FUTURE PERSPECTIVES

Micro study summary

1. INTRODUCTION

This micro study focuses on projects in preparation of the Olympic Games and Fifa World Cup in the cities of Manaus and Rio de Janeiro. Three traffic-related projects are studied. The first project is the construction of a monorail passenger system in the Amazon city of Manaus. The other two projects are situated in Rio de Janeiro and entail a Bus Rapid Transit system and the traffic management plans during the two events.

Special attention is given to the "future perspectives" of these projects. This means the projects are not only evaluated on their usefulness *during* the events, but also on their long term value *after* the events. In other words: how sustainable are the projects really? Experiences from previous large-scale events have shown that transportation measures can be particularly strong and positive if the infrastructure and management measures are maintained properly (Bovy, 2004).

Before the three projects are evaluated, a framework is set up which consists of a definition of sustainability, a study for similar projects and an analysis of the current infrastructure in both cities. Chapter 2 shortly describes the definition of the term sustainability as used within this report. This results in some criteria which the project should fulfill in order to be sustainable. Chapter 3 and 4 are studies of respectively literature on similar systems (monorails, Bus Rapid Transit systems) and traffic related projects for comparable events of the past. These chapters both lead to insights which can be translated into yet more criteria on which the three projects can be tested. Before finally looking at three projects themselves in chapter 6, the current infrastructure in Manaus and Rio the Janeiro are shortly discussed in chapter 5. The overall findings will be concluded in chapter 7 and in chapter 8 lists the remaining research questions which will, hopefully, be answered during the study tour in Brazil.

2. SUSTAINABILTY

The definition of sustainability, according to the book Our Common Future (World Commission on Environment and Development, 1987) is:"*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*".

There are many definitions about sustainability, in this micro study we focus on sustainability within the transport sector. The Council of the European Union's already formulated the following definition of a sustainable transport system:

People Allows the basic access and development needs of individuals, companies and society to be met safely and in a manner consistent with human and ecosystem health, and promotes equity within and between successive generations.

Planet Limits emissions and waste within the planet's ability to absorb them, uses renewable resources at or below their rates of generation, and uses nonrenewable resources at or below the rates of development of renewable substitutes, while minimizing the impact on the use of land and the generation of noise. (Council of the European Union, 2001)

Profit Is affordable, operates fairly and efficiently, offers a choice of transport mode and supports a competitive economy, as well as balanced regional development.

This definition will be the basis for sustainability in this report, categorized in the three criteria People, Planet, Profit. These three main areas of sustainability are the main subthemes throughout this research. For each area we formulated the following two criteria which will be described per chapter (Marsden, Kimble, Nellthorp, & Kelly, 2009):

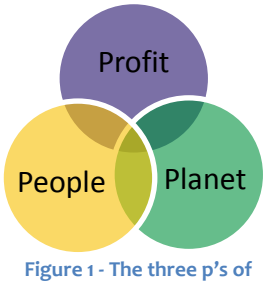

Figure 1 - The three p's of sustainability

People Poverty;
- The average real cost of journey to key destinations

Accessibility;
- Access to the transport system
- Access to key destination

Planet Resource Efficiency;
- Total non-renewable energy by all transport
- Energy use per person-trip

Total emissions

Profit Costs;
- Government, Operator, Users

Benefits;
- Government, Operator, Users

3. LITERATURE AND CASE STUDIES

This part of the research framework looks at the literature and other projects to set up a framework to try and better understand the concepts of public transport. The aim is to come up with literature and case studies that can be compared with the future plans in Brazil. Therefore the focus will lie on other projects in Brazil, or South America. This part focuses on Bus Rapid Transits (BRT), monorails and traffic management which should provide a useful context for the BRT project and the traffic management project in Rio de Janeiro and the monorail in Manaus.

Bus Rapid Transits

There are numerous definitions of BRT's, the following definition developed by the transportation research board gives a clear description of the essence of BRT's (Jarzab, Lightbody, & Maeda, 2002):

- BRT is a flexible, rubber-tired rapid transit mode that combines stations, vehicles, services, running way, and ITS elements into an integrated system with a strong positive image and identity. BRT applications are designed to be appropriate to the market they serve and their physical surroundings and can be incrementally implemented in a variety of environments.

In brief, BRT is a permanently integrated system of facilities, services, and amenities that collectively improve the speed, reliability, and identity of bus transit. In many respects, BRT is rubber-tired light rail transit (LRT), but with greater operating flexibility and potentially lower capital and operating costs.

Major BRT systems have been implemented in Belo Horizonte, Curitiba, and São Paulo, Brazil; Quito, Ecuador; and Bogotá, Colombia. These systems typically use physically separated median lanes along wide multilane arterial roadways. Stations are typically spaced 1,200 to 1,500 feet between major intersections, with provisions for overtaking on some systems via passing lanes at stations. Multi-door articulated (18 meter) and biarticulated (24.5 meter) diesel and trolley buses are used, depending on the system, and several systems offer off-vehicle fare collection. Peak-hour and peak-direction passenger flows range from 10,000 to 20,000 persons per hour (Gordon, Cornwell, and Cracknell 1991).

Sustainability

People

The accessibility of the Bus Rapid Transit system is relative high, this because the access to key points and the transport system is high. Because the BRT system has the option to make use of their own and the current infrastructure it's possible to reach a lot of key points. These key points could be situated in the residential areas as the industrial areas. The access to the BRT system itself is high because the stop density of the system is high.

The use of the BRT system by poor citizens is strongly dependent of the ticket price and the destinations of the BRT. For the poor citizens making and saving money is very important, so their reason for travelling will be much more business oriented than for leisure purposes. If the BRT has a direct connection between the households and the businesses it's conceivable that the poor people make use of this system.

The ticket price will be dependent of the investments and the operational costs of the BRT system. The investments costs are relative high in comparison with the operational costs. If it's possible for the poor citizen to increase their working circumstances by making use of the BRT, they will make use of the system.

Planet

BRTs reduce CO_2 emissions per passenger compared to conventional transport systems. This is achieved basically by using larger units, a higher occupation rate of buses, new and energy efficient units and a mode switch from other vehicle types to the BRT due to its speed and convenience (Grűtter consulting). The actual CO_2 offsets depend on each city.

The use of resources for building and operating a BRT is relative low because it makes use of low-cost infrastructure elements such as bus turnouts, boarding islands and curb realignments. BRT systems can also share existing roadways with other traffic or use bus lanes that restrict other traffic from a portion of the roadway. Service along public roadways can be improved by taking advantage of bus priority methods, so there is no need for using new resources. Another big advantage of the BRT system is its relative flexibility in changing the route. If appeared that some stops are not that popular it will not cost, financial and resources, much to remove that stop from the route.

Profit

The cost of a bus rapid transit system can be divided into construction costs and operating costs. Construction costs include the infrastructure investments of construction of stations, lane separations, and miscellaneous installation of signs, traffic signals, and other aesthetic installations. These investments are mostly done by the government and are mostly much higher than the operating costs. In systems around the world, infrastructure costs have varied from under $1 million per kilometer to over $10 million per kilometer (Instituto Nacional de Ecologia, 2008). These costs are in comparison with other big transport systems relative low. The operating costs are handled by the operator and consist of the investments of vehicles, employers and fuel. These costs must be compensated by the ticket sales.

Next to the costs, a BRT system has also economical benefits. Through a BRT system the travel times will reduce in comparison with car transport. There will also be an increase in economic productivity, employment and work conditions. The exact amount of these benefits depends on the situation.

Monorails

The definition of a monorail, as stated by The Monorail Society (TMS): "A single rail serving as a track for passenger or freight vehicles. In most cases rail is elevated, but monorails can also run at grade, below grade or in subway tunnels. Vehicles are either suspended from or straddle a narrow guide way. Monorail vehicles are wider than the guide way that supports them." (The Monorail Society, n.d.)

Brazil has known one monorail. This one was, however, not very successful, as indicated by the Monorail Society (The Monorail Society, n.d.): the monorail "started up in 1990, then a few months later shut down with safety/engineering problems."

Today, there is not a single working monorail in South America. Therefore monorail projects are studied, which are somewhat comparable with the situation in Brazil. A set of well functioning monorails are found in Japan, which is a developed country. The successful monorails in this country should however be an example to the future monorail in Brazil.

Sustainability

People

In general, the accessibility will increase when a new monorail is built. This is because it is a fast way of transportation, which probably improves the accessibility of the areas around the monorail. The situation where a monorail has the most advantages is a situation where there is a need for a fixed route through a built-up area and with an anticipated medium passenger load. A disadvantage of the monorail is that it has no at-grade junction, so that it is not very easy to change modes. (Fleming, Advantages of Monorail for Mass Transit , 2010)

The access towards the transport system depends on the area in which it is built, but is often harder than by another transport system, since the monorail is an elevated system along other infrastructure. There is little space for parking cars, so it is important that there is a good bicycle lane towards it and a good bicycle parking place. (Cunican, 2003)

The cost of a monorail ticket differs a lot around the different countries, but in most cases the fares are quite high. The price in other countries is often around or above 5 dollar when the passenger drives the whole route. This price is higher than most other modes. (Moscow News, 2007) (Sydney Monorail, 2010)

Planet

The monorail track is built with concrete. Because it is an elevated system, a lot of concrete is needed. The train of a monorail is built mostly of aluminum with rubber tires. Because a lot of resources is needed for the track, it is not efficient. Another important aspect which makes it inefficient is the flexibility of the system. If the system is not used anymore, a lot of materials are wasted and the trains cannot be used on another type of rail. (Worldlingo, 2010)

During the construction phase, a huge emission will take place, since a lot of materials are used in the construction. In the operational phase the total emissions are very low. A monorail is quite energy efficient and is mostly powered with electricity. (Long, 2009) A new technology of Metrail can power the monorails with a hybrid electric powertrain which is self-powering. (Metrail, 2010)

Profit
Building a monorail system is not very cheap and it costs more than regular bus systems. However, a monorail cost less than light and much less than heavy rail or subway systems. However it cost much more than a bus system, it could be better compared to a BRT system, with grade-separated crossings, these costs are also in the same range. (Fleming, Advantages of Monorail for Mass Transit , 2010)

The only revenue of a monorail system is the revenue of fees. Every user has to pay for using the system, so that is the income of the monorail system. But beside the revenue, it has more benefits. A new monorail system would, if implement correctly, improve the travel time between certain areas. This improvement in travel time means less delay for travelers, which is a benefit and this can be quantified when exact numbers are published. A third benefit is that improvement in accessibility, attract companies to settle along the route. This also can result in a lower unemployment number for the city.

All in all, there are a lot more benefits than only the revenues for the operator. The whole city can perceive the benefits if the system is implemented correctly.

Traffic Management

Traffic management entails a wide range of possible measures. All these measures are focused at establishing a more efficient use of the current infrastructure. Infrastructure enhancements are thus not part of traffic management. Measures such as rewarding behaviour with subsidies and guiding traffic via certain routes are typical examples of traffic management. In the previous Olympic Games in Beijing, the municipality used a fairly severe measure: only cars with an even licence plate numbers were allowed to drive on one day, cars with odd numbers on the other (also see chapter 4).

Below we will describe the way traffic management can contribute to the three P's of sustainability. However, since we do not know exactly what the specific management measures will be in Rio de Janeiro, the description below remains general.

Sustainability

People
Traffic management can change the equity situation between different groups. For example, when the government want to discourage car traffic by raises the car tax, the car captives are worse off than other people. Reducing traffic in a certain street by closing it of in certain periods will please the inhabitants of that street. But the traffic will probably drive through another street. In the Beijing example (not allowing to use the car on certain days based on license plate number), accessibility for the poorer people is worsened, while the rich people who are able to afford a second car do not experience any less accessibility.

If we look at the accessibility criterion, it is hard to say whether access to transport can really be changed through management plans. Access to destination can be improved, for example if the route to a destination is less congested due to a management measure. The same is true for the poverty criterion: the total trip costs can be reduced (but also increased) when certain measures are taken into effect.

Planet
The environment is a typical externality of traffic management. Traffic has influence on several variables on a local scale (smog pollution, noise levels) as well as a global scale (CO_2 emissions). Rerouting traffic can solve or relocate local problems, while modal shifts toward clean modalities contribute to solving the problems on global scale.

The energy-use per person trip criterion can of course be decreased when applying a strategy focussed on establishing a modal shift toward clean modalities. The same holds for the non-renewable energy consumption criterion. Both criteria in fact need a modal shift to change, which can be achieved by various management strategies.

Profit
Management measures can have investment and operating costs themselves, but can also influence the profit of public transport operators, petrol stations, car parks, etc. Strategies which establish a modal shift will automatically support industries which depend on the use of a certain modality.

Looking at the users, changes in profit can become clear when the government for example decides to subsidise public transport, which reduces ticket fares for the users.

Criteria for sustainable transport systems

At the construction of new infrastructure it is important that *the route runs along key destinations* in the city. Key destinations are for example, residential areas, the industrial areas and the city center. This is essential to get a high number of passengers into the transport system.

Another important criterion for success is *the number of stops* on the system and *the feeding possibilities*. Those two will also help to get passengers into the system. The feeding of the system can be done by short walking distances to the stops or a connected feeding system with other modes (bicycle or public transport).

To attract passengers, and especially poor people, *the ticket price should be low*. In that way all people, even the poorest can use the system and this will increase accessibility for the people.

To make the system environmentally sustainable, *the occupation of the buses or trains should be high*. When the occupation is high, the emission per passenger kilometer is low, and this is desirable for the environment.

To implement successful traffic management measures, *the measures should affect all people* (all income groups) to keep or improve social equity; it should definitely not worsen it. Also traffic management should be implemented to *affect a high number of people*, to have the biggest effect and thus the most success.

Another important criterion for traffic management is that *it should not relocate problems but solve them* by e.g. creating a modal shift. If traffic management relocates problems it is not really a sustainable solution.

4. FUTURE PLANS OF PREVIOUSLY HOSTED MEGA-EVENTS

In this part of the framework of the micro study, there will be looked at traffic and transportation measures of previously hosted mega-events and the future plans of those. First the plans and measures and how was dealt with the demand peak of the different mega-events will be described. After that, there will be a description about how the infrastructure and measures were used after the event and with that, criteria for a useful legacy will be described. In the end, also the profitability of the measures from previously hosted mega events will be described.

For this part of research the Olympic Games in Beijing in 2008 and the World Cup in 2002 in Seoul (South Korea) are chosen, because both are big metropolitans in a developing non-western country. This situation is comparable with the current situation in Brazil.

Dealing with the demand peak of a mega-event

Planning and managing the transportation infrastructure for mega-events is a complex and difficult task. Host cities already have traffic problems and must secure acceptable levels of service for the increasing traffic needs during the event. A large effort is necessary to manage the addition of large traffic generated by a mega-event, and it requires a considerable improvement of the existing infrastructure and additional measures to manage the traffic.

In almost all biddings of previously hosted mega-events you will find both investments in new infrastructure as well as additional traffic management measures. The hosts are convinced that only new infrastructure wasn't enough to secure an acceptable level of service for traffic during the mega-event, and that is why also traffic management is included in the plans. In the next few paragraphs several traffic plans of different mega-events are described to see in what way new infrastructure and traffic management plans are combined.

Olympic Games Beijing 2008

The organization committee of the Olympic Games in Beijing in 2008 saw the games as a unique opportunity for huge investments in the transportation sector. The next quote from the Olympic Action plan shows the willingness to upgrade the transportation sector in the city of Beijing:

"The modernization process of transportation construction and management in Beijing will be greatly advanced to provide convenient, rapid, safe, orderly, efficient and environmental friendly transport services. The construction of railway, urban road, expressway, interurban transport hubs and modern transportation operation administration systems will be accelerated to provide sufficient transport support that guarantees the development of Beijing's social economic development and urban construction, and to offer first class urban transport services for the Olympic Games."

Eventually among other things new roads and rail were developed, a rotation system of alternative driving days based on the last digit of the license plate and also working days were staggered.

World Cup Seoul 2002

In Seoul, during the preparation for the world cup in 2002, the organization committee also focused on both traffic management and new infrastructure. Although the investments for a host city for the FIFA World Cup are lower that for the Olympic Games, the host city of Seoul saw the world cup also as an opportunity to develop the transportation sector in the city. They wanted to:

"promote a safe road environment by improving the traffic conditions around the competition arena in preparation of the large event as well as establishing proper transportation strategies to deal with the increased transportation demand and the traffic congestion in the surrounding area" (S. Lee, 2003)

In Seoul, 30 projects were undertaken, including the development of a road system for easy access to the Sangam main stadium, and the enhancement of the quality of the subway system. Also implemented was a system where people were allowed to drive only on alternative days based on whether their license plate was odd or even. The maintenance of traffic signs and the introduction of a mobile phone interpretation system for easier communication between taxi drivers and foreign customers were also introduced.

Sustainability

All newly build infrastructure is of course permanent, so this will remain after the mega-event took place. But the usage afterwards can be quite different than the usage during the mega-event. Also the traffic demand management measures can be ended at the same as the event itself. In this paragraph the legacy for the city from the traffic and transportation plans of the mega-event are described.

People

That new infrastructure doesn't necessarily improve accessibility for citizens is shown in Beijing; the newly built metro line towards the famous Birds Nest stadium almost attracts no travelers anymore after the Olympics, and is by far the most desolate metro line of Beijing. One metro station along the line has even been closed already.

But other new public transport facilities kept a high number of passengers after the Olympics; the fare level in Beijing's metro and bus systems has been implemented as part of Beijing's transport system development strategy and did not expire at the end of the Olympic and Paralympic Games. This led to a large amount of citizens that still uses public transport after the Olympic Games took place (Official Beijing Organizing Committee, 2008). Thus some of the new infrastructure build for the Olympic Games did improve accessibility for the inhabitants of Beijing.

In Seoul also the newly built infrastructure remained as a legacy, but no further traffic management policies remained. The schedule of the public transport also changed back and there was no big change in passengers due to the World Cup. Because most of the measures were temporary and because Seoul was only host city of 3 matches, the improvement in accessibility for the citizens of Seoul was not as high in Beijing during the Olympic Games of 2008.

Planet

The construction of new infrastructure by itself has always a negative impact on the local environment. The materials used are in general not sustainable and the new situation is always less environmental friendly than before (e.g. concrete instead of nature). But it can provide positive impacts on the environment on the long term, and in that way new infrastructure can have a positive effect on the environment.

As written before, in Beijing the new metro line towards the Bird Nest Stadium almost attract no travelers and one of the stations is already closed. Of course, in such a short time, the negative impact of the

construction can't be compensated by the positive effects in the long term. This is thus not an environmental friendly way of implementing new infrastructure for a mega-event.

Traffic management can also have a positive effect on the environment by improving air quality. In Beijing the traffic demand management measures continued after the Olympic Games (at least until 2012). It is said to have been effective in relieving traffic jams on major roads and improve air quality in the city. Current evaluation reports state that the average length of traffic jams on Beijing roads has decreased from the previous 1 hour and 45 minutes to just 45 minutes since the implementation of traffic control (EChinacities.com, 2010). This means that emissions due to traffic jams are declined, and the air quality in the city is improved. A comparison of Wang and Xie (2009) between the predicted street concentrations in Beijing before and during the Olympic traffic control period shows that the overall on-road air quality was improved effectively, due to the 32.3% traffic flow reduction.

Profit

Measuring all the economic impacts associated with a mega-event is an impossible task. This is because the impact on the society is so huge and broad and almost everything in the city is affected by it. That is why it is very difficult to say anything about the profit of the transportation measures at mega-events. In Beijing transportation improvements are part of the environmental improvements. Plans include expansion of public transportation systems and conversion of city buses to clean energy. The plans address a wide range of topics, everything from highway construction and pollution control to teaching English to cab drivers and improve the driving habits of the general population (Owen, 2005).

What mainly can be said about investments in transport during a mega event is that it is probably not economical profitable on itself. For example; public transport in Beijing is still subsidized to attract passengers, it cannot generate enough passengers when they have to pay the full price. That is why environmental and societal benefits are included in the estimations. And when you do include other benefits than only the economic ones, the investments in infrastructure and other transport measures during a mega event can be profitable.

Criteria for a useful legacy based on previously hosted mega-events

Most important is for what reason infrastructure and traffic management plans are designed. In that way, an important criterion is that *the infrastructure must not just be a connection from the airport to the stadium or vice versa, it should connect different parts of the city with each other*. In that way local people can use the infrastructure as an alternative/new option for daily trips (home-work etc.) after the mega-event took place.

Another criterion is *the stimulation of usage of new public transport*. When people are stimulated to use public transport (e.g. low fares) more people will remain using it after the mega-event took place. When public transport is not stimulated afterwards, it can lead in a huge drop in passengers, because citizens will return to their normal travel behavior afterwards.

Traffic management can be a useful legacy if it affects local people. Traffic management measures based on car use will affect local people the most, because foreign travelers will mostly use public transport. If a traffic management measure based on local people's car use will improve air quality and reduce traffic jams during an event, it will also have positive benefits afterwards.

The criterion for traffic management measures to be a useful legacy for the city is that the *measure must affect local people the most*, and one way to do this is by implementing measures based on car usage.

5. THE CURRENT INFRASTRUCTURE

In order to place the projects of chapter 6 into context, this chapter describes the current characteristics of the infrastructure in the cities of Manaus and Rio the Janeiro.

Manaus

One of the most economically important cities in the Amazon area is Manaus. The transport infrastructure in the area now (air, land and river) characterizes the service of marine transport, related to long course and coastal traffic. When referring to coastal traffic, Manaus comes in first place in some of the services

now in operation. In the long course, the cities of Belém and Manaus are scales of international services, making the Amazon an important center for countries such as the United States and the Far East, up to the Caribbean harbors (Silva & Dacol, 2006). The public transport in Manaus takes formally place by bus, on the other hand the intercity transport is mostly done by boat.

Bus transport

In Manaus 250.000 passengers travel by bus a day. This transport of passengers is, since 2002, supported by the public transport system Saturday. The system consists of 124 buses; each bus holds 180 passengers and travels on an exclusive bus lane. The new system replaces some 400 "traditional" buses that are a major source of downtown rush-hour traffic jams. Brazil's national development bank BNDES helped finance the bus purchase and necessary infrastructure (Manaus rolls out US$60mn public transport system, 2002).

There is not much known about the quality of the bus transport, reason for traveling, and the actual travel data. So it's not directly possible to say something about the need for developing a new system with new directions.

Water transport

Next to the city transport in Manaus, most of the intercity transport in the Amazonas is done by boats. From Manaus it's possible to travel by boat to Belém, Porto Velho and Santarém. There are 36 firms who facilitate the transport of passengers by boat. A total of 550 000 passengers a year make use of this service. This amount of passengers is relatively low in comparison with the 250.000 passengers a day who travel by bus.

The main reason for traveling by boat is business (34%), followed by personal affairs (29 %), leisure (21%), health (10 %) and others (6%) (Alves, 2007). During the big events, Olympic Games and Word Cup, it's conceivable that there will be a shift in these reasons, where an increase in leisure and a decrease in business visits is imaginable. Through these big events there will also be a higher demand of transport and therefore it's necessary to increase the total capacity and frequency of the boats.

Rio de Janeiro

The Rio de Janeiro public transport system is very complex with many bus lines, two metro lines, a ferry and a tram line. There are even lots of (illegal) low capacity services (vans) operating on many busy transit lines (Balassiano & Braga, n.d.). The tram line is mainly an attraction used by tourists. The following section will discuss the most important of these, namely the metro systems, the bus system and the van operators.

The Metro system

Rio de Janeiro has the second largest metro system of Brazil, after São Paulo. The quality of the metro system is high. It is for example fast, safe, clean and air-conditioned. (WHL Travel, 2006).

The metro lines do not cover the whole city. Only the eastern and northern parts are serviced. The municipality therefore plans to extend the metro with new lines. There will be a further extension in the western direction, along the coast. The latter is scheduled to be completed before the 2016 Olympic Games.

Currently, this limited coverage problem is addressed by offering travellers combined tickets. This means that a passenger travels part of his route by metro and part by another modality, such as a bus or a train. The combined ticket is cheaper than two separate tickets. (WHL Travel, 2006)

Bus system

The bus is the cheaper mode of public transport and is widely used in Rio. The coverage is high since there are over 440 bus lines covering the city frequently, which transport over 4 million passengers a day. The buses also attend all parts of the city. The services are carried out by many different operators. (World Travel Guide, 2010)

In contrary to daytime, the bus system is not always safe at night. (TripAdvisor, 2010) The bus system experienced a decrease of passenger in the 90s due to the increasing amount of low capacity transport and the rapid increase of car ownership. (Balassiano & Braga, n.d.)

Low capacity transport

In addition to the metro and bus, there are also many low capacity vehicles operating in many Brazilian cities, including Rio de Janeiro. The vehicles are mostly operated by independent operators who own one or two vehicles. The fares are usually higher than those of the bus and users grade the van services quite high according to research by Balassiano & Braga (n.d.). For the whole Rio de Janeiro metropolitan region, it is estimated that about 6.200 vans transport 310.000 passengers every day, which is about 5% of total public transport.

The government started to regulate vans operated services in 1996. The operators are only allowed to run contracted services (which means only transfer passenger from points specified, such as school to home; picking up passenger along the route is not allowed). However, due to a lack of enforcement, there are still thousands of illegal operating van services in the Rio de Janeiro metropolitan area. (Vasconcellos & Balassiano, n.d.)

Competition between buses and vans

Since almost 90% of Rio's public transport is handled by buses, the van services usually drive parallel to the bus routes, as well on internal as inter-municipal routes. The van services drive by bus stops to pick up and drop off waiting passengers. Obviously, the bus operators are not happy with the many vans. Although the van operating is indeed illegal and there is enforcement of these laws, it is not nearly enough to ban the van operators. Once van operators become part of the status quo, it is very hard to shut them down for authorities.

The bus operators are trying to compete with the vans by diversifying the offered services. For example, they introduced conventional buses with air-conditioning and mini-buses with air-conditioning which charge higher fares (respectively 2 and 3 times the normal fares). The conventional bus fleet is expanded as well. (Balassiano & Braga, n.d.)

6. TRANSPORT PROJECTS IN BRAZIL

T5 Bus Rapid Transit Project (Rio de Janeiro)

The mobility in Rio de Janeiro is not optimal. There is a lot of car traffic which leads to congestion and the traditional bus system in Rio de Janeiro is not of a good quality. To develop the bus system, this T5 will be built. This project should make the city more accessible, since this is a big problem in Rio de Janeiro and should be improved for the World Cup and the Olympic Games. (Prefeitura da Cidade do Rio de Janeiro, 2009) In figure 6 the route of the T5 is given with the red line.

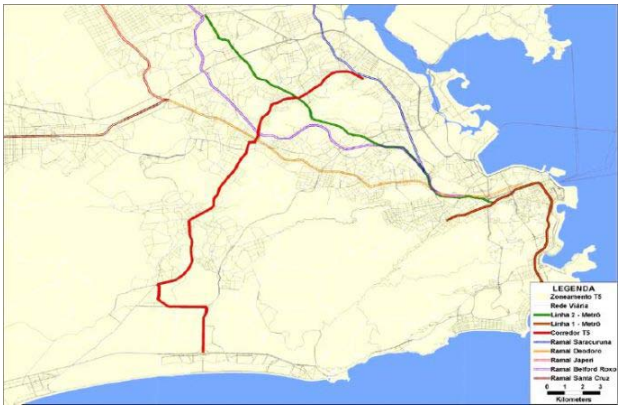

Figure 2: The route of the BRT T5 (Bias, 2009)

As can be seen in the figure, the T5 connects the west side with the northern end of the city. The metro systems are the green and the brown line, which is in the eastern part. And also the good quality buses are all in the eastern part of the city. This bus rapid transit line is a missing link in the public transport system of Rio. The distance of the trip is 28 km with 38 stations.

Along the route, the bicycle use is higher than the average of Rio. This has to do with the fact that there are a lot of residential areas along the route and not as much hotels and apartments. This could be an opportunity to get people more on the bike. In the design stage of the BRT is dealt with this opportunity. The areas around the stations will be safe with a maximum speed of 30 km/h. There will be cycle lanes towards the stations. These measures are taken to create a modal shift towards a combination of bicycle and public transport. (Institute for Transportation and Development Policy , 2008)

Sustainability

The T5 is not only built for the mega-events, but is still present when the events are over. In this chapter the sustainability of this system is described.

People

The route of the T5 is, as described above, a missing link in the public transport system of Rio de Janeiro. By implementing a good quality public transport system on that route, a huge increase in PT users can be reached. Even more because the travel time will be just 47 minutes instead of 96 minutes nowadays. (Government of Rio de Janeiro, 2009) Important for the amount of users is the route of the T5. The T5 goes through 12 neighborhoods and covers the most important areas of the city, like Tijuca, Meíer and Zona Sul. These areas are important living and working areas, which can lead to a high usage of the system. Along the route, a lot of poor areas are covered. The beginning and the end are more wealthy and touristic areas, but in between a lot of residential areas are covered. The low price of a ticket, which cost $1.30, is also attractive. (Dias, 2009) It is estimated that the T5 has 350.000 passengers per day, a lot of them are daily commuters. (Government of Rio de Janeiro, 2009)

The accessibility towards the system could be a problem, but therefore the bicycle lanes are created. Another negative point is that a lot of people have to move because a lot of houses are destructed for the construction of the BRT lane. (Dias, Prefeitura porá abaixo imóveis mesmo que haja discussão judicial , 2009)

Planet

Most important aspect of the BRT is that it is a flexible system. When it seems that it does not work as good as expected, there is only one concrete lane built. This could probably be used for anything else, like a road. Also the buses can be used easily somewhere else. Another flexibility of the BRT system is the route. When it seems that an important area is missing, it is not real hard to change the route of a bus system.

Noting is said about the emissions of using the T5. Usually a BRT system reduces the emissions because the occupancy is a lot higher than traditional bus systems. But about the T5 specific, is nothing described.

Profit

The project cost are estimated at 400 million US Dollar. This are solely project cost, all side cases are not included. The costs of binding people to move are more than 150 million US Dollar. Also the cost of the stations and buses are over 75 million US Dollar. These side costs are more than 50% of the project itself. These costs are often not shown and probably not considered well in the beginning of the project. (Dias, Rio dá a largada para Transcarioca, 2009)

The total costs of the whole project are now estimated at more than 600 million US Dollar. This is much more than was described in chapter 3. This is caused by the case that there are a lot of grade-separated junctions, which have a high cost.

The benefits of these grade-separated junctions can be seen in the travel time. The T5 is more than twice as fast as the current public transport system. The reduction in travel time loss is a huge benefit, since there are a lot of commuters which are going to use this T5. However, the benefits are not quantified anywhere.

Monorail (Manaus)

A requirement of the Fifa for the World Cup host is a good urban mobility. To create a good mobility in Manaus the monorail will be built. This monorail can supply 170.000 people per day and the time reduction can be up to one hour. The monorail project has to be a safe, comfortable system with a good accessibility. It is a sustainable project, since it has a new technology that reduces the nuisance and the emission. Another important aspect is that the monorail system has to fit the environment. The costs of the project are estimated at $ 550 million. This is financed both public and private. (SEPLAN, 2009) In figure 7 the route of the monorail line is given.

Figure 3: The route of the monorail in Manaus (SEPLAN, 2009)

As can be seen in the figure, the monorail will connect the Eastern tip with the Southern Center of the state. The driverless monorail system passes through the historical center of Manaus, which includes the city's port. It also will interconnect with existing terminals. The monorail also will pass the stadium for the World Cup. The system is not only a monorail; it will be extended with Bus Rapid Transit lanes. Where the monorail is from north to south, the BRT lanes have to cause accessibility through the other parts of the city. (Farah, 2010)

There is stated that the price of a trip with the monorail has to be accessible, what that price will be is not mentioned. The length of the trip will be 13.6 km and it will take 26.5 minutes, which means that the average speed is 36 km/h, in comparison: This is the same average speed as the North|South-line in Amsterdam. (SEPLAN, 2009)

Sustainability

The legacy of the monorail developed for the 2014 World Cup in Manaus is, of course, the infrastructure that remains. The monorail will not only be developed for the World Cup, but also for the long term to improve traffic and transportation in the city. The sustainability of this legacy is described below.

People

The monorail route will run through mostly dense areas like the city center and it is also connected to the port of Manaus and the new stadium. The monorail will also be connected to Bus Rapid Transit lanes, to service a bigger part of the city. Some of the main resident's areas are served by the monorail, but most are serviced by the BRT that is connected to the monorail. The connected BRT lines will also connect industrial areas to the monorail. The monorail journey should take one hour less than the time taken at present with the use of conventional buses, which take almost two hours to reach the city centre from the East Zone.

The monorail route will pass mainly through the areas with medium and high incomes (>$ 1667 per household per month), it will not pass areas with the lowest income (<$ 833 per household per month). But these low income areas will be serviced by the BRT lines that will be connected to the monorail.

In general, almost all inhabitants will have access to the monorail (direct, or serviced by the BRT lines). And because of the BRT lines that are connected to the monorail, the accessibility to the transport system can be high, but this depends on the service (number of busses etc.) offered by the feeding system. The whole system can provide accessibility to a big number of key destinations, but the success of this will depend on the service of the monorail and the connected BRT lines.

The fare price of the monorail is not determined yet, but SEPLAN stated that the price of a trip has to be accessible. This, of course, is meaningless, because a price that is accessible in general is maybe not accessible by a big group of inhabitants with low incomes. Because the fare price is not known yet, there is nothing sensible to say about this.

Planet

The construction of a monorail will always have costs for the environment. Materials used are often not sustainable due to the use of concrete and metal. So the construction itself is not sustainable. But Manaus has given itself the name "green host city" for the Fifa World Cup 2014 and this result in a policy whereby every ton of carbon emitted, will be compensated. This is done by a deposition in an environmental financial fund. So the carbon emitted by the construction of the monorail will be compensated and will return benefits to the environment. In what way this will be is not known.

The operation of a monorail is in general environmentally sustainable, because it is using electricity instead of fossil fuels. But this electricity can also be generated in ways which are more or less sustainable. According to studies from SEPLAN, the monorail will have some great environmental benefits for the city. They state that when the monorail is operating, it will reduce CO_2 emissions with 50,000 tons per year, which is equal to planting 1,000 trees a day. It is not known where these assumptions are based on, so this should be handled with care.

SEPLAN also state that the monorail will contribute to a better urban environment, because there will not be much noise. The noise of a monorail is always lower than the noise of most other transport systems, so this will be a real environmental benefit for the city of Manaus.

Profit
The construction costs of the monorail in Manaus are $ 550 million for a length of 13.6 kilometer. This is around $ 40 million/km. The construction costs of other monorails around the world vary between $ 10 million/km and $ 130 million/km (see paragraph 3.2). The costs for the monorail in Manaus lies a bit below average, this means that the construction of this monorail is cost efficient.

When the construction of the monorail is completed, there are still some costs left; the operational costs. The operational costs of other monorails vary between $ 0.07 / passenger km and $ 0.40 / passenger km (see paragraph 3.2). The operational costs of this monorail are not known, so nothing sensible can be said about this.

The economical benefits of the monorail for the society are, according to calculations of SEPLAN, around $ 18.5 million per year. This estimation is based on the reduction in travel time, which is 47,000 labour hours per day. But again, it is not known were these assumptions are based on. Also the fare price is not known, so the benefits for the operator cannot be estimated.

Traffic and transportation management (Rio de Janeiro)

For the Fifa World Cup 2014, but especially for the Olympic Games in 2016, Rio de Janeiro will take measures in traffic and transport management. What these measures will be is not known, only that the general policy will be that the spectators and the workforce will use public transport. (Comittee, 2008)

Next to the management strategy, the city invests heavily in new infrastructure. Besides the previously discussed BRT system, this involves an extension of the metro system and the construction a new road and pedestrian tunnel. Further, investments are mad in the bicycle infrastructure. (Sectran, n.d.)

The question raises which traffic management measures are taken to promote the use of this new infrastructure among citizens of Rio de Janeiro as well as travelers for the Olympics. At this moment, not much information on such strategy is made public yet.

Some information is available with regard to the bicycle use. The idea is that people use the bicycle and the BRT system as consecutive modalities in their trips (Institute for Transportation and Developement Policy, 2008). Bicycle use will be promoted via different means, such as the following (Sectran, n.d.):

- Encourage bicycle use among people who now travel by foot
- Integrating cycling with other transport modes
- Support municipalities to build cycling infrastructure
- Encourage bicycle use in sporting and cultural events

These measures are not specifically designed for the Olympic Games, but are a policy effective in the Rio de Janeiro state. They are enforced in conjunction with infrastructure improvements, such as the construction of bicycle racks.

The three Ps are shortly discussed for the bicycle program only. Once there is more information available during and after the tour, they can also be filled in for other measures.

Sustainability

People
Accessibility to the new BRT system will be increased if cycle parking facilities are placed near the bus stops. Whether the poverty will be influenced by the cycle program depends on the fares of the BRT and how they compare the costs of other modes.

Planet
The bicycle plan seems to be mainly aimed at people who are currently travelling by foot. However, if bicycling is really made attractive, it will probably attract car users too. In this respect, the management measures might have a positive contribution on emissions and noise levels. Since the exact plans and effects are unknown, we cannot say more about planet besides these expectations.

Profit
Not much can be said yet about the effect on the costs and benefits. More information is needed before we can say anything with respect to profit.

7. GENERAL CONCLUSION

This study investigated three Brazilian projects: the Monorail in Manaus and the T5 Bus Rapid Transit system in Rio the Janeiro are two brand new infrastructure projects which are planned to be ready for use before the Olympic and Fifa World Cup. The third project is traffic and transport management in Rio de Janeiro. Throughout the report, special attention was given to the sustainability of the projects.

Manaus is planning a modern monorail system for the city, which will probably suffice in handling the peak demand during the Olympic Games. On the longer term, doubts remain about the accessibility of the system. This mainly depends of quality of the bus connection and the fares, which have yet to be determined. The project is said to be environmental friendly, but the assumptions these statements are based on are still vague. The same holds for statements about economic benefits.

The T5 Bus Rapid Transit System of Rio de Janeiro seems to be a more flexible system. The investment costs are relatively low and changes in the system (for example the routing) can be made easily and cheaply. This makes it easy to adjust the system for daily life after the two events. The exact cost-benefit ratio remains unknown for now. Another remaining question is how environmental friendly the buses are and what measures might be taken to compensate any pollution.

During the Olympic Games and the World Cup several traffic management measures are taken into effect. There is unfortunately no information on what these measures will be exactly. This remains to be seen in the presentations and company visits in the study tour. We do know that part of the plan is to stimulate bicycle use, but this is not a measure specifically taken for the two events.

This concludes our study of three traffic related projects which are carried out for the Olympics and Fifa World Cup. The above summarizes what we already know and what we don't know yet. Hopefully, many of these ambiguities will be addressed again in the final report with more information. The next and final chapter will summarize all research questions we hope to be able to answer in Brazil.

8. ON-TOUR RESEARCH QUESTIONS

The following repeats the main research question which will serve as a guideline during the company visits and presentations in Brazil.

T5 Bus Rapid Transit (Rio de Janeiro)

- There is stated that the infrastructure towards the T5 is cycle-friendly, is there any policy to get everybody on the bike?
- What is done to get the buses of the BRT environmental friendly?
- Are the benefits quantified? And how is the cost-benefit ratio?

Monorail (Manaus)

- How is the service provided by connected BRT lines (number of busses, number of stops)?
- What will be the fare price for the monorail?
- How is the carbon compensation into a environmental fund designed exactly?
- Where are the assumptions about reduction in emissions based on?
- What will be the costs and benefits for the operator of the monorail?
- Where are the assumptions about economic benefits for society based on?

Traffic and transport management (Rio de Janeiro)

- Which traffic management measures does the government take exactly in Rio de Janeiro?
- What are the effects of these measures on the three Ps?
- Do the measures support the use of new infrastructure build for the Olympics and World Cup?

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