Learn from São Paulo: Politicians learned how to keep going on urban policies, while having different mayors / parties as well as to cooperate to work towards a common goal
Include all social classes	➢ Implement the best urban design for poor people, otherwise we will perpetuate the gap between rich and poor ➢ Create a balanced supply: Everyone has to move to the same destination, with the same opportunity in the same time ➢ Encourage an urban design, that allows people to talk with each other, and do not create "fences“ between them
Innovate	➢ Innovation requires: 1) Diversity: if everybody thinks the same, there will be no innovation, 2) Density (amount of people): to be able to discuss with people that don't think the way you do, and 3) Good moral values
Establish good relationships	➢ Establish good relationship between all three levels of government which are necessary for funding and implementation

RATIONALIZE CAR USAGE	
Discourage the use of the car	➢ Organize a system which focuses on the rationalization of the car usage ➢ Reverse the current model, using carrot or stick approaches ➢ Modify the lines of desire (trip generation) of the peoples mobility ➢ Encourage better mode choices by providing a general scheme of mobility, in which people can choose their best mode of transportation, regarding time, cost and distance ➢ Implement a dependable public transportation system with a reasonable fare system; The middle class uses the automobile, so they have to gain something personally (time, comfort, safety, money) in order to use public transportation ➢ Encourage an efficient use of the car (not based on SUV's); Automotive industry participates already in the discussions of the sustainable car usage
Develop new policies	➢ Create conditions, in which the use of the automobile is more expensive than public transportation to change the peoples modal choices which is based on time and cost, although car culture is difficult to change within Brazilian society because: 1) People have the money and are eager to buy new cars and the federal government cannot prohibit this, 2) Taxes are already high, and the reimbursement for the people is low (corruption). Thus, middle class is not willing to pay (“breathtaking" change) ➢ Restrict the use of automobiles by means of: “rodizio” concept[38], fuel taxes, parking fees (distimulate free parking, charge for on-street parking, and higher prices for parking garages), vehicle taxes (small chances), and congestion charge (last option) ➢ Create public policies within all three levels of government which direct more public funds to walking, cycling and public transportation (cheaper / faster), and disincentivize automobile ownership
Reeducate decision makers and technicians	➢ Change the mindset / consciousness of planners by means of awareness building campaigns; Planners have to understand that their goal is to move people instead of cars; It is not a technical issue, rather a problem to change the political will ➢ Work on technical capacity, change mentality, systematic reeducation for every traffic engineer, then you have less resistance because they understand what you want, and it is easier for them to implement changes (e.g. take park space away)
Encourage car-sharing and car-pooling	➢ Car-sharing and -pooling can is a part of the solution (long-term approach) ➢ Car-sharing for this type of person, who wants to buy the second or third car ➢ Organize car-pooling within the condominium block

38 In São Paulo, automobiles are prohibited within the internal mini-ring road, during morning and evening rush hour (7-10 hrs and 17-20hrs), according to their final license plate number, which depends on the weekday. [CET]

Educate citizens	➢ Awareness building campaigns in companies and schools, national campaigns similar to anti-smoking campaigns, driver education and training, distributing flyer's on streets, speak directly to automobile drivers ➢ Show people what is possible in transport, that transport does not mean to go only by car, and what are the real costs of it ➢ Inform people about: the benefits of each mode of transport, the best mode for each type of travel, and how the PT system works ➢ Demonstrate people the benefits of public transportation, an integrated network and that integrated transfers do not mean a loss of time ➢ Explain them to take responsibility for their group (neighbors, building, neighborhood) > solidarity ➢ Teach them how to take intelligent life decisions on mobility, so that people choose to live close to their work ➢ Motivate pedestrians, cyclists, and car drivers to share the road with each other: They must understand that the street is for everybody ➢ Indicate the benefits of walking and cycling to the individual, they spread the message throughout society (as multiplicators) ➢ Illustrate to people, that it is not too hot for cycling from April to December (moderate weather)
Change culture	➢ Change culture towards a good quality of life ➢ Move to another level of economy / capitalism, move from “owning a car” towards “access to mobility”; The European crisis will enable this cultural change: new economy, new capitalism, new way of life
REFORM PT SYSTEM	
Design an integrated network	➢ Create an integrated metropolitan public transport network, consisting of all modes of public transportation (metro, train, bus, …) ➢ Develop a cooperative institution of the state and municipal government which designs and manages the integrated PT network of the RMRJ as well as defines the service quality of the PT ➢ Interconnect PT system with each other in terms of physical integration and adjusted timetables (Train > Metro > BRT > Local bus) ➢ Create a circular metro network instead of a linear system ➢ Create a new PT corridor (BRT) parallel to the metro in the South zone of Rio de Janeiro ➢ Create feeder lines for the metro which does not compete, rather complement the PT system (similar to RJ's metro system) ➢ Encourage people, who live close to PT-corridors, to use PT because apartments are expensive there, so people have more cars
Inform users about PT system	➢ Make the PT system understandable for the people because they don't know it ➢ Create an entire system of information about the PT network featuring: timetables, information on bus lines, expected travel times, an integrated route map on PT system (as a communication tool with users), at bus stops and the internet (PT website) ➢ Give real time information (apps, website) to enable intelligent mobility choices because in 3 hours the situation can be different ➢ Spread mobility information throughout society by means of social networks (real time help of friends via smartphones)

Invest in efficient mass transportation	➢ Improve PT system drastically, by investing in a high quality mass public transportation systems (metro, train, ferry boats, cable cars); only a very high level of convenience, in terms of low travel times, comfort and reliability, will shift the middle class car users back to the PT share ➢ Create a balanced system with adequate capacity, e.g. increase the capacity of the train system which will also improve the bus system (less people use buses, better service quality), a single system will soon be overcrowded (similar to RJ's metro) ➢ Implemented track-based systems instead of motorized transportation by bus ➢ Include services similar to the chartered buses (air condition, wi-fi and newspapers) which provides a new utility of time spend in PT ➢ Promote chartered bus service within condominium blocks or within the traffic management of companies
Integrate the fare system	➢ Enable intelligent integration of all PT modes by means of one single fare (daily / monthly ticket system); It is very difficult to change the fare system because of the power of the operators and high costs for the government (subsidies), but São Paulo's “bilhete unico” (eng.: single ticket) was the most important revolution of urban transport in Brazil ➢ Integrate the “vale transporte”[39] ➢ Lower fare for low-income class (subsidies) ➢ Modify fare system in combination with the new BRT-corridors
Reorganize bus system incrementally	➢ Improve the quality of buses: low-floor buses, take out turnstile ➢ Reduce the number of bus lines: e.g. one bus line which connects Leblon with the city center and passes through all neighborhoods similar to the metro (Mini-BRT, with precise timetable and route); from the transportation engineering point of view, it is possible to change ➢ Offer bus services, where it is necessary and with adequate capacity of buses
Create exclusive bus lanes	➢ Grant road space to PT (exclusive bus lanes) ➢ Demonstrate the priority change of the public spaces design with BRT-system (symbolic image: go by bus instead by car) ➢ Invest in smaller systems (BRS); Easier to implement and take away space from the car > it is just a political decision; The disadvantage of BRT-systems are the vast dimensions in widths: 90 % of all corridors in large Brazilian cities do not have sufficient demand to justify a classic BRT-system ➢ Reorganize traffic flows and rearrange bus stops by means of the BRS-system ➢ Expand BRS-system because it was a good upgrade, at low costs, important returns for users, cutting down travel times by half ➢ Implement a traffic control system (camera surveillance) at BRS-corridors
Advertise the new system	➢ Promote the use of PT system in TV shows such as soap operas ➢ Present the short travel times of the BRT-system to car users ➢ Show people that transportation is a great ally of the environment ➢ Advertise the benefits (utility of time) of PT

39 Due to the “vale transporte“ (created in 1985), every worker can spend at most up to 6 % of their salary for transportation. When this percentage exceeds their costs, the company is obliged to pay the complement of the workers expenses. [RIO CARD]

PROMOTE WALKING & CYCLING	
Improve planning processes	➢ Paradigm shift to actually promote NMT-modes ➢ Respect the quality of walking and cycling as a part of the solution ➢ Create solutions neighborhood by neighborhood (completely different realities) ➢ Convince people to use NMT-modes with safe, pleasant, clean, less polluted and good quality infrastructure ➢ Invest in social houses in the city center, so that people would walk or cycle, instead of gentrifying the area by upper and middle class office buildings (Porto Maravilha) ➢ Implement cycle lanes and sidewalks for the plain areas of the city ➢ Enforce a maximum speed of 30 km on residential streets, makes the city safer for pedestrian and more comfortable for cyclists ➢ Focus on rich and poor parts of the city; There is more motorized transport in the rich parts, so it helps to reduce congestion; but people of the B, C, D classes would benefit the most (more comfort, better health, less chances of being killed or injured)
Integrate NMT with PT system	➢ Think systematic: NMT is a part of the mobility system, Walking is very good in connection with a dense PT system; Cycling is a good feeder system for the BRT-system (NMT + PT is good for commuting to work) ➢ Create access to PT system for NMT-modes by means of good sidewalks and bicycle lanes (also for handicapped people); start within a radius of 1 km around all PT stops in the network ➢ Promote Walking to PT stops for upper class with good quality sidewalks (trees, illumination) and public security to ensure safety of the people ➢ Implement bicycle parking at train station in the periphery (especially Western parts of RJ) ➢ Enable full bicycle integration within the metro system ➢ Implement bus racks to carry bicycles with local buses
Change the image of cycling	➢ Create a longing for cycling by making it attractive for people ➢ Focus on middle class: Lower class wants to behave like the medium and high classes, if they use cars, they are attracted to, if they use bicycles, they will also want to use it ➢ Shows to people that you can use bicycles to go to party's, restaurants, or ride it with good cloths, by means of bicycle user groups[40] ➢ Travel to Europe: Rich peoples in Rio started to cycle because they went to Europe and saw people like them, who were cycling ➢ Implement public bicycle system: If people use public bikes on Sundays, maybe they start to use it during weekdays
Walking issues	➢ Pay attention and take responsibility to sidewalks ➢ Institute a system of uniform design (manual of sidewalks) ➢ Redesign streets and design new street in regard to pedestrians ➢ Improve sidewalks: Remove holes, make them free of obstacles, design a certain standard of surface (substitute Portuguese cobbles) ➢ Implement a sidewalk policy, so that people do not to park at sidewalks

40 Passeio completo is a bicycle user group in Rio de Janeiro which promotes cycling by offering bicycle tours with a mobile sound system. More information available online at: http://pt-br.facebook.com/people/Passeio-Completo/100000984863976

Cycling issues	➢ Create an efficient and complete bicycle network throughout the city, but start locally to attend local demand for short trips (do not implement 300 km of bike lanes, implement 300 bike lanes of 1 km); Many short bike lanes will support local communities and their specific needs and promote cycling in general ➢ Listen to locals: if they don't use bicycles, it does not make sense to implement cycle lanes ➢ Identify already existing demands (e.g. train stations) and promote more demand by connecting these places to the network ➢ Design straight connections instead of the old design for leisure ➢ Create a map on how to go the fastest and safest from one bike rental station to another (SAMBA system, RJ), and then built adequate infrastructure in cooperation with municipality for these connections ➢ Create a comfortable environment for cyclists by means of pavement markings and shaded bike lanes ➢ Implement good bicycle parking infrastructure (security), but focus on both demands: rich people buy expensive bikes (pedelecs) and poor people cheaper ones ➢ Create more political attention to cyclists by a higher demand

3.2.3 ADDITIONAL INFORMATION

This chapter provides additional information on the transferability of measures between Curitiba and Rio de Janeiro, the impact of the sports events in Rio de Janeiro, and information on future challenges for urban transportation in Brazil. Figure 28 shows the overview of the code system.

Figure 28: Overview of the code system of additional information

TRANSFERABLITY OF MEASURES	
PROFESSIONAL CITY ADMINISTRATION	**PUBLIC TRANSPORTATION ISSUES**
URBAN PLANNING ISSUES	**UNIQUENESS OF CURITIBIAN CASE**

IMPACT OF SPORTS EVENTS IN RIO DE JANEIRO	
PACEMAKER EFFECT	**DRAWBACKS**
ASSETS	**FORTUNATE CIRCUMSTANCES**

FUTURE CHALLENGES FOR URBAN TRANSPORTATION IN BRAZIL	
URBAN PLANNING	**MODAL SHIFT**
REFORMATION OF PT SYSTEM	**TECHNOLOGY**
AWARENESS BUILDING	

TRANSFERABLITY OF MEASURES

PROFESSIONAL CITY ADMINISTRATION

- CTBA has the same problems, but the solutions are different
- CTBA's unique planning process, based on creative solutions, enabled by cooperative colleagues, knowledge exchange and continuity of the team (IPPUC); IPPUC's currency is creativity which provokes the municipality and the population; The city knew how to take advantage of the good human resources, that were formed within the city's institutions
- CTBA's good city marketing: IPPUC's planning team always had special care about the quality of the design, not only the contents, but the package of the content, and the residents appreciate this quality, and complain in case of a bad design

URBAN PLANNING ISSUES

- CBTA's good urban policies should inspire other cities, within their own commitment and needs
- Combined land use and public transportation planning
- Interconnection between population density and access to public transportation; (high densities next to PT corridors, decreasing with greater distances)
- Integration of the society by controlling the size of the building (e.g. eight story buildings are high enough to allow more density, high enough to promote upper and middle class and low enough not to attract millionaires
- City center management because Rio de Janeiro's city center is abandoned
- Cepac policy, where the city sells the right to built higher buildings, and uses this money to develop green spaces
- Classification of streets, enabled a decent urban development and promoted walking and cycling
- Valorization of the periphery by means of PT corridors

PUBLIC TRANSPORTATION ISSUES

- Resilience on the prioritization on public transportation over individual transportation (not give space to the car): CTBA's municipality and state government has a strong tradition of supporting PT, and CTBA was successful in shifting the modal share towards PT, although it has the highest car ownership rates in Brazil,
- Administration of bus lines within the metropolitan area: URBS has agreements with the surrounding municipalities, due its good quality and high respect, although CTBA's municipality is not allowed to administer bus lines which do not belong to their territory
- BRT-features, such as exclusive and segregated bus lanes, enclosed stations, pre-paid boarding, and overtaking lanes at bus stops, although CTBA's citizens say, that the BRT-system doesn't work as good as what it is known for throughout the world
- Reformation of an old highway into a high quality BRT-corridor (Linha Verde)

UNIQUENESS OF CURITIBIAN CASE

- CTBA's processes were not always perfect because of the military dictatorship; CTBA had a powerful administrator (despot) at this time which had the power to implement drastic changes
- CTBA had a good team of urban planners which had a different vision at an important point of the city's history (Population grew from 500,000 to 1,000,000 in a very short time)
- CTBA had a good background and used the benefits of this time, but it is difficult to replicate in other cities

IMPACT OF SPORTS EVENTS IN RIO DE JANEIRO

PACEMAKER EFFECT

- Historical moment in Rio de Janeiro's history because of the World Cup in 2014 and the Olympic games in 2016 (host city)
- Vast changes arising from these sports events, not only for the transportation sector, but they do not originate from an internal planning process, rather because the municipal government was forced to improve its transportation system in order to win the Olympic bid 2016 (the city lost the Olympic bid for 2012, due to its weak transportation system)
- After the city won the Olympic bid in 2009, it was forced to do serious planning to improve its mobility system, due to the external interest of the FIFA and the Olympic committee
- A landmark for the public transportation system because the currently built infrastructure measures have been on paper for 30 years
- Rio de Janeiro promised to construct a new PT network and the technicians decided to implement a BRT-mass transportation system because of its low costs and fast implementation

ASSETS

- Rio de Janeiro will have a comprehensive, metropolitan, mass public transport network in 2016
- Existing public transportation network will almost duplicate until 2016
- Entire design of the mobility will change and improve traffic conditions
- Isolated philosophy is changing towards an integrated philosophy
- BRT-corridors function as a basis to integrate the already existing system, local buses will be reorganized, bus lines rationalized, and a new trunk and feeder system created
- If the train receives the upgrade, the metro increases the capacity, the BRT-system will be created, and new buses be bought, we will have a good PT system
- Without sports events, none of these infrastructure measures would have been implemented

DRAWBACKS

- Biggest concern is the integration of the new infrastructure into the urban development
- New infrastructure must be useful for all citizens in order to accomplish a good upgrade from 2010 to 2016 (in case of the World summit in 1992 and the Pan-American games in 2007, new infrastructure was built just for the events and afterward nothing changed)
- New infrastructure benefits only wealthy people, while investments should focus on the North zone not the South zone because more people are living there
- Rios metro extension should cover another area (Gávea, Botafogo, Laranjeiras)
- The new metro Line 4 will fill up the existing metro system even more (no capacity)
- False information about BRT-projects are disseminated to justify projects (e.g. capacity numbers)
- New BRT-system will provide a higher quality for the people who already use PT, but it will not reduce car usage because the projects include new road infrastructure for the automobile, thus they will create more automobile traffic

FORTUNATE CIRCUMSTANCES

- It is the right time for innovation because of the pacification of *favelas*, a higher income of the people, and the current renovation of the city
- Also exists a good relationship between municipal, state and federal government and the mayor has the political acceptance
- Rio de Janeiro has capable technicians at all involved institutions (SETRANS / SMTR) and maybe the best background of all World Cup host cities because Fetranspor's employees are willing to change the current situation

FUTURE CHALLENGES FOR URBAN TRANSPORTATION IN BRAZIL
URBAN PLANNING
➢ To create an institutionalized and integrated urban- and transportation planning system ➢ To enable short, medium and long-term planning processes which include mobility and land use issues as well as social-economic issues into the planning process ➢ The urban planning process has to think about how many people can life in the city, regarding density and quality of life (lower maximum densities, while stimulating the city in another way) ➢ To change the urban road design and taking public responsibility for sidewalks ➢ To create open spaces, squares, parks, so that we can see other people
REFORMATION OF PT SYSTEM
➢ To create an efficient mass transportation system (future demands will force recent BRT-projects to be transformed into a metro system) ➢ To invent new ways of combining fast and slow mobility with each other ➢ To include the lower classes into the mobility network with the right fares ➢ To change the fare system: the fare has to be 1 R$, instead of using subsidies ➢ To give space to bus system for better operation
AWARENESS BUILDING
➢ To change the mind of the people ➢ To show people the benefits of sustainable transportation, and the connection between different transportation systems ➢ To educate values to create a mentality, in which people see the city as a way of living
MODAL SHIFT
➢ To provide a sufficient level of public transportation services, so that people do not want to migrate to private individual transportation ➢ To rationalize the automobile use by defeating the ideas of having free parking spaces, building new urban highways, and creating more infrastructure for the automobile ➢ To make people use bicycles: there is a high potential of the bicycle in Brazil, e.g. bike use in Santos is 15 % (almost as high as cities in Germany)
TECHNOLOGY
➢ Find advanced technology (traffic monitoring technologies and information systems) ➢ Make use of new technology developed at UFRJ (hydrogen bus, MagLev Cobra[41]) ➢ Our future is to implement what already exists in the world

41 The MaglevCobra is a superconductive, magnetic levitation train. More information available online at: http://www.maglevcobra.com.br

3.3 SUMMARY

During a three month research period in Brazil, 20 expert interviews were conducted with relevant stakeholders in urban- and transportation planning of Rio de Janeiro, Sâo Paulo, and Curitiba. Seven interviews were selected for further audio-based qualitative content analysis which was implemented in five phases:

1. The determination the material,
2. the creation of a written protocol, using an audio-based quotation process,
3. the differentiation of the code system by means of visualized code maps,
4. a revision of the code system, and
5. the processing of results.

This content analyzes gives a concise insight into the current transport situation in large Brazilian cities. The output contains current transportation problems of Brazilian megacities, integrated approaches for tackling transport problems of Rio de Janeiro, in particular for the reformation of the public transportation system and the promotion of non-motorized transportation modes. Moreover, it examines the transferability of infrastructure measures in between Rio de Janeiro and Curitiba, reveals the impact of the upcoming sports events as well as future challenges for urban transportation in Brazil.

4 RECOMMENDATIONS

4.1 TACKLING TRANSPORT PROBLEMS

4.1.1 BACKGROUND

Brazil and especially the megacity Rio de Janeiro are undergoing significant changes. The country's vibrant economy generates a higher income for the population and the upcoming World Cup in 2014 as well as the Olympics in 2016 cause an intense, rapid urban development of Rio de Janeiro. Unfortunately, this process is characterized by vast social inequality and numerous transportation problems.

Today, Rio de Janeiro's road system is no longer capable to serve current traffic flows. At the same time the city suffers from an inefficient mass public transportation system which results in a lack of mobility choices. Previous approaches focused on the expansion of the road system, prioritized low-capacity local buses, and neglected non-motorized transportation modes. This created an unsustainable development in which car traffic demand is constantly growing. In view of the country's dramatic development of registered new vehicles, it is imperative to tackle Rio de Janeiro's transport problems.

Meanwhile, Curitiba developed a model BRT-transportation system within the past 40 years, known worldwide for its integration, efficiency, and cost effectiveness. Although Curitiba has one of the highest car ownership rates in the country, the city successfully managed to maintain its public transportation share, using this system as a key tool to direct the growth of the city and not as a response to immediate problems of traffic congestion.

Currently, Rio de Janeiro's strategy has changed by implementing a new mass public transportation system and promoting walking and cycling as mobility alternatives. Nevertheless, this process mainly derives from the external force of the upcoming sports events and is not a result of an internal urban planning process. Thus, the city still requires adequate approaches to develop a sustainable urban transport concept based on the lessons drawn from the Curitiban experience and supported by the pacemaker effect of the sports events.

4.1.2 ADAPT URBAN PLANNING PROCESSES

In the context of Brazil, a sustainable urban transport concept is enabled by providing equal access to urban space, prioritizing public and non-motorized transportation modes, and reducing urban sprawl, while this concept has to be in reconciliation with environmental sustainability.

In order to initiate a sustainable development of the megacity Rio de Janeiro, the urban planning process must be integrated with transportation planning and executed by a metropolitan agency which is responsible for the entire RMRJ for the definition of mobility corridors, infrastructure projects, and investments. Thus, this agency might be able to overcome short-time planning processes.

Hence, an independently growing long-time planning process – encouraged by the movement of the upcoming sports events in 2014 and 2016 – has to be enforced by this metropolitan agency, whose prime directive must be in accordance with the principles of sustainability. Then, urban planning processes will be able to focus on the inclusion of all social classes to implement the best urban design for poor people and create a balanced supply of transport infrastructure, so that everyone has the same opportunity of sound and seamless travel. Thus, the gap between rich and poor will not be further perpetuated.

Furthermore, Rio de Janeiro's urban structure has to be decentralized and urban transport infrastructure redesigned, so that people do not have to travel enormous distances to go to the city center. Instead of having one CDB, sub-centers with all urban facilities have to be created in every neighborhood. This reorganization can be implemented in accordance with the current restructuring of the city: Integrated BRT-stations with public and social services, for example kindergartens, hospitals, and shopping centers, can be built along the new BRT-corridors, as well as recreation areas, squares, and cycle lanes to revitalize the surrounding areas of the BRT-system.

For a successful implementation and funding of infrastructure projects, Rio de Janeiro has to establish continuous relationships between all three levels of government. This might soon be stimulated by the PNMU, the new legislative instrument on urban development and mobility issues.

4.1.3 RATIONALIZE CAR USAGE

In Brazil, urban mobility is characterized by a strong need for motorized transportation based on a strong car culture within the Brazilian society and supported by the prioritization of the automobile by politicians and technicians. In order to rationalize the use of private motorized transportation, future policies have to encourage better mode choices by providing a general scheme of mobility, in which people can choose their best mode of transportation, regarding time, cost and distance.

Therefore, all three levels of government have to create conditions in which the use of private motorized transportation is disincentivized by making it more expensive. This can be achieved by means of restrictive fiscal policies, such as: 1) parking fees (distimulate free parking, charge for on-street parking, or higher prices for parking garages), 2) fuel- or vehicle taxes, or 3) a congestion charge. Likewise, more public funds can be directed towards public transportation, making it faster and cheaper than private motorized transportation.

This process has to be accompanied by a systematic reeducation for all decision makers, planners and traffic engineers in Rio de Janeiro in order to change their mindset and improve technical capacity, clarifying that the goal is to move people instead of cars. At the same time, awareness building campaigns for citizens should be performed to inform people about the benefits of each mode of transport, the best mode for each type of travel, the real cost of the car, and the functioning of an integrated public transportation network. The citizens have to learn how to take intelligent decisions on mobility. In addition, pedestrians, cyclists, and car drivers should be motivated to share the road with each other.

Eventually, a paradigm shift from “owning a car“ towards “access to mobility” has to be initiated in which car-sharing and car-pooling is seen as a part of the solution. Such a long-term approach can be initiated within condominium blocks or shopping centers, due to the high demand for these places by the middle class car users.

To ease the prevalent transport situation in Rio de Janeiro, the key objective for all urban transportation activities has to be the supply of a decent transport system, not for the upcoming events rather for the city, to maintain and increase the current share of public and non-motorized transportation.

4.1.4 REFORM THE PUBLIC TRANSPORT SYSTEM

The first step towards an efficient mass public transport system is to create an integrated metropolitan public transport network, consisting of all modes of public transportation (train, metro, BRT, ferry boats, cable cars, local buses, etc.). In such an integrated network, the BRT-system as well as local buses function as feeder lines for the train or metro system which do not compete, rather complement the entire public transport system, similar to the already existing *metrô na superfície* (eng.: surface metro) integrated in Rio de Janeiro's metro system.

This network has to be designed and managed by a cooperative institution (transport association), deriving from the state and municipal government which also defines the system's service quality. The different public transportation modes have to be physically integrated with each other and should feature in the best case interconnected timetables with optimized transfer times. This metropolitan public transport network also depends on an integrated fare-system which enables intelligent transfers between all public transport modes with one single fare (daily / monthly tickets). In consequence of the vast differences in income of Rio de Janeiro's citizens, these fares have to be subsidized for the low-income class.

In general, Rio de Janeiro has to improve its existing public transportation system by investing in efficient, high-quality transportation which focuses especially on the needs of the car users (mainly middle class), so that these people gain a personal benefit (time, comfort, safety, reliability) and eventually shift back to public transportation modes. Thus, it is imperative to create a well-balanced system in which the capacity of each mode is equilibrated, so that overcrowded stand-alone solutions are avoided. Likewise, public transportation has to offer similar services, already known from chartered buses (air condition, wi-fi and newspapers), to provide a new utility of travel time for its users.

However, the most significant change will be accomplished by reorganizing the existing local bus system, due to the fact that it carries the highest share of public transportation users. This process consists of three incremental steps:

1. Improve the quality of buses by investing in low-floor buses and taking out turnstiles in buses which will enable easy and convenient entry and exit of passengers and simultaneously minimize station stop times.

2. Make the system more efficient by expanding the new BRS-system which will reorganize traffic flows, rearrange bus stops, and rationalize the number of bus lines.
3. Rationalize bus lines drastically by merging various lines into one single “Mini-BRT-corridor” which features exclusive bus lanes, high capacity buses, unique bus stops, and pre-paid boarding. Such a public transportation corridor can be implemented as a parallel system of the metro as a response to the excessive demand in the South zone.

Moreover, Rio de Janeiro has to invest in useful information on the public transportation system in order to enable intelligent mobility choices. Such information is literally unknown for Rio de Janeiro's citizens. Thus, in order to make the public transportation system more understandable for the people, there has to be created an entire new system of information on public transportation stops featuring timetables, information on bus lines, expected travel times, and integrated route maps about the metropolitan public transport network. The *MobiRio*[42] – an integrated map of the metropolitan transport network – is a first approach from the UFRJ towards an adequate system of information. Furthermore, real time information can be provided at websites or via smartphone applications, using the internet as a communication tool with the users. In addition, mobility information can be disseminated throughout society by means of social networks, enabling real time support by friends or other users.

Eventually, the new system can be promoted based on adequate advertisements. The benefits of the new public transportation system (shorter travel times and new utility of time) can be broadcasted via *telenovelas* (eng: soap operas), reaching the entire country and making Rio de Janeiro the leading city for high quality public urban transportation in Brazil.

4.1.5 PROMOTE NON-MOTORIZED TRANSPORTATION

In order to tackle current transport problems of Rio de Janeiro, the promotion of non-motorized transportation is indispensable. In respect of the high share of pedestrians and the great potential of cycling within Rio de Janeiro's society, a paradigm shift must be performed towards the use of non-motorized modes of transportation as a daily mobility alternative.

42 More information available online at: http://mobirio.poli.ufrj.br/ or see Appendices A.VII, A.XI, A.XII.

In general, solutions have to be developed neighborhood by neighborhood, due to the completely different realities of the various parts of the city. Good quality non-motorized transportation infrastructure has to ensure a safe, pleasant, and clean environment, while a maximum speed of 30 km on residential streets produces safe and comfortable conditions for pedestrians and cyclists. Therefore, existing streets have to be redesign and new streets planned in accordance with a standard sidewalk policy (manual of sidewalks), enabling a uniform design, and taking into account the responsibility, deriving from the high share of pedestrians. In any case, the condition of sidewalks has to be improved by removing holes, making them free of obstacles, and ensuring a certain standard surface.

Cycling can be promoted by implementing infrastructure which focuses on the local demand for short trips. These measures can be interconnected with each other in order to build a complete bicycle network throughout the city with direct connections. This infrastructure has to ensure a safe and comfortable environment for cyclists by means of good bicycle parking facilities, adequate pavement markings and shaded bike lanes. Moreover, specific demands should be identified, for example at train stations, and promoted by connecting these places to the existing infrastructure network in the surrounding areas which is especially important in the Western parts of Rio de Janeiro.

In general, technicians should think more systematically in order to promote the integration of non-motorized transportation with the public transportation system. Every public transportation user is also a pedestrian or cyclist, feeding the system. Therefore, non-motorized transportation modes play an important role in the mobility system, completing the group of ecomobile modes of transportation which was often neglected by Brazilian technicians.

Thus, it is significant to create good access for non-motorized transportation modes at public transportation stops by means of sidewalks and bicycle lanes, equally considering the needs of handicapped people. Infrastructure investments should focus on a 1 km radius around every public transportation stop in the network. In order to promote intermodal mobility, it is necessary to implement good quality sidewalks with trees and illumination. For the upper class, it might be useful to meet their high demands in regard to security by means of public security guards.

Nevertheless, it will be difficult to change the image of cycling within Brazilian society. This can be achieved by showing to people that they can use bicycles for everyday mobility by means of bicycle user groups, awareness campaigns, or even a public bicycle system. They have to understand and see that it is possible for example to go to restaurants by bicycle or to cycle with good cloths to work. Thus, multiplicators play an important role within the promotion of cycling because the lower class people intend to behave like the medium and higher classes and they on the other hand went for example to Europe and started to cycle in Rio de Janeiro because they saw people like them and thought that it is fashion. In fact, if people start to cycle more on Sundays by means of the public bicycle system SAMBA, they might be more attracted to cycle during weekdays and eventually creating a higher demand incrementally.

4.2 TRANSFERABLITY OF CURITIBIAN MEASURES

Curitiba, as the mother of the BRT-system, is also a model city for urban- and transportation planning in Brazil. Nevertheless, the city has the same transport problems similar to other large Brazilian cities, but it provides different solutions. In Curitiba, a professional city administration is enabled by a distinctive planning process which is based on good human resources that were formed within the city's institutions. Furthermore, the basis of IPPUC's creativity and good city marketing is an active knowledge exchange in between cooperative colleagues in combination with the continuity of the employees.

Curitiba's good urban planning policies should inspire Rio de Janeiro, within its own commitment and needs, to develop a well-managed city. Thus, the most important lessons for Rio de Janeiro are:

- The resilience on the prioritization of public over individual transportation;
- The integration of public transportation into the urban planning process, by combining land use- and public transportation planning;
- The interconnection of high density areas with mobility corridors, lowering density with greater distance to public transportation corridors;
- The classification of streets which enabled a decent urban development and promoted walking and cycling; and
- The valorization of the periphery by means of public transportation corridors.

Another important issue is the administration of bus lines within the Metropolitan Area of Curitiba. URBS has agreements with the surrounding municipalities, due to its good quality and high respect, although legally the company is not allowed to administrate bus lines outside of the municipalities' territory. This could be a useful approach in order to implement Rio de Janeiro's cooperative institution and to manage the public transportation network of the RMRJ.

Furthermore, Curitiba's public transport system features innovative approaches, such as the integrated transport network, exclusive and segregated bus lanes, bi-articulated five-door buses, and unique tube stations with pre-paid boarding as well as overtaking lanes which provide useful ideas for the reformation of Rio de Janeiro's local bus system. Likewise, Curitiba's good integration – in terms of service and fares – between trunk and feeder lines overcomes capacity issues, uses buses efficiently, and optimizes the operation. Thus, it shows that BRT-systems are capable of carrying a high number of passengers at speeds equivalent to those of LRT-systems. In fact, passenger handling delays can be minimized and high levels of operational performance achieved with this type of organization and design. In addition, even the trinary road system could be implemented within the new transit corridors of the BRT-system because they are in a process of massive redevelopment.

However, the Curitiban case is unique because of its historical background which makes it difficult to replicate these approaches in other cities. Nevertheless, it remains a prime example of a well-managed Brazilian city and demonstrates what can be achieved within the same legislation.

4.3 IMPACT OF SPORTS EVENTS IN RIO DE JANEIRO

The World Cup in 2014 and the Olympic games in 2016 are a landmark for the public transportation system in Rio de Janeiro because the currently built infrastructure measures have been on paper for over 30 years. Unfortunately, these changes do not arise from an internal planning process because the municipal government promised to improve its public transportation system in order to win the Olympic bid for 2016. Thus, after the city won the bid in 2009, it was rather forced by the external interest of the FIFA and the Olympic committee to implement the new infrastructure measures until 2014 / 2016.

Nevertheless, if Rio de Janeiro is able to implement all planned infrastructure measures until 2016, it will create a comprehensive metropolitan mass public transportation network. In this network, the new BRT-corridors will function as a basis to integrate the already existing system by reorganizing local buses, rationalizing the number of bus lines, and implementing a new trunk and feeder system. This will change the entire design of the mobility as well as its philosophy from an isolated towards an integrated view. All these measures represent adequate approaches towards a sustainable urban transport concept which would have never been implemented without the pacemaker effect of the sports events.

However, the biggest concern is the integration of this infrastructure measures into the urban development. There will be no institutionalized and integrated urban- and transportation planning process which enables short, medium and long-term planning processes and includes social-economic issues. Moreover, the new infrastructure will not be useful for all citizens because it mainly benefits the wealthy South zone instead of providing decent public transportation for the high populated North zone. Furthermore, the new BRT-system will not be able to reduce car usage because the projects include new road infrastructure for the automobile which will create even more automobile traffic demand. Hence, in the future it will be more and more difficult to rationalize the use of automobiles and provide a sufficient level of public transportation services, so that people do not migrate to private individual transportation.

In fact, the sports events will not be able to achieve an integrated sustainable urban transport concept for the megacity Rio de Janeiro because several challenges for the urban transportation sector remain unsolved: First, the sports events will not be able to ease social exclusion by means of the new mass public transportation system. Second, the true intention behind the BRT-system was to improve the road system, thus it does not entirely prioritize public transportation. Third, it does not reduce urban sprawl, rather promotes it by creating infrastructure in less developed areas with great distance to the city center.

However, it is the right time for this innovative process because of the currently ongoing process of the pacification of *favelas*, a higher income of the people, and the massive reformation of the city. In addition, there is a good relationship between the municipal, state and federal government and the mayor has the political acceptance. Likewise, the city has capable technicians at all involved institutions and they are wil-

ling to change the current situation which creates one of the best backgrounds of all World Cup host cities.

Hence, the sports events have the potential to initiate the first step towards a sustainable urban transport concept of Rio de Janeiro, but it will also depend on the right guidelines and principles from technicians and decision makers to plan and enforce a sustainable urban development and eventually improve the mobility for all people living in Rio de Janeiro.

5 CONCLUSIONS

In Brazilian megacities, the use of automobiles has dramatically increased, the public transportation sector is marked by severe problems, and non-motorized transportation modes cope with a poor infrastructure design. Hence, creative approaches are required to tackle current transport problems. In view of the World Cup in 2014 and the Olympic Games in 2016, the megacity Rio de Janeiro is going through an important change which offers a unique opportunity in order to ease the current situation and achieve an integrated sustainable urban transport concept.

Therefore, the objectives of this Diploma thesis were to create an overview on the current transport situation in large Brazilian cities, in particular for Rio de Janeiro; to provide integrated and sustainable approaches in order to tackle current transport problems of Rio de Janeiro, focusing on the reformation of its public transportation system and the promotion of non-motorized transportation; and to analyze the transferability of infrastructure measures between Curitiba and Rio de Janeiro.

Implemented in a top-down process, the literature review provided an overview of the relevant transport issues in Brazil, Rio de Janeiro and Curitiba. Furthermore, the conduction of expert interviews and its audio-based content analysis gave an insight into the current transport situation in large Brazilian cities, especially for Rio de Janeiro.

In order to achieve a sustainable development of the megacity Rio de Janeiro, the urban planning process must be integrated with transportation planning and executed by a metropolitan agency. Furthermore, an integrated metropolitan public transport network has to be created, designed and managed by a transport association, deriving from the state and municipal government. In addition, the local bus system has to be reorganized in three incremental steps by improving the quality of buses, expanding the new BRS-system, and rationalizing bus lines.

For the promotion of non-motorized transportation modes it is necessary to develop solutions neighborhood by neighborhood. Existing streets have to be redesign and new streets planned based on a sidewalk policy. Likewise, the condition of sidewalks has to be improved by ensuring a standard surface. Cycling infrastructure has to be implemented in regard to the local demands, incrementally building a comprehensive bicycle network. Moreover, cycling to train stations should be further promoted, in particular in the Western zones of the RMRJ.

The most important lessons for Rio de Janeiro – deriving from the Curitibian urban planning experience – are the prioritization of public transportation, the integration of urban- and transportation planning, and the interconnection of high density areas with mobility corridors. In addition, Curitiba's public transport system features innovative ideas which are useful for the reformation of Rio de Janeiro's local bus system.

Without doubt, the upcoming sports events are a historical moment in Rio de Janeiro's urban transportation history. Unfortunately, the new infrastructure measures do not arise from an internal planning process, rather because the city was forced by external interests. In fact, Rio de Janeiro's future mass public transportation system has the potential to become a comprehensive metropolitan mass public transportation network, but the megacity will not be able to achieve an integrated sustainable urban transport concept.

In conclusion, future transport measures have to focus on the mobility behavior of the middle class, while ensuring a needs-oriented mobility for all social classes. Decision makers should concentrate on the three “I's”: 1) Information which enables real transport mode choices through better information on public transportation, 2) Integration which facilitates sound and seamless travel by means of an integrated fare system as well as physical integration, and 3) Inclusion which attracts more people towards ecomobile transportation modes by means of awareness campaigns. Eventually, a paradigm shift towards ecomobility is needed in order to enable a sustainable urban transportation concept for today's and future generations.

However, this thesis has no claim to completeness. Further research should compare the findings deriving from this study with previously published research documents. Moreover, the city's fare system, institutional aspects of urban-and transportation planning in Rio de Janeiro as well as the actual mobility conditions of the people living in the suburban areas should be analyzed in detail. This could not have been achieved within the framework of this diploma thesis.

In addition, it is expedient to assess the consequences of the PNMU for Brazilian megacities and the upcoming PDTNM and PDTU for Rio de Janeiro. Eventually, future investigations should reveal the impact of the mobility crisis in large Brazilian cities in regard to environmental damage, air and noise pollution as well as psychological stress.

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ANNOTATION: Logo on front page adapted from http://www.freeclipartnow.com/transportation/traffic-signs/bus-symbol-black-01.jpg.html [Acessed: 06-09-2011]

APPENDICES

Sustainable urban transport approaches for Brazilian megacities – the examples of Rio de Janeiro and Curitiba

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A RIO DE JANEIRO

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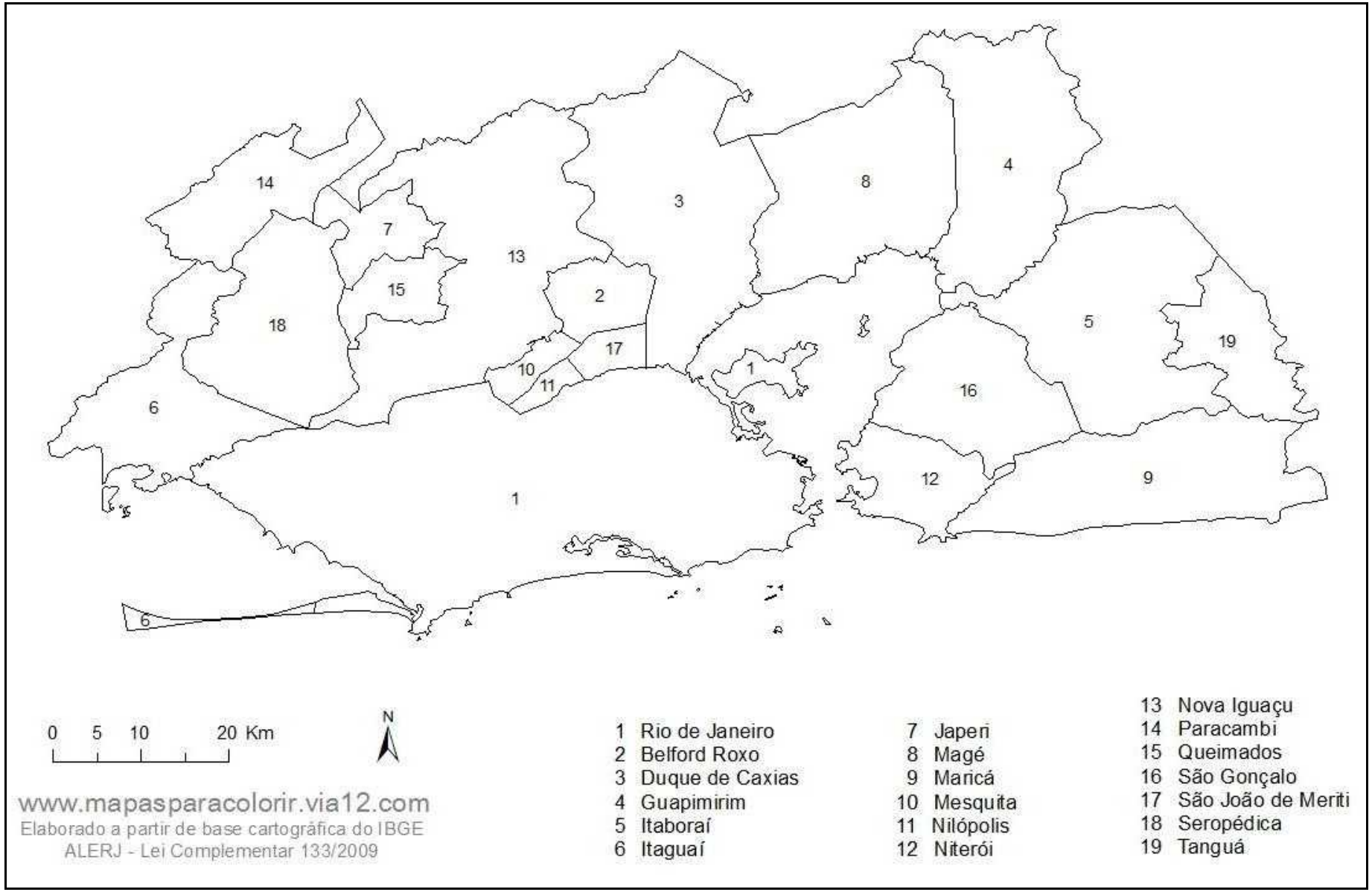
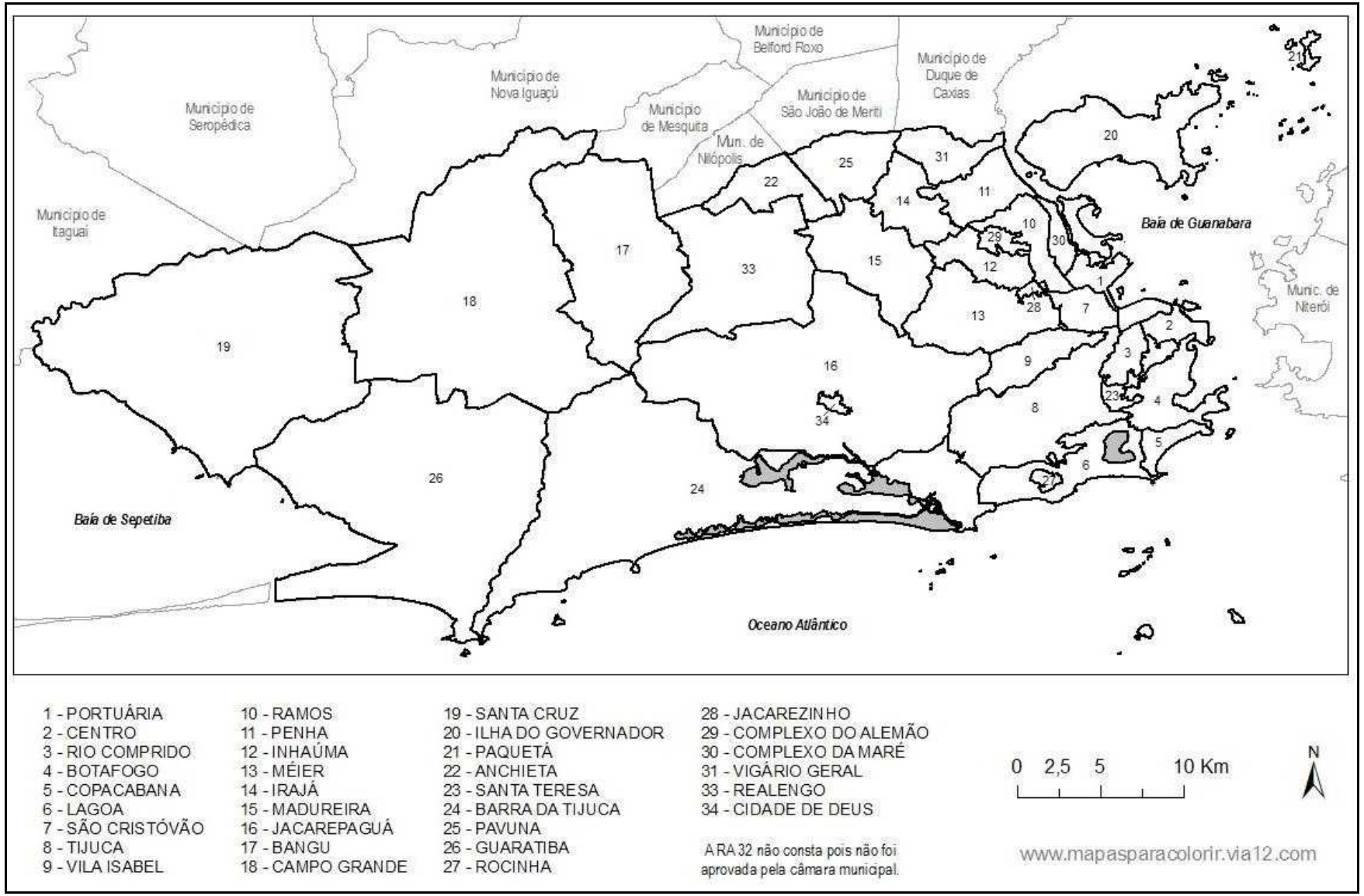


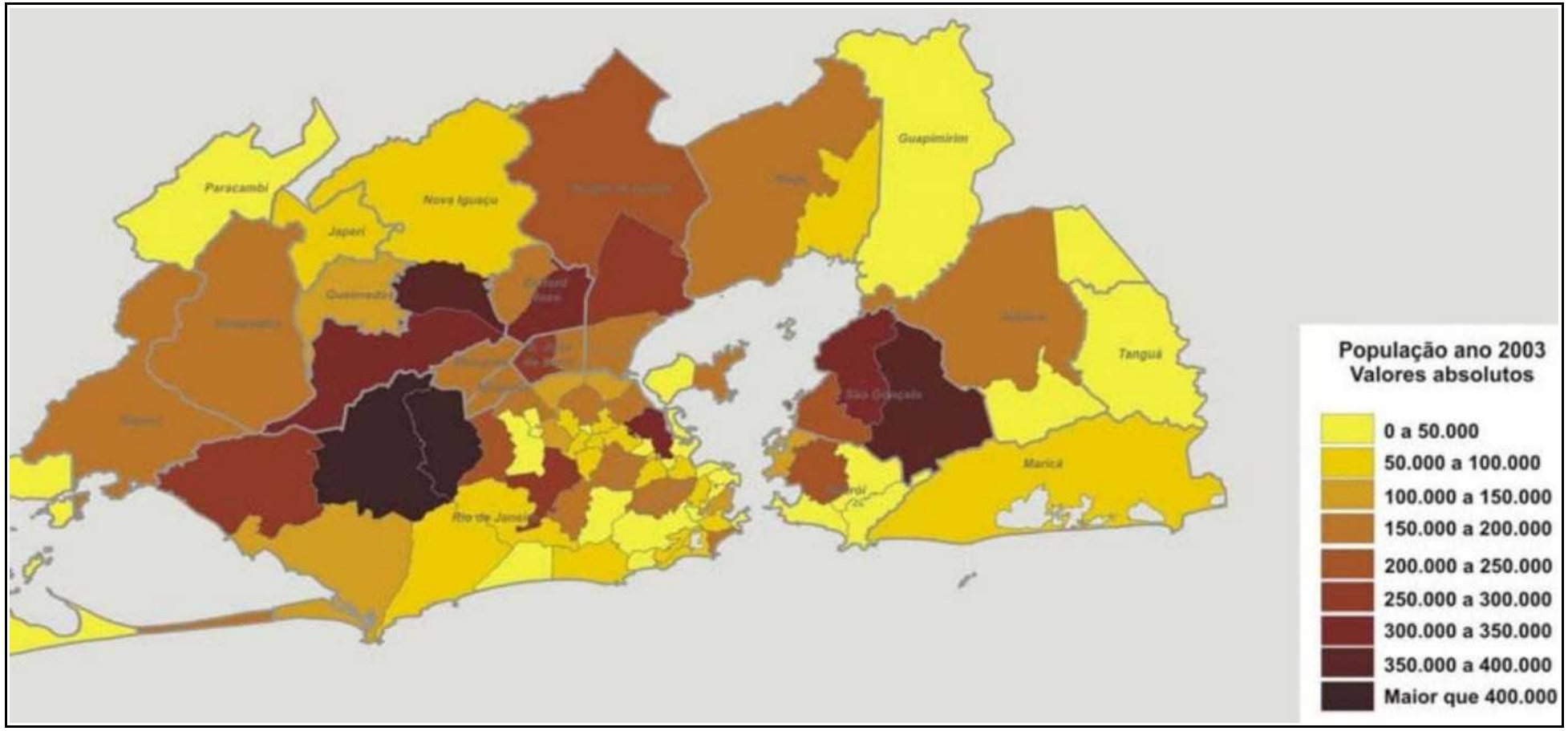
Source: [Mapas para Colorir 2011a]

A.II ADMINISTRATIVE REGIONS OF THE CITY OF RIO DE JANEIRO



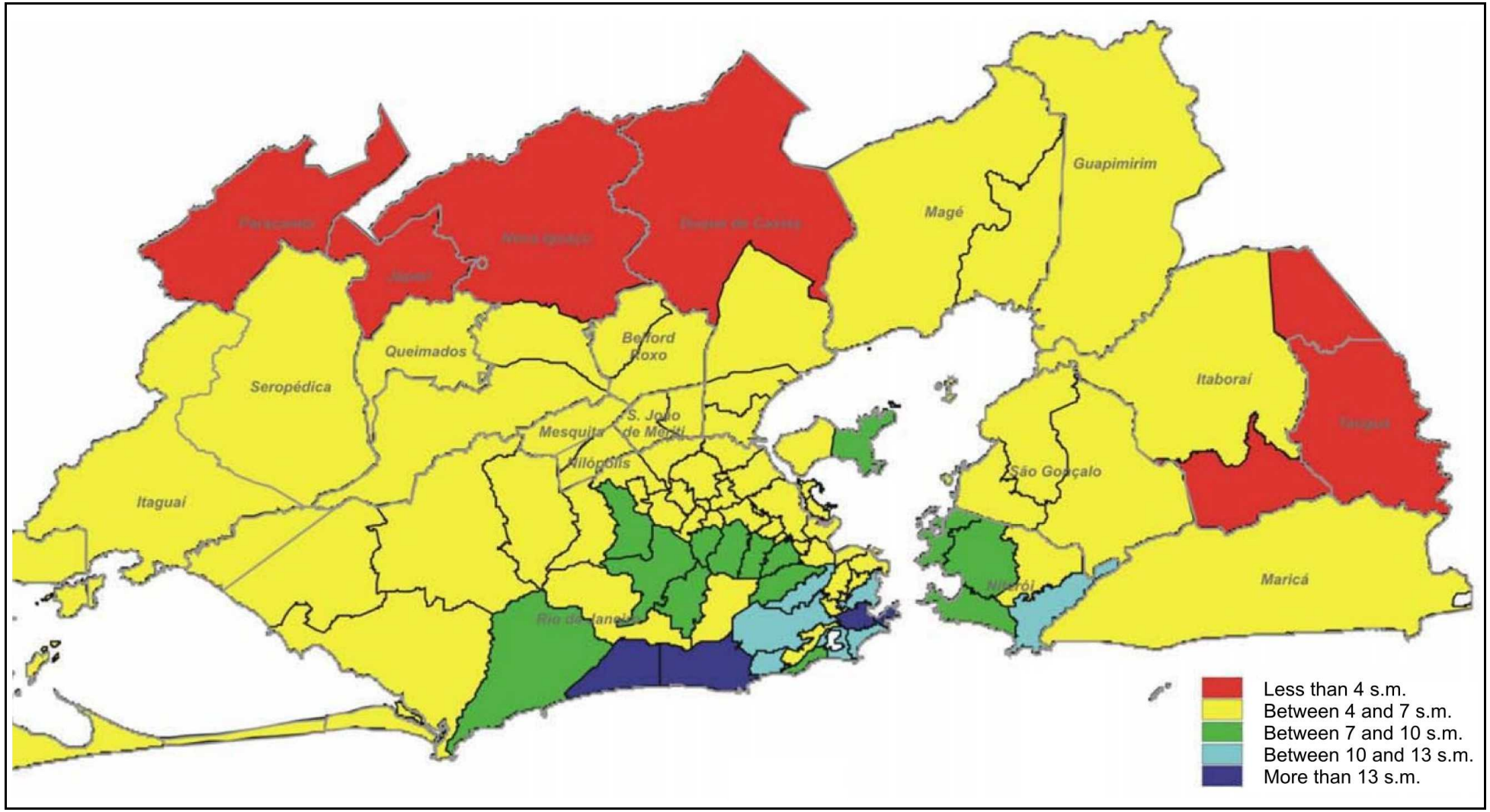
Source: [MAPAS PARA COLORIR 2011b]

A.III DISTRIBUTION OF POPULATION OF THE METROPOLITAN AREA OF RIO DE JANEIRO IN 2003



Source: [Governo do Estado do Rio de Janeiro 2005, P. 3–5]

A.IV AVERAGE INCOME IN MINIMUM WAGES



Source: Adapted from [Governo do Estado do Rio de Janeiro 2005, P. 3–20]; **Annotation:** Minimum wages (port.: Salario minimo (s.m.)) refers to the lowest monthly income

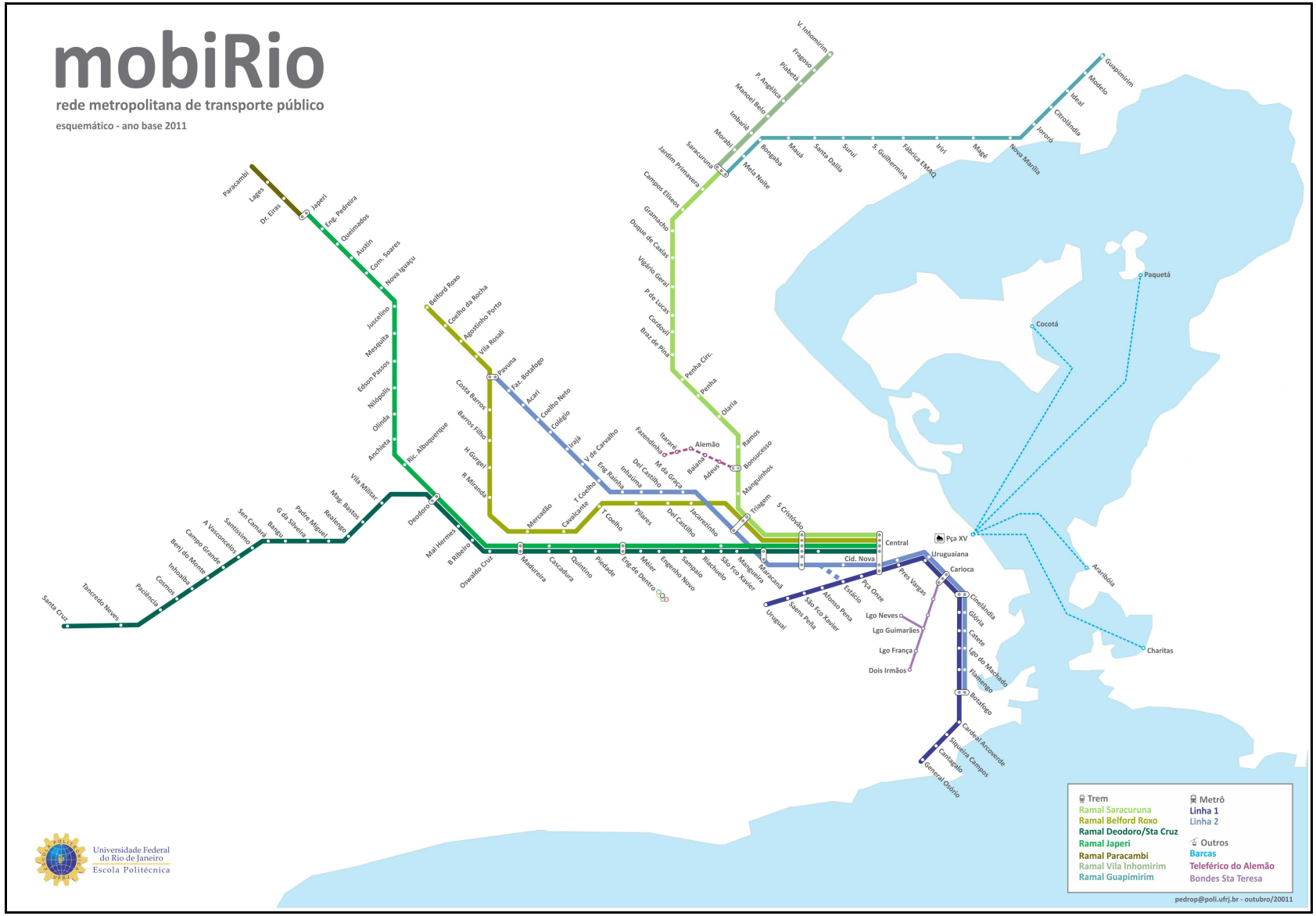
A.V TRANSPORT INFRASTRUCTURE OF THE METROPOLITAN AREA OF RIO DE JANEIRO

Source: Adapted from [Fundação CIDE]; **Annotation:** Due to changes of the size of the RMRJ (see Chapter 2.2.1), this map does not include all municipalities. Thus, it gives a very good overview of the existing transport network.

A.VI MAJOR METROPOLITAN TRANSPORT CORRIDORS

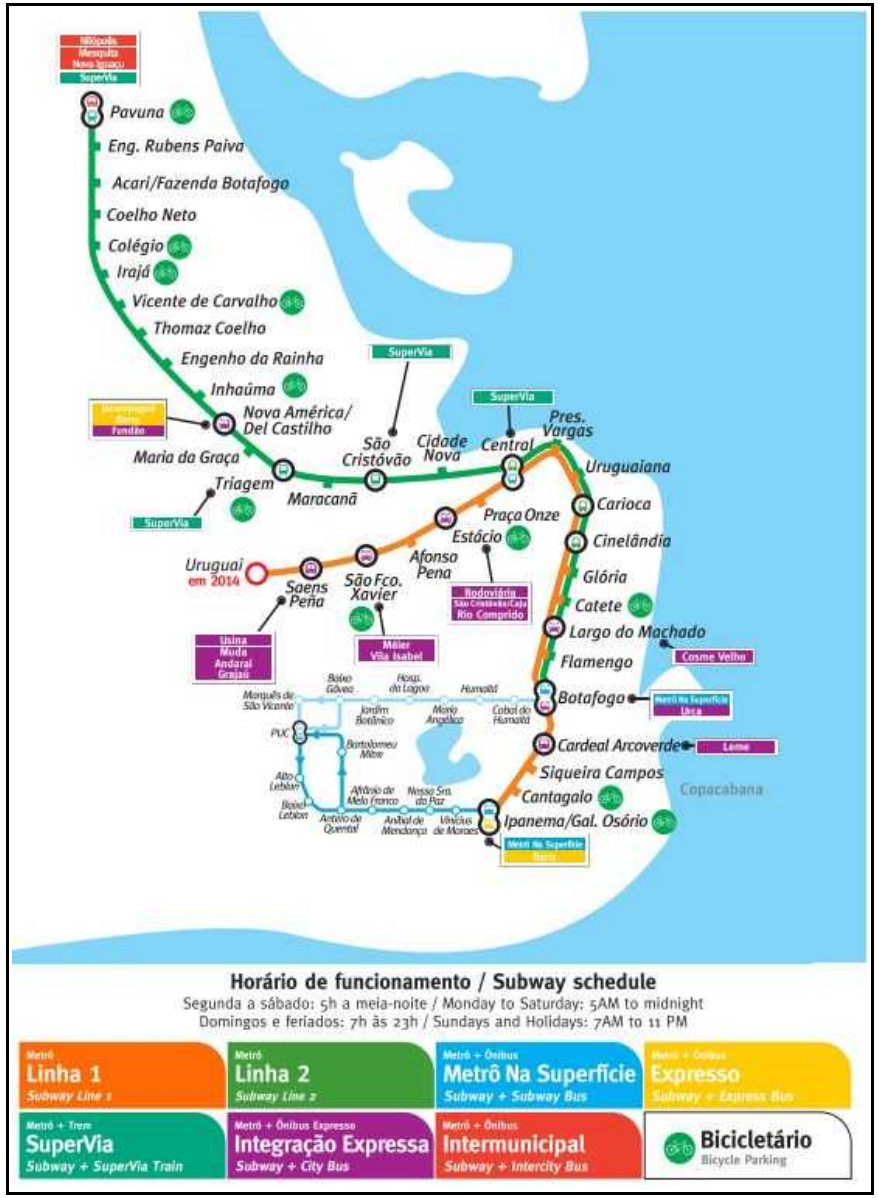
Source: [GOVERNO DO ESTADO DO RIO DE JANEIRO 2005, P. 2–19]

A.VII METROPOLITAN PUBLIC TRANSPORT NETWORK OF RIO DE JANEIRO (2011)



Source: [SOUZA 2012], Online version available at http://mobirio.poli.ufrj.br/; **Annotation:** This map does not include the local and inter-municipal bus system, the alternative transport system and other public transport modes

A.VIII METRO NETWORK OF RIO DE JANEIRO



Source: [METRÔRIO 2012]

A.IX RAIL SYSTEM OF THE REGIÃO METROPOLITANA DO RIO DE JANEIRO

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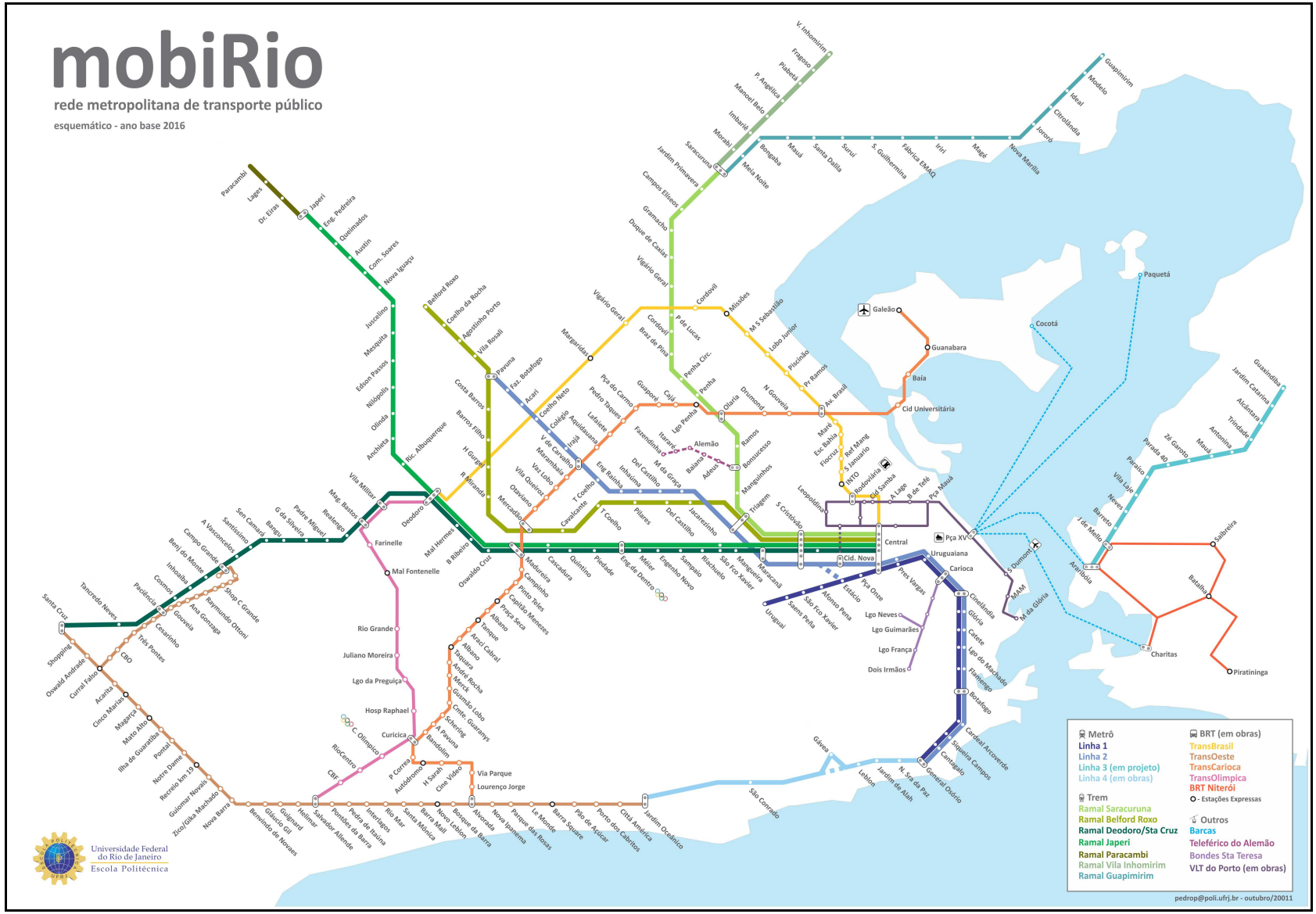
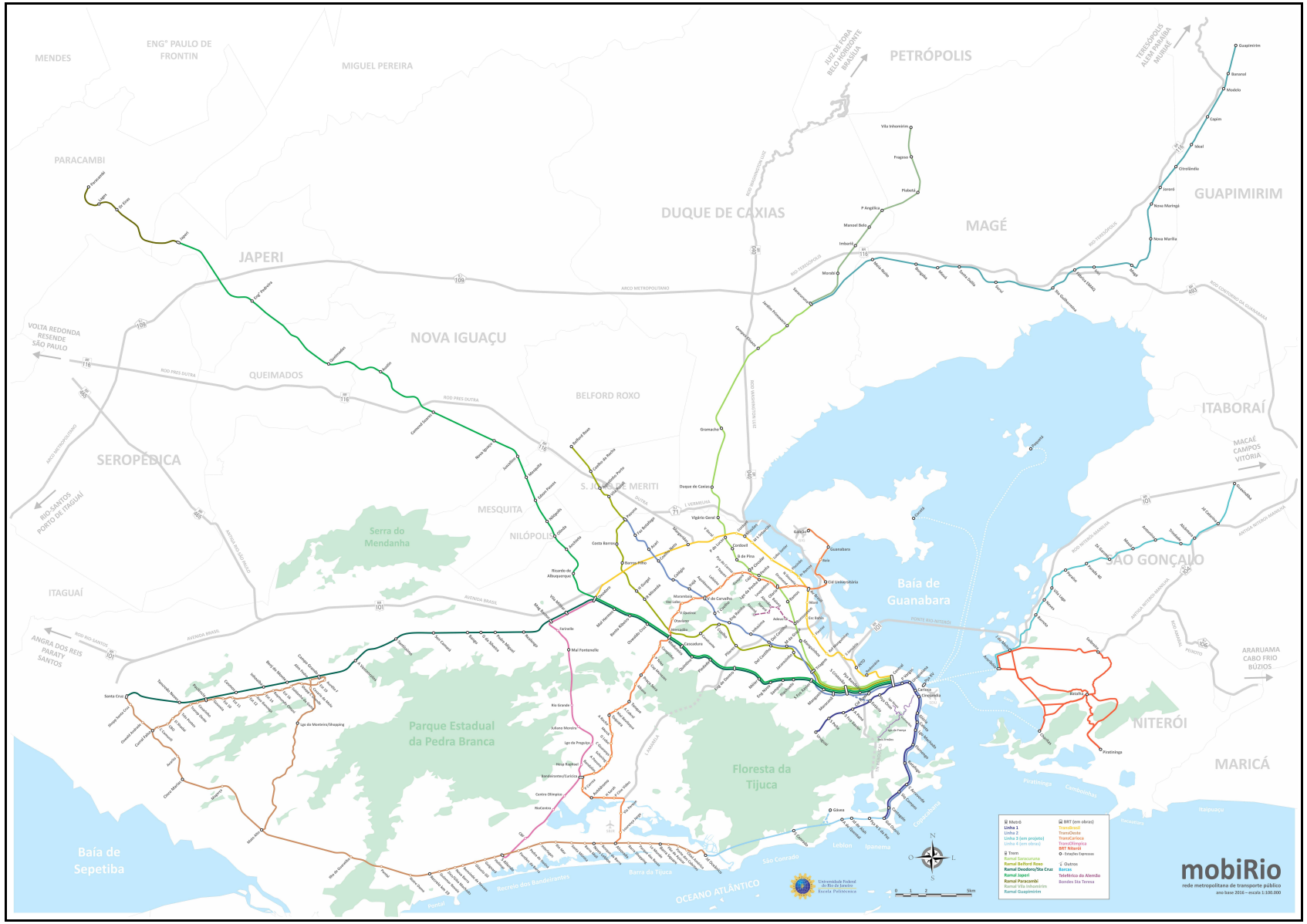
A.XI METROPOLITAN PUBLIC TRANSPORT NETWORK OF RIO DE JANEIRO (2016) - SCHEMATIC



Source: [SOUZA 2012], Online version available at http://mobirio.poli.ufrj.br/; **Annotation:** This map does not include the local and inter-municipal bus system, the alternative transport system and other public transport modes.

A.XII METROPOLITAN PUBLIC TRANSPORT NETWORK OF RIO DE JANEIRO (2016) – GEOGRAPHIC

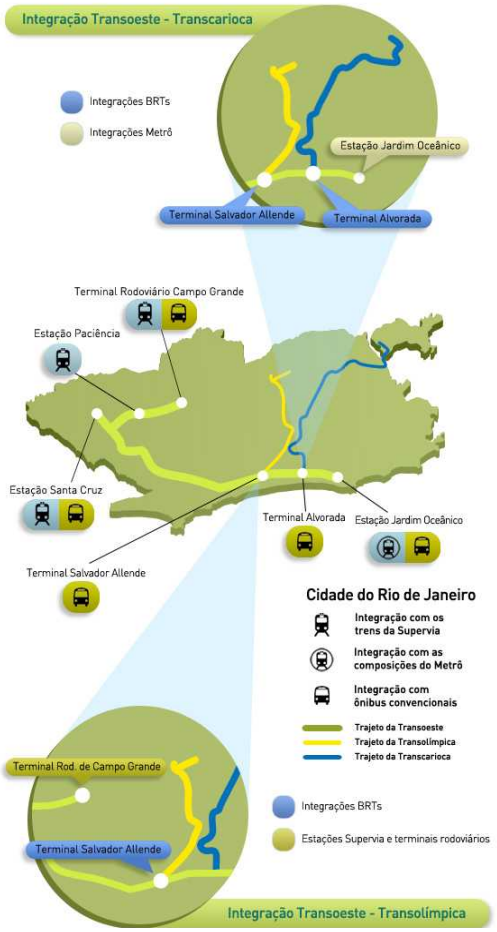


Source: [SOUZA 2012], Online version available at http://mobirio.poli.ufrj.br/;

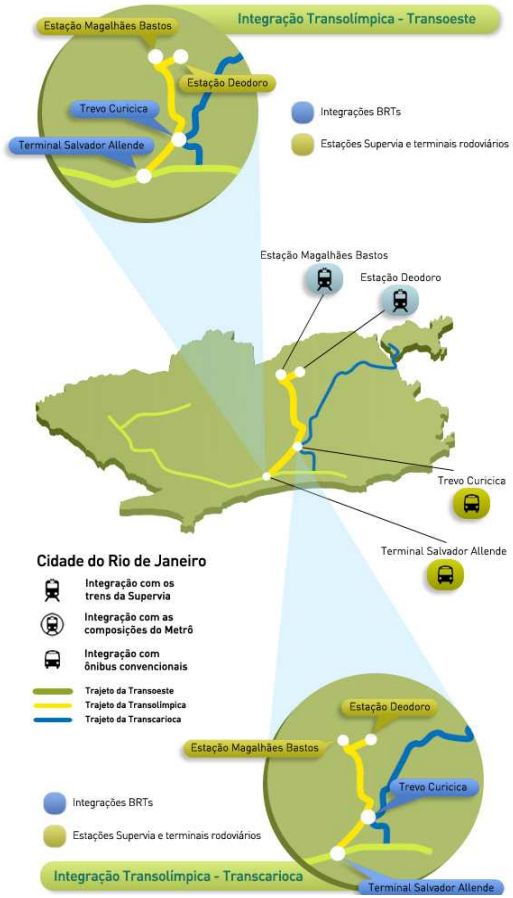
A.XIII BRT SYSTEM

TRANSCARIOCA

TRANSOESTE



TRANSOLÍMPICA



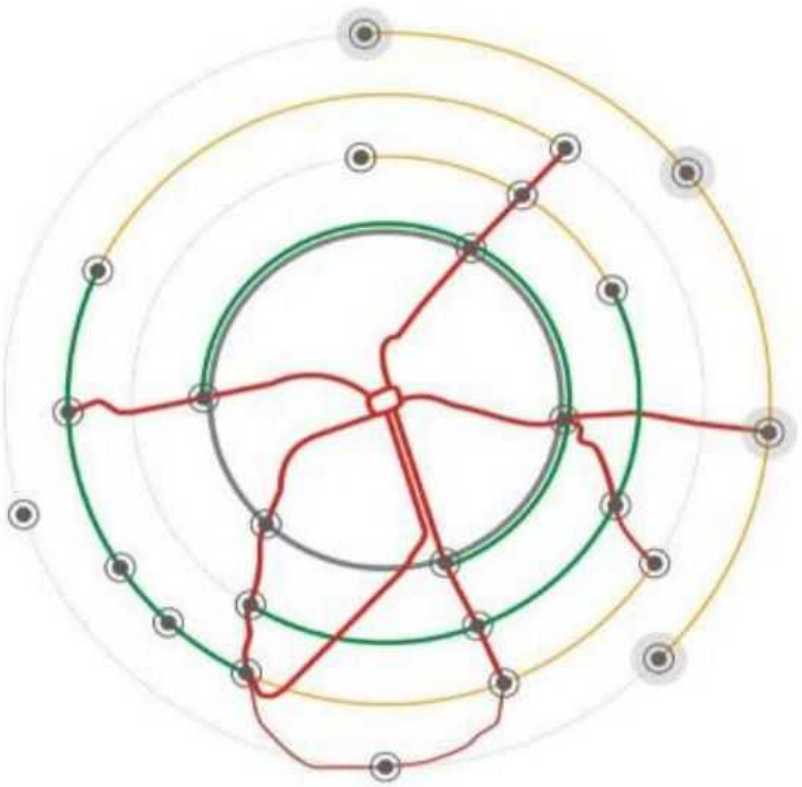
Source: [MOBIRIO]

A.XIV LIGHT RAIL TRANSIT NETWORK

Source: [CDURP]

B CURITIBA

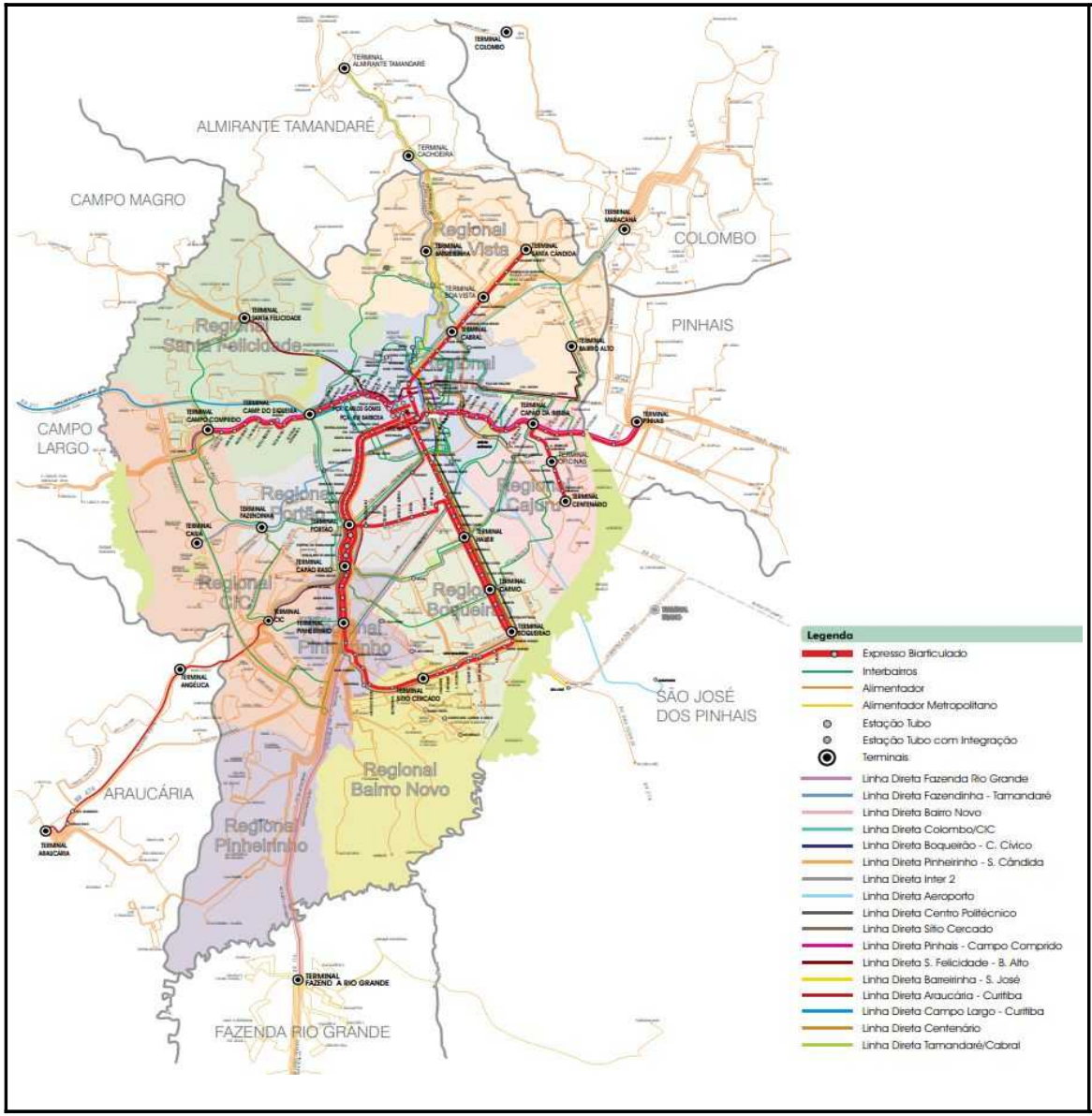
B.I SCHEME OF INTEGRATED TRANSPORTATION NETWORK AND BUS HIERARCHY

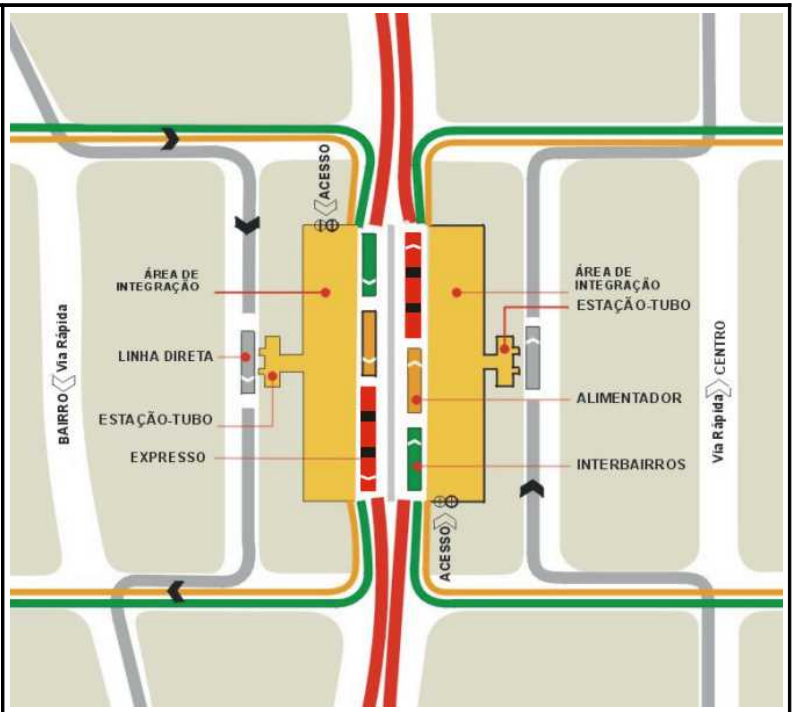


LINE TYPES	VEHICLE	CAPACITY
LIGEIRÃO EXPRESS	BIARTICULATED	250
EXPRESS LINE	BIARTICULATED	230
	ARTICULATED	170
DIRECT LINE	ARTICULATED	150
	PADRON	110
INTERDISTRICT LINE	ARTICULATED	140
	PADRON	100
FEEDER LINE	ARTICULATED	140
	COMMON	85
	SPECIAL MICROBUS	70

Source: {Santos Ramos 12.12.2011 #574}

B.II INTEGRATED TRANSPORTATION NETWORK IN 2006 AND EXAMPLE OF INTEGRATED TERMINAL





Source: {Instituto de Pesquisa e Planejamento Urbano de Curitiba 2009 #511: 209}

Source: {Santos Ramos 12.12.2011 #574}

B.III THE GREEN LINE

Source: [RAMOS 2011]

Source: M.Kiepsch, 12/2011

C EXPERT INTERVIEWS

C.I INTERVIEWGUIDE

BACKGROUND

TOPIC	Sustainable urban transport approaches for Brazilian megacities - the examples of Rio de Janeiro and Curitiba.
RESULT	A diploma thesis analyzing the current situation and providing suitable approaches to tackle recent transport problems
RESEARCH QUESTION	What are the most eligible approaches for tackling current transport problems in Brazilian megacities ?
METHOD	Structured interviews with stakeholders in urban- and transportation planning (representatives of PT, municipality, Ministry of Cities, researchers, World Cup infrastructure measures, bicycle experts)
OBJECTIVES	Create an overview (baseline study) of the current transport situation of Curitiba and Rio de Janeiro for decision makers, researchers and international organizations.
	Identify main transport problems > Find integrated solutions regarding all transport modes.
	Research on transferability of measures in between Rio de Janeiro and Curitiba, as a model city.
	Give recommendations on tackling transport problems, reformation of the public transport system and promotion of ecomobility.

INTRODUCTION

INFORMATION

PLACE		
DATE		
TIMEFRAME	START	END

PERSONAL DETAILS

NAME		
COMPANY		
POSITION		
FURTHER INFORMATION		
RECORDING	YES	NO

INITIAL QUESTIONS

1	E	How do you go to work every day?
	D	Wie kommen sie jeden Tag zur Arbeit?
	P	Como você vai ao trabalho todos os dias?
2	E	What mode of transport would you prefer?
	D	Welches Verkehrsmittel würden sie bevorzugen?
	P	Qual meio de transporte você usaria em vez de usar …. ?
3	E	Why are you not using it?
	D	Warum nutzen sie es nicht?
	P	Porque que você não usa - lo?

1. CURRENT DEVELOPMENT

1	E	What are the main transport problems in your city?
	D	Welches sind die größten Verkehrsprobleme in ihrer Stadt?
	P	Quais são os grandes problemas de transporte na sua cidade?
2	E	How can these transport problems be solved?
	D	Wie können diese Verkehrsprobleme gelöst werden?
	P	Como que eles podem ser resolvidos?
3	E	How can the rising demand for motorized transportation be reduced?
	D	Wie can die steigende Nachfrage nach motorisiertem Individualverkehr reduziert werden?
	P	Como que a grande demanda para o transporte motorizado pode ser reduzido?
4	E	What are the reason for this existing development?
	D	Was sind die Gründe für die bestehende Entwicklung?
	P	Quais são as razões desse desenvolvimento existente?
5	E	How did the city / municipality react?
	D	Wie haben die Städte auf die vorherrschende Situation reagiert?
	P	Como que a cidade reagiu?
6	E	And where do these problems occur?
	D	Wo treten Verkehrsprobleme in beiden Großstädten auf?
	P	A onde os occorrem?

2. SPORTS EVENTS

1	E	What potential do the currently build infrastructure measures (WC 2014 / Olympia 2016) have to solve transportation problems?
	D	Welches Potential haben die momentan in Rio de Janeiro geschaffenen Verkehrsinfrastrukturmaßnahmen (WM 2014 / Olympia 2016) zur Lösung der Verkehrsprobleme?
	P	Qual é o potencial das novas medidas de infraestrutura para solver os problemas de transporte?
2	E	What are the benefits for the people?
	D	Welche Vor- und Nachteile für die Bevölkerung?
	P	Quais são os beneficios pelo povo?
3	E	What happens after the World Cup and Olympia?
	D	Was passiert nach der Weltmeisterschaft?
	P	O que acontece depois da copa?
4	E	Are the infrastructure measures which are currently constructed for the World Cup 2014 / Olympia 2016 new approaches or have they been planned in advance (PAC)?
	D	Sind diese neu entstehenden Infrastrukturprojekte neue Ansätze oder bereits länger geplant?
	P	Os novos medidas de infraestrutura são novos projetos ou foram planejados antes?

3. TRANSFERABILITY

1	E	What modules of CTBA's transport concept can be transferred to Rio de Janeiro?
	D	Welche Bausteine aus dem Verkehrskonzept von CTBA können auf Rio de Janeiro übertragen werden?
	P	Quais módulos do conceito de CTBA no de transporte podem ser transferido para o Rio de Janeiro?
2	E	What can Rio de Janeiro <> CTBA learn from CTBA <> Rio de Janeiro? (infrastructure measures)
	D	Was kann Rio de Janeiro von CTBA lernen? (und andersrum)
	P	O que é que o Rio de Janeiro pode aprender de CTBA?
3	E	How can these measures transferred successfully to Rio
	D	Wie gelingt die Übertragbarkeit von Lösungsstrategien nach Rio?
	P	Como que essas medidas podem ser transmitidos para o Rio?
4	E	What does Rio de Janeiro has to do to reach CTBA's standard?
	D	Was muss Rio machen, um den CTBA Standard zu erreichen?
	P	O que o Rio de Janeiro tem que fazer, para alcançar ao mesmo padrão como CTBA?
5	E	Why didn't Rio de Janeiro manage to profit earlier from the Brazilian experience made in CTBA?
	D	Warum hat es Rio de Janeiro nicht früher geschafft von dem Wissen von CTBA zu profitieren?
	P	Porque o Rio de Janeiro não consegui aproveitar do conhecimento Curitbano?
6	E	How can CTBA continue to be a model city?
	D	Wie wird CTBA in Zukunft "cidade modelo“ bleiben?
	P	Como que CTBA pode continuar ser a cidade modelo?

4. REFORMATION OF THE PUBLIC TRANSPORT SYSTEM

1	E	What can be done to accelerate / improve public transport? (BRT 2.0)
	D	Was kann getan werden, um den ÖPNV zu beschleunigen / verbessern?
	P	O que pode ser feito para acelerar / melhorar o transporte publico?
2	E	How can Brazilian megacities reform their PT system to reduce the rising demand for motorized transportation?
	D	Wie können brasilianische Großstädte ihr ÖPNV System gestalten, um der steigenden Nachfrage des MIV entgegenzuwirken?
	P	Como que as megacidades brasileiras podem reformar o seu sistema de transporte publico para reduzir a grande demanda para o transporte motorizado?
3	E	Why do not exist timetables / integrated PT route maps at PT stops?
	D	Warum gibt es keine Fahrpläne (Abfahrtszeiten) / Netzpläne an den Haltestellen?
	P	Porque que não existem itinerários / rede de rotas planos nos pontos do ônibus?
4	E	Why does not exist a fully integrated ticketing system which enables citizens to change freely in between the different transport modes?
	D	Warum existiert kein völlig integriertes Ticketsystem, das den Bürgern ermöglicht verschiedene Verkehrsmitteln während einer Fahrt zu benutzen ohne erneut zu bezahlen?
	P	Porque que não existe um bilhete único que possibilita a integração entre os diferentes modos de transporte numa viagem?
5	E	What is the role of the informal transport?
	D	Wie schätzen sie die Rolle des informellen Verkehrs ein?
	P	Qual é o papel do transporte informal (vans)?

4. REFORMATION OF THE PUBLIC TRANSPORT SYSTEM

ADDITIONAL QUESTIONS > PT		
6	E	Does exist a negative image of PT in Brazilian culture?
	D	Existiert ein negatives ÖPNV Image innerhalb der brasilianischen Gesellschaft
	P	Existe uma imagem negativa do transporte publico no Brasil?
7	E	Do you believe that buses blocking each other causes a bad reputation of PT?
	D	Glauben sie, dass sich gegenseitig behindernde Busse einen schlechten Ruf erzeugen?
	P	Você acredita que os ônibus que bloqueiam um do outro criam uma reputação negativa do TP?
8	E	What potentials do cable cars have in Rio de Janeiro?
	D	Welches Potential haben Lifte in Rio de Janeiro?
	P	Qual é o potencial do teleférico no Rio de Janeiro?
ADDITIONAL QUESTIONS > BRT		
9	E	How can isolate applications be avoided, when constructing a new BRT system
	D	Wie können bei Einführung eines BRT System Insellösungen vermieden werden?
	P	Como que soluções isoladas podem ser evitados na implementação do projeto?
10	E	Why did Rio implemented a BRT-system only now, almost 40 years (1974) after its creation in CTBA?
	D	Warum kommt das BRT-System erst jetzt, 40 Jahre nach seiner Implementierung in CTBA (1974), nach Rio übertragen werden?
	P	Porque foi implementado um sistema de BRT no Rio de Janeiro tão tarde (40 anos depois de CTBA)?

4. REFORMATION OF THE PUBLIC TRANSPORT SYSTEM

11	E	What will there be after BRT?
	D	Was kommt nach dem BRT?
	P	O que vai chegar depois do BRT?
12	E	What would be a good name for a new BRT-system?
	D	Was wäre ein guter Name für einen BRT?
	P	Qual seja um bom nome para um novo sistema de BRT?
ADDITIONAL QUESTIONS > INFORMATION		
13	E	How should a PT route map be designed, so that Brazilians will understand it?
	D	Wie sollte ein Liniennetzplan aussehen, damit sie Brasilianer auch verstehen?
	P	Como que um mapa do transporte publico seja desenhado, para que os Brasilieros o entendem?
14	E	Does a PT route map already exist for Rio de Janeiro (draft)?
	D	Gibt es schon einen ÖPNV - Liniennetzplan in Rio (Entwurf)?
	P	Existem um mapa intergrado do transporte publico no Rio?
14	E	What transport links are most important for the World Cup and Olympic Games?
	D	Welche Verkehrsbeziehungen sind die wichtigsten für die WM und Olympia?
	P	Quais ligações de transporte dentro da cidade são importantes pela Copa & Olimpiadas?
15	E	What IT – systems are suitable to inform Brazilians?
	D	Welche IT – Systeme sind geeignet, um Brasilianer zu informieren?
	P	Quais sistemas inteligentes de transporte servem para informar os Brasilieros?

5. PROMOTE WALKING & CYCLING (NMT)

1	E	What projects were realized recently which are improving the situation for NMT?
	D	Welche Projekte wurden kürzlich realisiert, die die Situation für den NMIV verbessern?
	P	Quais projetos foram realizados recentemente, que melhoram a situação para TNM?
2	E	How should bicycle infrastructure be designed, so that cycling will be more accepted by Brazilians?
	D	Wie sollte Radverkehrsinfrastruktur gestaltet werden, damit das Radfahren von Brasilianern besser akzeptiert wird?
	P	Como que a infraestrutura de bicicleta deveria ser redesenhado, para que os Brasileiros aceitam melhor?
3	E	How could the allocation of urban space be redesigned to promote NMT?
	D	Wie könnte der städtische Raum umgestaltet werden, um NMIV zu fördern?
	P	Como que o espaço urbano pode ser redesenhado, para promover o TNM?
4	E	Which social groups would benefit from an NMT plan?
	D	Welche sozialen Gruppen profitieren von einem NMIV Plan?
	P	Quais grupos sociais aproveitam de um plano TNM?
5	E	What were the impacts of these projects?
	D	Was sind die Auswirkungen dieser Projekte?
	P	Quais são os impactos desses projetos?
6	E	What were the main factors to make it happen?
	D	Was waren die Hauptfaktoren, die dies möglich gemacht haben?
	P	Quais são os principais fatores para realiza-los?

5. PROMOTE WALKING & CYCLING (NMT)

7	E	Does noise- and air pollution interfere with NMT?
	D	Beeinflussen Lärm und Abgasbelastung den NMIV?
	P	A poluição sonora e as gases de escapamento interferem com o TNM?
8	E	Is NMT considered to be a safe and reliable mode of transport?
	D	Wird der NMIV als sicher und zuverlässig betrachtet?
	P	O TNM está considerado seguro e fiel?
9	E	Is the image of cycling a barrier for decision makers?
	D	Ist der Ruf des Radfahrens ein Problem für Entscheidungsträger?
	P	A reputação dos ciclistas é uma barreira pelas tomadores de decisões?
10	E	If so, how can a positive image be created?
	D	Wenn dem so ist, wie kann ein positives Image erzeugt werden?
	P	Como que uma imagem positiva pode ser criado?
11	E	What potential do pedelecs (Electric bicycle) have to foster NMT in Brazil?
	D	Welches Potential haben pedelecs zur Förderung des NMIV?
	P	Qual é o potencial dos pedelecs no Brasil para promover o TNM?
12	E	How important is walking in Brazilian society?
	D	Wie wichtig ist der Fußverkehr in der brasiliansichen Gesellschaft?
	P	Qual é a importancia de ir a pé na sociedade brasileira?
13	E	What can be done to promote NMT in RIO / CTBA?
	D	Was kann zur Förderung des NMT in Rio und CTBA getan werden?
	P	O que q pode ser feito para promover o NMT no Rio / CBTA?

6. FUTURE MOBILITY ISSUES

1	E	What are five main challenges in urban transport in the next 10 years?
	D	Was sind die fünf größten Herausforderungen des Stadtverkehrs in den nächsten 10 Jahren?
	P	Quais são os grandes desafios do transporte urbano nos próximos 10 anos?
2	E	How do you wish to go to work in 10 or 20 years?
	D	Wie wünschen sie sich in 10 oder 20 Jahren zur Arbeit zu fahren?
	P	Como que você gostaria de ir ao trabalho em 10 or 20 anos?
3	E	Will you use your favorite mode of transport by then?
	D	Werden sie ihr Lieblingsverkehrsmittel nutzen?
	P	Você vai usar o seu modo de transporte preferido?

LEGEND

☐ Primary questions of each topic

E Englisch

D German

P Portuguese

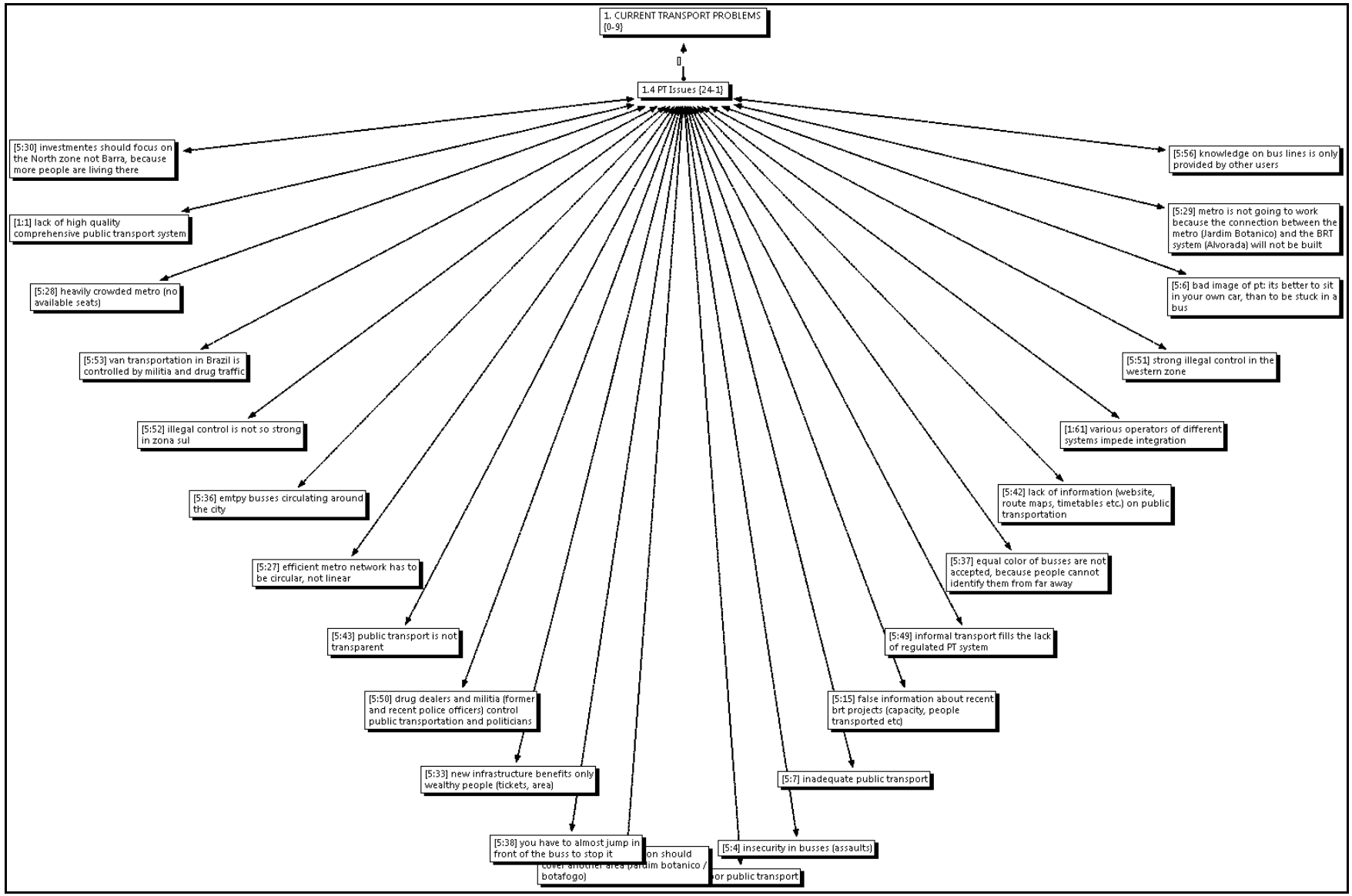
C.II EXPERT INTERVIEW DATA

EV	FOCUS GROUP	NAME	COMPANY	POSITION	FURTHER INFORMATION (SELECTION)	DATE	PLACE	TIME
xxx	Activists	Cecilia Herzog	INVERDE	President	> 2002 – present Landscape designer > 2005 Post Graduate Program in Urban Planning (UFRJ) > Member of the Intern.Association for Landscape Ecology	23.11. 2011	RJ, Parque Lage, Cafe	50 min
xxx	Bicycle specialists	José Lobo	Transporte Ativo	President	> 1992 – present Active in bicycle planning issues in RJ > 2003 – present Founder and President and of TA	22.11. 2011	RJ, Apartment	40 min
xxx	International experts	Alberto Paranhos	UN-HABITAT IPPUC	Consultant	> 1975 – 1982 Manager of IPPUC > 1884 – 1988 Consultant for World Bank, GTZ > 1993 – 2010 UN-Habitat senior staff	07.12. 2011	CTBA, Cafe in the city center	80 min
xxx	International experts	Jonas Hagen	GIZ, Transporte Ativo	Consultant	> 2011 – present Independent consultant (GIZ, TA) > 2007 – 2011 Deputy Country Director for ITDP > 2005 – 2006 Project Head of Regional Capacity Building Seminar on Sustainable Transport and BRT, Montevideo	31.10. 2011	RJ, Café in Ipane-ma	60 min
xxx	Public Transport representatives	Marcos Bicalho	ANTP	Superinten-dent	> Architect / urban- and transport planner since the 1980's > 2001 – 2004 Secretary of transportation in Campinas > 2005 – present 50% Consultant / 50% Superintendent at ANTP	18.11. 2011	SP, ANTP, Office	70 min
xxx	Researchers	Eva Vider	UFRJ	Professor	> Professor at DET / UFRJ (Urban transportation / Transport economics)	27.10. 2011	RJ, DET,Office	60 min
xxx	Researchers	Ronaldo Balassiano	UFRJ	Professor	> 1992 – 1995 Doctorate in Transport Engineering; University of Westminster; Titel: The Future of the Urban Bus (1995) > 1996 – present Professor at COPPE/UFRJ (Transport Eng.) > 2009 – 2010 President of ITDP Brazil	16.11. 2011	RJ, COPPE, Office	50 min
xx	Architects and engineers	Alceu Carnieri	C & C Consultoria Arq. e Plan.	Architect	> 1969 Graduation in urban transportation, UFPR > Former professor at UFPR (urban transport planning) > Project coordinator at IPPUC	28.11. 2011	CTBA, C. Com. Italia, Office	70 min
xx	Architects and engineers	Fernanda Salles	Fernanda Salles Arquitetura	Architect	> Arquitect and Urban planner – over ten years experience on reha-bilitation projects of slums (Santa Marta, Rio Cidade) > Former president of the ASBEA-RJ	10.11. 2011	RJ, Branch office, Meeting room	60 min
xx	Architects and engineers	Garrone Reck	Logitrans	Manager	> 1983 Master in Transportation Engineering (COPPE/UFRJ) > 1986 – 1988 Manager of URBS from > Former manager of COMEC (Metropolitan Transportation)	02.12. 2011	CTBA, Logitrans, Office	55 min

EV	FOCUS GROUP	NAME	COMPANY	POSITION	FURTHER INFORMATION (SELECTION)	DATE	PLACE	TIME
xx	Bicycle specialists	Reginaldo Paiva	ANTP	President of Bicycle commission	> Head of the Instituto de Engenharia (NGO) > Employee at Transportation planning management of CPTM	17.11. 2011	SP, CPTM, Meeting room	65 min
xx	Government representatives	Freddy Casquero	SETRANS	Non-Motorized Transport Advisor	> 1992 NMT Plan in Lima, Peru > 2008 – present Advisor for NMT at SETRANS > Post graduate studies in public transportation at UCT	14.11. 2011	RJ, SETRANS, Terrace	70 min
xx	Government representatives	Marcos Tognozzi	SMTR	Coordinator of Regional Transport	> Transport inspector in the city center for 2 years > 2007 – present working at SMTR > 2010 – present Regional Coordinator of Transportation of the planning area 5 (AP5) West Zone	23.11. 2011	RJ, SMTR, Meeting room	45 min
xx	Public Transport representatives	Luiz Filla	URBS	Operation Manager of PT	> Since 1979 working with public transportation issues > Since 1986 working in the sector of inspection and operation of the public transport system	05.12. 2011	CTBA, URBS, Auditorium	40 min
xx	Public Transport representatives	Rogério Belda	Metrô de São Paulo	Technical Assistant	> Former planning director of the Companhia do Metrô de SP > Board Member and former president of the ANTP > Lecturer at the Government school in São Paulo (urban policies)	17.11. 2011	SP, Cafe in the city center	25 min
xx	Researchers	Ricardo Esteves	UFRJ	Professor	> Architect, specialized in Urban and Regional Planning, > 2002 – present Professor at FAU/UFRJ (urban transportation) > Consultant for Urban Mobility and Urban Master Plans	21.11. 2011	RJ, Bennett, Cafe	60 min
x	Bicycle specialists	Ricardo Correia	TC URBES	Consultant	> Master in urban planning with focus on transport (USP) > Founder and employee of TC URBES	17.11. 2011	SP, TCURBES, Lounge	35 min
x	Government representatives	Henrique Torres	CET-RIO	Engineer	> Mass public transport plan for Rio de Janeiro (IPP) > 2002 – present Engineer at CET-RIO (Management of PT)	23.11. 2011	RJ, CET RIO, Office	20 min
x	International experts	Frederic Saliez	UN-HABITAT, ROLAC	Official of Human Settlements	> Architect / Engineer	03.11. 2011	RJ, Laranjeiras, Square	40 min
x	Researchers	Romulo Orrico	UFRJ	Professor	> Under Secretary of Transportation of the City, SECTRAN > Vice President of the ANTP > 1979 – present Professor at COPPE/UFRJ (Transport Eng.)	03.11. 2011	RJ, COPPE, Office	45 min

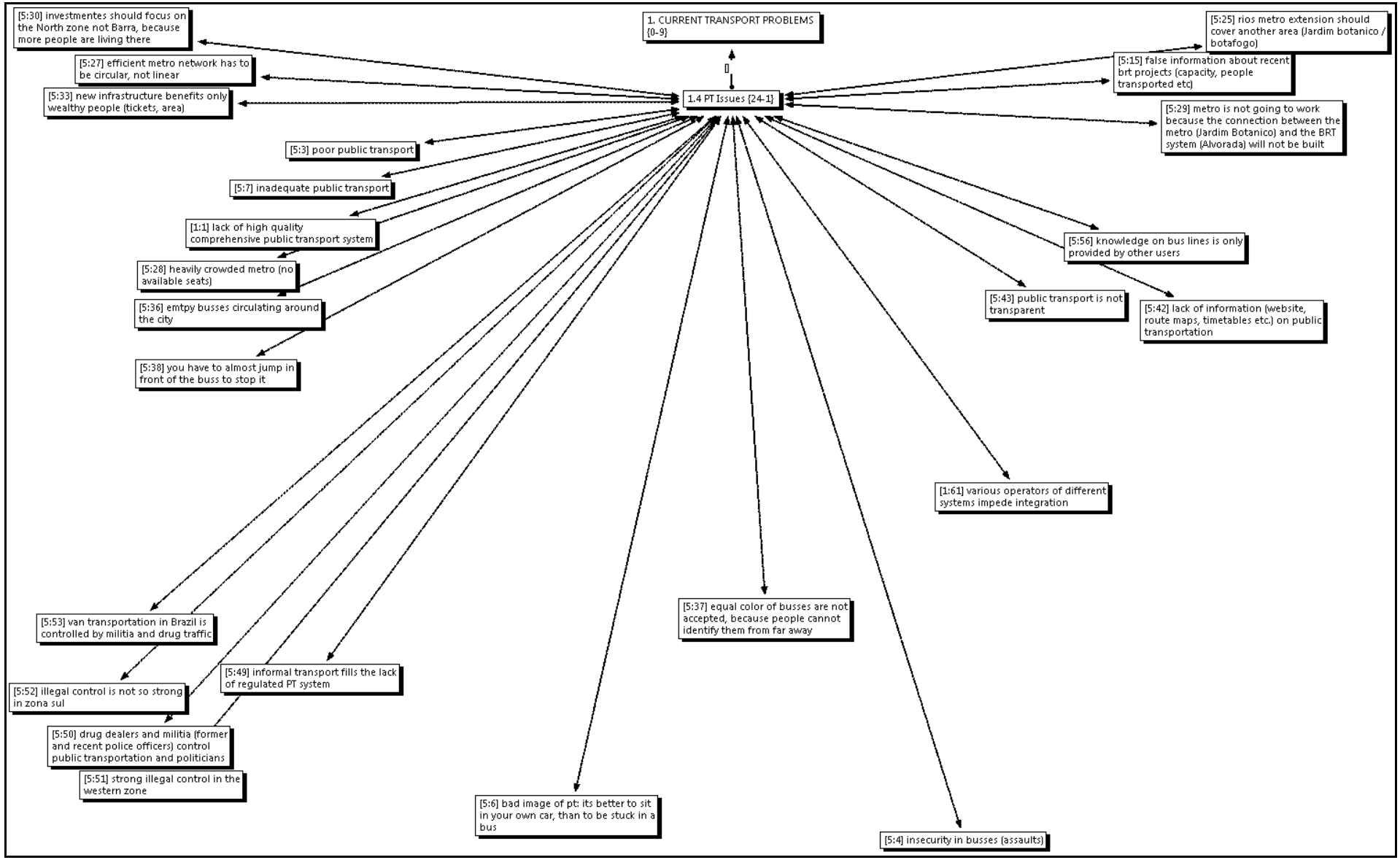
C.III DIFFERENTIATION OF THE CODE SYSTEM USING "VISUALIZED CODE MAPS" (EXAMPLE OF INTERMEDIATE STEP)

1) INITIAL SITUATION



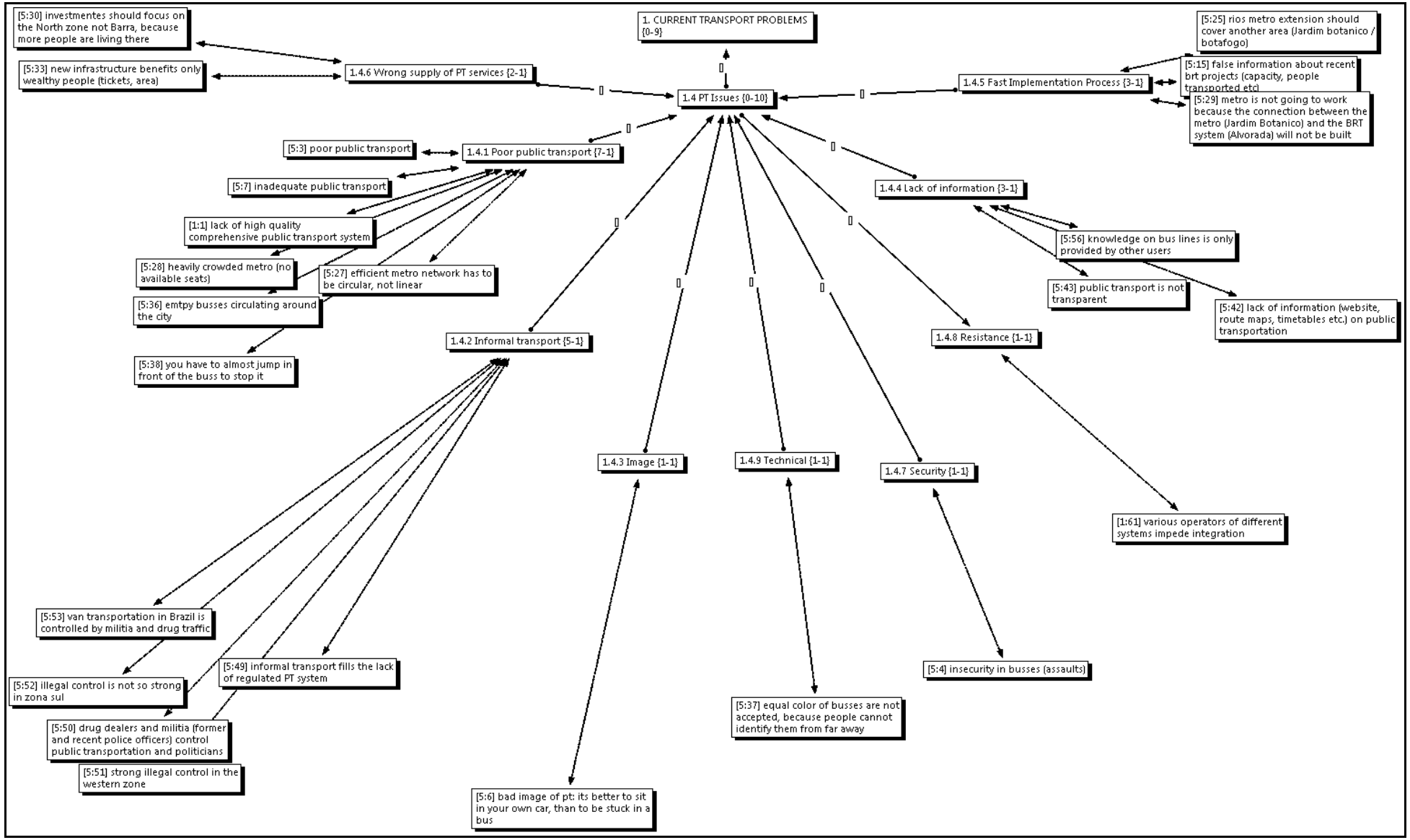
Source: Network view (semantic layout), created with ATLAS.ti by Matthias Kiepsch

2) CLUSTERING OF QUOTATIONS



Source: Network view (self-sorted), created with ATLAS.ti by Matthias Kiepsch

3) CREATION OF SUB-CODES



Source: Network view (self-sorted) including new sub-codes, created with ATLAS.ti by Matthias Kiepsch