

## A critical evaluation of the Colombian model of mass or bus rapid transit systems

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### Abstract

A great number of cities in the world and in Latin America is nowadays developing projects of massive transit based on the Colombian model and experience of bus rapid transit, BRT (TransMilenio of Bogotá), characterized by large 'high floor' buses in exclusive bus ways and elevated platforms as closed bus stations. The article compares the TransMilenio Bus Rapid Transit model with the alternative of mass transit with the technology of 'low floor' buses. It shows the serious deficiencies for the passengers of the TransMilenio model: the system is relatively slow, too expensive, causes social exclusion and does not contribute to Millennium Development Goals. The article evaluates the two alternatives applying environmental, social, economic and financial criteria of sustainable development. Its principal bases are the experiences of Bogotá and Santiago de Cali, Colombia.

**Key words:** *Sustainable urban transport, Bus rapid transit (BRT), Bus technologies, Social exclusion, Public transport*

INGENIERÍA AMBIENTAL

## Una evaluación crítica de sistemas de buses de transporte masivo en Colombia

### Resumen

Un gran número de ciudades en el mundo y en América Latina están desarrollando en la actualidad proyectos de transporte masivo con base en el modelo y la experiencia colombiana del sistema de transporte rápido en bus (BRT, bus rapid transit), el TransMilenio de Bogotá que se caracteriza por el uso de buses articulados de 'plataforma alta' en carriles exclusivos y estaciones elevadas cerradas. El artículo compara el sistema TransMilenio de BRT con la alternativa del transporte masivo con la tecnología de buses de 'piso bajo'. Muestra las deficiencias serias del modelo TransMilenio para los pasajeros: el sistema es relativamente lento, muy costoso, produce exclusión social y no contribuye al cumplimiento de los Objetivos de Desarrollo del Milenio. El artículo se basa principalmente en las experiencias de Bogotá y Santiago de Cali, Colombia.

**Palabras claves:** *Transporte urbano sostenible, Transporte rápido en bus (BRT), Tecnologías de buses, Exclusión social, Transporte público colectivo*

## 1. Introducción

Bus rapid transit systems (BRT) are already working or are in construction and amplification process in many cities in the world, such as León (Mexico), Kapstadt, Dar es Salaam, Dakar, Lagos, Jakarta and Bangkok (Hidalgo & Herrmann, 2004; Wright, 2002). In Santiago de Chile, the Transantiago BRT, entered in service at the beginning of the year 2007. Several cities of Colombia, such as Santiago de Cali, Pereira, and Cartagena de Indias are also developing projects of mass or BRT systems. All of these projects have in common as its theoretical and practical basis, the TransMilenio model of BRT in the Colombian capital Bogotá, which is based itself on the experiences of Curitiba, Brazil, and of Quito, Ecuador. In Colombia, the TransMilenio is already running in Bogotá with a range of bus-lines in exclusive bus-lanes called 'troncales'; Santiago de Cali is still constructing the infrastructure but initiated service in the first 20 kilometers of exclusive bus ways. Pereira is running a bus line with the Metrobus.

It is generally found a high appreciation of that mode of urban mobility in articles and conferences about BRT systems (Hidalgo & Herrmann, 2004; Menckhoff, 2005; Wright, 2002), especially of the TransMilenio example of Bogotá, because it there forms part of an integral strategy for sustainable urban transport. The following characteristics are mentioned as very positive in this system: The exclusive bus ways ("troncales") for the articulated buses with a capacity for 160 passengers which permit a very high passenger mobility along the system; closed and elevated bus stations which allow easy access for passengers; the unique electronic ticket which allows trips in all its bus lines by paying only once; and the elimination of the usual chaos in the public transport system as a consequence of a variety of organizational measures. Another important advantage can also be mentioned: the lower costs of BRT systems in comparison with a subway system.

But very surprisingly, the articles don't mention an important characteristic of the TransMilenio model of BRT systems: the generalized use of the technology of high-floor buses (with the

exception of the Santiago de Chile BRT which works with low-floor buses).

This article wants to show the great importance of the bus technology for the quality of the massive transit system, its total costs, the financing of the infrastructure and so on. The article evaluates critically the experiences with TransMilenio in Bogotá, its way to organize the massive transit, and the application of the model in Santiago de Cali, capital of the Cauca Valley State with 2.3 million habitants in the South-East of Colombia. In Cali, the Masivo Integrado de Occidente (MIO) BRT initiated operation in march of 2009. The TransMilenio model of BRT with its high-floor buses is compared with the alternative of a system functioning with low-floor buses in the case of Cali. The growing problems of TransMilenio in Bogotá very serious damages in the exclusive bus lane's surface, high costs of its repairs, problems with the financing of new exclusive bus-ways because of an important increase in costs, protests from passengers against TransMilenio criticizing the system's deficiencies, high levels of user's dissatisfaction and so on invite us to realize a profound revision of the TransMilenio model of BRT.

The MIO in the case of Santiago de Cali, is still in its construction phase, but initiated a partial operation in some exclusive bus lanes and with feeder buses. An important argument in favor of a critical review of the model, in case of Cali, is the alarming rise in the necessary public investment which initially had been defined in 345 million of US-Dollars, then was estimated in 517 million of US-Dollars, and the total costs in 2009 has been estimated in 1.281 million US-Dollars. Other arguments in favor of a review of the MIO version of the TransMilenio BRT model are: the predictable deficiencies of the service, the traffic chaos caused by the building of the infrastructure during the first four years of construction and also the multiple cases of corruption.

In this article, it will be shown that the 'TransMilenio' model of BRT is excessively expensive for a barely adequate or bad service of massive transport. The system produces social exclusion because of the technology of the buses used for the feeder service and the costs of a ticket,

the transport is slow for the passengers, and the system as a whole does not fulfill the environmental, social, economic and financial criteria for a sustainable urban development and transport. It does not contribute to the Millennium Development Goals. (Naciones Unidas, UNDP, 2000, 2006).

## 2. The TransMilenio model of bus rapid transit

The BRT systems in Bogotá, Cali and other Colombian cities have their legal bases in special documents of the Consejo Nacional para la Política Económica y Social, CONPES (DNP, 2000, 2002, 2005). The design of the massive transport in all the Colombian cities is based completely on the TransMilenio model of BRT of Bogotá. The following are the basic features of the Bogotá model and its twin system in Santiago de Cali.

The BRT type TransMilenio consists in the application of various organizational principles jointly with the use of the technology of articulated high-floor buses for 160 passengers in exclusive bus lanes in the main bus lines. The articulated high-floor buses have their entrance at the height of one meter above the street level, and therefore it is necessary to construct bus stations with the same height.

The passenger buys his ticket, for one or various rides, in the form of an electronic card, in a cashier in the entrance of the bus station or in other selected sites in the city. He has to pass through a barrier, using and devaluating the card. From this moment on he can mobilize himself in all the bus lines of TransMilenio whenever he wants to stay inside the massive transport system.

In order to assure a good speed, the BRT functions with exclusive bus lanes in the main bus lines for the articulated high-floor buses. Its high weight nearly 32 tons with passengers makes it necessary to construct and reinforce the exclusive bus lane. In the streets with the exclusive TransMilenio bus lanes ('troncales'), the circulation of other buses of the public transport system is forbidden. In this way one of the structural elements of the so called daily "penny war" ("guerra del centavo") is eliminated: various enterprises (which affiliate buses), various bus owners and the bus drivers struggle in the same routes for mobilizing a maximum number of passengers per bus that establishes the bus owners' and drivers' daily income in the traditional public transport system, and also (but only partially) of the enterprises. (Moller, 2006) The TransMilenio bus lines are served from 5 o'clock in the morning till 11 o'clock in the evening. The passenger can read inside each station the information about the frequencies and routes. A complementary service with feeder buses, characterized by their tall high steps at entrance and exit doors, move to and from the head



Figure 1. Articulated high-floor bus of TransMilenio with the elevated bus station and the exclusive bus way

terminals and certain bus stations of the exclusive TransMilenio lines carrying passengers to their city quarters.

In the case of Bogotá, the organizational and entrepreneurial structure of BRT is the following: TransMilenio S.A. is the public enterprise of the mass transport system which receives 3 % of the total income in order to fulfill its functions, to define the characteristics of the system and to control its fulfillment. It gives concessions to various bus operation enterprises which carry out the service with the articulated and the feeder buses. The companies operating the principal bus lines (“troncales”) receive 65 %, while the feeder routes receives 20 % of the system's incomes. Another company administers the distribution and sale of the tickets and electronic cards for multiple rides at the entrances of the bus stations and other sites. This company receives 11 % of the total system incomes for its functions. 1 % of the incomes is for an investment fund. The operation enterprises are paid on the basis of the total of circulated kilometers by each of its buses. The driver works for a fixed wage, independent of the number of passengers transported. (Hidalgo & Herrmann, 2004). In Bogotá, at the end of 2009, 84 kilometers of main routes (“troncales”) were served by TransMilenio. (Transmilenio S.A., 2006). It had been thought to begin the construction of phase III during the year 2007; finally the construction initiated in 2009.

The TransMilenio enterprise purpose is to construct a total network of 388 kilometers in Bogotá of bus lines in exclusive bus ways, in order to cover supposedly all the city in 2016 (but there are already delays), with estimated total costs of 1.970 million US- Dollars of the year 2000. (DNP, 2000)

In the Cali's version, the mass transport system named MIO has suffered some changes in comparison to the original model of TransMilenio. Finally only 40 kilometers of exclusive bus lanes will be constructed for articulated high floor buses and the respective bus stations (Metrocali S.A., 2006), representing only 20 % of the total projected length of bus lines. The BRT-service is accomplished in 80 % of the city with a type of feeder buses similar to those known

today in the public transport, some for 80 passengers (the called “pre-troncales”) and others smaller (the called “rutas complementarias”), characterized by its high steps in the entrance and exit doors (“rutas pretroncales”: 78 Km.; and feeder routes: 116 Km.).

### **3. Alternative of BRT or public transport systems based on the technology of low-floor buses**

It is presented in the following section of this article an alternative for a public (or massive, or BRT) transport which will serve as a reference point in the later comparison and critical evaluation of the TransMilenio model of BRT and its MIO version. (Moller, 2004; Moller, 2006) This alternative could not only be accomplished in all of the Colombian cities whatever large they were also in Latin America exists an example in execution with the Transantiago of Santiago de Chile, functioning with low-floor buses. The public transport based on low-floor buses could be considered a point of reference for other cities in the so-called “Third World”.

The alternative, suggested in this work is different from the TransMilenio model in various technological and organizational aspects. Some of these differences have a direct relation with the technology of the buses. Among them are the technology of low-floor buses which permits the amplification, intensification and different organization of the bus lines, and another type of bus stop (or station). We have also thought another entrepreneurial organization of the operation, and a different management of the social process of transition which is inevitably related to the elimination of the current inefficient public transport system.

#### **3.1 The technology of low-floor buses**

This work is based on the technology of low-floor buses which are characterized for having its large entrance and exit doors practically on the same height of the sidewalk, in order to find the best solution of public (mass or BRT) transport with an integral and environmental vision of sustainable urban transport. Within the bus the passengers move at the same height of the entrance (see of

Figures 2 and 3), there exist no steps, the buses have enough space for wheelchairs, baby carriage, and big bags. In the case of Cali, the low-floor buses should function with natural gas, the less toxic combustible available in the Colombian market, which additionally would allow reducing the operation costs of the system and thus the price of a bus ticket: natural gas costs half of diesel in Colombia and is more friendly to the environment.

### 3.2 The different organization of the bus lines

The low-floor buses (for 60, 100 or articulated for 160 passengers) can use whatever street with pavement, without the necessity to construct a more resistant bus lane, because they are less heavy than the high-floor buses. This is a very important advantage because it allows a more dense network of bus lines which covers all town and not just some sectors of it.

In the case of Cali, it is proposed the creation of a 350 kilometer-long network of bus lines in a total street network of 2300 kilometers (while the MIO only foresees one of 250 km), with an average distance of only 700 meters between the bus lines. The combination of lineal and circular bus lines, reflecting the structure and growth of the city, would permit the majority of the passengers reach whatever destination in town by changing the bus line only once, thus significantly reducing the total time of the ride.

### 3.3 A different type of bus stop

For low-floor buses, it is not necessary to construct tall bus stations, reducing in this way the environmental impacts related to absolutely all the infrastructure construction. (Moller, 2006) Low-floor buses may circulate in the center of a road or in the right one of already existing traffic lanes. Using the right lane of a street permits in Cali and other Colombian cities the use of the already existing well designed bus stops. (See Figure 4) Consequently, in the case of Cali, this proposal is that the low-floor buses would always use the right lane of the roads, also in the roads with high passenger demand. In our opinion it is not necessary to have them circulate by the center of the road, thus allowing a significant reduction of the construction costs of the BRT system.

### 3.4. Exclusive bus lanes only where it is necessary

In order to assure the average velocity of minimum 25 Km/h for the BRT (already achieved by TransMilenio in Bogotá), it is necessary to create exclusive bus ways also for the low-floor buses. But it is proposed to do it only in those roads of the city, where the risk of traffic congestion exists. In the roads of the city, where common traffic flows well, the buses could ride among all other motorized vehicles. The exclusive bus lanes can be created at very low costs with the well known separators from Bogotá. (See Figure 5).



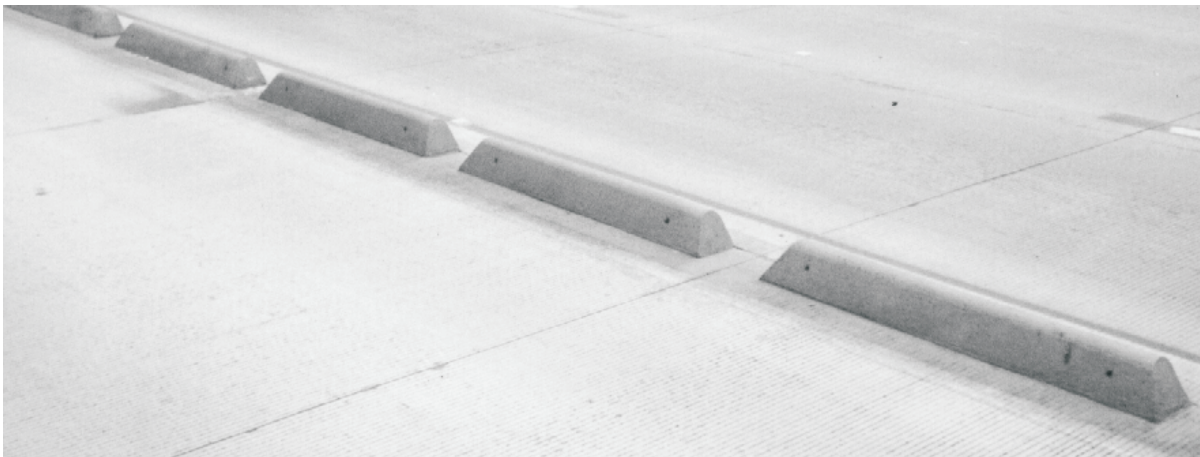
Figures 2. The technology of the low-floor buses



Figures 3. Entrance of the low-floor buses



*Figure 4. Model of a bus-stop*



*Figure 5. Separators for the creation of exclusive bus lanes*

While the previously mentioned elements of our alternative depend directly or are closely related to the technology of the low-floor buses, there are others very important, which do not have direct relationship with the technology.

### **3.5. The differentiation in the price for a bus ticket**

As our alternative for the unique bus ticket of the TransMilenio model, it is proposed the differentiation in the price for a bus ticket based on the distance of the bus ride in the BRT system: in the case of Cali that means that there will be linear bus lines from the right ends of the city to the center, and circular routes which surround the center with a distance of 700 meters among them. The persons who want to ride a short distance use only one of these bus lines. They pay half of the fee of those passengers who want to cross the whole city, or have a large ride, and therefore have to pay for two bus lines. In the case of Cali this means that in order to pay 0.8 US-Dollars for a whole net ticket (value of public transport today and for a TransMilenio or MIO ride), those who use only one bus line would pay just 0.2 US-Dollars for the ticket. Crossing all the city would cost only 0.4 US-Dollars (estimated values adjusted to the year 2009) (Moller, 2004, 2006). Using low-floor buses would mean a reduction of the ticket price in comparison with the nowadays price and the ticket price in the TransMilenio model of mass transport. There exists the possibility to differentiate more the ticket's price in the future, based on the hour of the day, the distance of the bus ride, possibly the social status of the passengers, or tickets for daily, weekly or monthly use.

### **3.6. The public-private operation company**

For the operation of the mass transport system It is proposed the creation of a public-private enterprise, based on shares, with a participation of the city which administers the BRT. In Cali, it is proposed 28 % of the shares in the hands of the city, 24 % in the hands of the companies which actually operate the public transport, 24 % in the hands of the present bus owners, and 24 % of the shares for new investors. The mixed public private enterprise would operate the system, sell the tickets, and administer the finances. The mixed

enterprise would be the owner of the low-floor buses, would pay to each of the share holders their participation in the corresponding earnings in the whole mass transport system. The private share holders would assure the economic efficiency of the system, and would prevent corruption or political influence because only in this way they can expect earnings. The city would represent the social function of mass transport and assure the high quality of its service for the passengers.

### **3.7. The social solution for the employees in the transition process**

Contrary to the practice in TransMilenio and the MIO, in this alternative, it is proposed that all the people working nowadays in the public transport will find stable employment and a salary for a dignified life in the new mixed operation enterprise. Obviously, today there is an excess of employees working in the public transport service of the town. It is one of the management's duties to adapt gradually in a period of 3 to 5 years the number of employees to the level really necessary for an efficient mass transport system, without firing anybody, using the well known methods of human management in processes of staff reduction.

## **4. The critical comparison and evaluation of the two models of BRT with criteria of sustainable development**

The anterior description and characterization of the two models of a public (o mass) transport (or BRT) serves as a base for its comparison and critical evaluation. (Moller, 2004, 2006).

The urban transport is a transversal activity which affects the accomplishment of the Millennium Development Goals accorded in the frame of the United Nations and accepted by Colombia, especially the goal to reduce the poverty to half of its today's level until 2015, assuring the access of all persons to the places of employment and education, and to foment gender equity. (Naciones Unidas, División de Desarrollo Sostenible, 2006). The urban transport and within it the systems of public (or mass) transport have to fulfill the criteria of sustainable (urban) development, a

concept which in Colombia forms part of the political Constitution, and is political reference point also to many other Latin-American countries. That's why it is first defined as an important criteria of sustainable development, which a public transport system has to fulfill; (Moller, 2006) and then it will evaluate important aspects of the public transport or BRT, among them the quality of the system for the passengers, its costs, its environmental impacts, its economic and financial impacts on the public investment and treasury.

#### **4.1. The criteria of sustainable development**

The concept of sustainable development is still highly controversial, with very diverse and contradictories interpretations.(Sachs, 1996). In the context of urban transport in Latin America. It is defined, for the purposes of the next comparison and critical evaluation of public transport systems, the following criteria:

##### **Environmental criteria**

The public transport system must be the least poisoning and noisy, technically possible. It must use the least poisoning combustible, preferably natural gas in Colombia, which makes the motors also less noisy. The system should fulfill at minimum the EURO III emission standard. There should be a minimized environmental impact caused by the materials and the energy used in the construction of the infrastructure (bus stations, exclusive bus lanes, pedestrian bridges and so on) and of the buses.

The quality of the public transport system must allow and promote the reduction of the daily use of private automobiles and motorcycles.

##### **Social criteria**

From the point of view of the passenger, the public or massive transport system must satisfy the mobility needs of all citizens, without limitations or social exclusion for reasons of earnings, gender, age, or physical and health conditions. The service must define a time schedule for each bus stop and the time of a bus ride from the starting station to the final, or must be calculable for the

passenger. The public transport must contribute to social and gender equity in the urban transport. It must cover all the town, including its rural zones, and should provide a good integration with the smaller cities in the metropolitan area, in the case of the BRT of a big city. It must not create social exclusion of the poor due to the costs for a bus ticket. The public transport must contribute to the reduction of poverty, guaranteeing the free access of all citizens to the sites of education, work and recreation. From the point of view of the persons who work in the public transport system, it must offer sane labor conditions and earnings for a dignified life of the workers and their families.

The change to a highly efficient public transport system must be made without causing the trauma of unemployment. The change should be made with social criteria, regarding not only the interests of the owners of the enterprises and vehicles of the present public transport, but also that of the employees.

The public investment in the BRT or public transport system must not reduce the social investment capacity of the central and local governments to finance the investment in other unsatisfied basic necessities of the population, like education, health, housing, security and so on.

##### **Economic and financial criteria**

The public transport system has to promote the economic development of the city and its metropolitan area, elevating the regional economic productivity, giving access to the sites of work and education of its habitants. It should assure the participation of regional enterprises in the construction and the operation of the system, at least when the technical and administrative capacity is disposable in the city.

Because of the risks, which constitute high levels of indebtedness of the national and the local governments, for the quality of life of future generations, the public indebtedness should be avoided as much as possible. Not only the financing of the infrastructure construction must be guaranteed, but also its maintenance in the moment when the first signs of erosion inevitably appear, after some years of constant use. Only in



this way the long-term financial sustainability of the public transport system could be assured. The system must be constructed with the best quality cost relationship.

### **Political criteria**

A public- or mass-transport system must be designed as an essential element of an overall sustainable urban transport. At the same time of the BRT creation (or even better before), more options for a secure and pleasure walking and use of bicycles all over the town should be created, because a massive use of these mobility modes would permit reduce the size of the public transport system, with many additional positive public health and environmental effects. The system must promote the more rational and reduced daily use of private automobiles and motorcycles. (Alcaldía Mayor de Bogotá / World CarFree Network / Fundación Ciudad Humana, 2006; Peñalosa, 2002; Wright, 2005) Together with a good public transport system the existence of a rational and well organized, high quality public transport with taxis should be guaranteed.

### **4.2. The comparison and critical evaluation of the two models presented**

Taking in account the anterior criteria and elements of sustainable development it is now possible to compare the TransMilenio model with the alternative of a public or mass transport (or BRT) system, based on the technology of low-floor buses with a different entrepreneurial organization, following the aspects:

#### **The quality of the buses and of the service for the passengers**

In Bogotá the general impression is that the TransMilenio system will cover the whole town with the articulated high-floor buses in their exclusive bus ways. But in reality, there only a bus line network of 388 kilometers will be constructed with its exclusive bus lanes for the articulated high-floor buses. This means that in a total road network of about 7.000 kilometers (IDU, 2004) only a very limited part of the population will have a direct access to the articulated buses and the elevated bus stations. The passengers who live at a

distance of more than 500 meters from the exclusive bus lanes, will have to walk at least 12 minutes just for entering in the bus station. But what makes the things still worse is that at least half of all passengers has and will have to use first a feeder bus in order to be transported to the terminal bus station where they can transfer to the TransMilenio bus line (Castro, 2006). The majority of the passengers will have to walk afterwards large distances to their destination. The obligation to change once or twice the bus line makes the ride slow for the passengers. This effect is increased because of the necessity to walk long distances, crossing large pedestrian bridges in order to enter the bus station, and within the bus station in order to find the exit door for the respective bus line. (Cámara de Comercio, 2005). About 70% of the citizens will not have access to the TransMilenio buses, but will have to use the bad buses of public transport.

Having to change possibly more than once the bus line, and losing time walking long distances is a direct consequence of the creation of exclusive bus lanes with elevated bus stations for the high-floor articulated buses for 160 passengers of the TransMilenio model of BRT. Bus lines with such a high passenger capacity are only economically viable if a high passenger concentration is attained. It is necessary to bring first a huge number of passengers to these exclusive bus lines, in order to distribute them afterwards to their destinations, despite the fact that the average ride in Bogotá is not longer than 8 kilometers. This type of the bus-line network organization increases the ride time for many passengers. The high costs of the exclusive bus lanes (“troncales”) make it impossible to construct a more dense network. (Sarmiento Palacio, 2004; Cámara de Comercio, 2005)

In Bogotá, Cali and all the other Colombian cities which introduce a massive transport system based on the TransMilenio model, it is obligatory the use of feeder buses, with high stairs in their entrance and exit doors (See Figure 6). Thus, there is no change in the present situation of social exclusion caused by this type of bus which creates difficulties or the impossibility to board the bus to many people: persons in wheelchairs or with physical limitations, with problems of obesity,

with baby carriage or babies in their arms, with a large baggage, children and so on. With the use of this type of feeder bus, the TransMilenio model perpetuates the social exclusion for a significant part of the potential passengers. In Cali, this social exclusion will affect more than 80 % of the bus lines.

Also, the entrance barriers in the elevated and closed bus stations trouble the life of persons in wheelchairs or with baby carriage. They make necessary the permanent and expensive presence of a person to open the entrance for these passengers.

In comparison, our alternative with the low-floor buses permits the comfortable entrance and exit of absolutely all persons, without any restriction, in all the bus stops of the town; this is still more valid in buses with an hydraulic mechanism which

permits them descend even more to the entrance level.

The alternative with low-floor buses would permit in the case of Cali and in all other cities the creation of a very dense bus-line network, with distances of no more than 700 meters between them, which would permit the great majority of the passengers reach their destination with only one change of the bus line in the worst case. Being able to reach destination without or with a single changing will make the bus ride much more speedy for the passengers. The short distances between the bus routes will result in a reduction of the distances to walk to the nearest bus stop or to destination. Thus the system liberates productive time or free time for the family, education, to have fun and so on.



*Figure 6. High stairs in feeder buses*

This special quality of the low-floor buses permits its use for absolutely all of the citizens, and makes very desirable its use in all the bus lines in the whole town. But there exists a limitation: it is not possible to use low-floor buses in streets without pavement. Thus, it would not be possible to use them in quarters where streets with pavement don't exist. It is necessary, the paving of streets in the poor quarters of the town, but not only to permit the entrance of low-floor buses of the public transport, but also to prevent that pedestrians and cyclists have to mobilize themselves among dust or mud. For reasons of social equity the street pavement in poor neighborhoods should be a political priority in Colombian towns.

In the case of very big cities, it is also important to organize a bus line network within the suburbs based on internal mobility necessities, and not just as feeder buses to terminal stations of the exclusive bus lanes. In the case of Bogotá, for example, some of the feeder zones are in reality "towns" with approximately 100.000 and more of habitants, many of which have their own mobility necessities within the suburb.

### **The value of a bus ticket**

The value of a bus ride in all TransMilenio lines in Bogotá and the MIO lines in Cali is, at the end of 2009, equivalent to about 0.8 US-Dollars. This price for a bus ticket means that many people in poor homes will not be able to use the massive transport system because of the lack of sufficient income: to use the bus twice a day, 26 days monthly, would mean monthly expenses per person of about 42 US-Dollars, or about 17 % and more of the monthly income of the majority of the Colombian families (who live with the so called legal minimum monthly wage; more than half of the Colombian population lives below the level of poverty). The Colombian review "Semana" informed that one million people in Bogotá (of a total population of about 8 million) have to walk each day because they do not have sufficient money to buy a bus ticket. (Semana, 2006)

This alternative with the low-floor buses and a differentiated ticket price would permit to many new clients in the case of Cali to have a ride to the city center (or other short distances using only one

of the bus lines) for the price of about 0.2 US-Dollars. Crossing all town - changing once the bus line - would cost about 0.4 US-Dollars, based on our estimations (adapted at the values of 2009). The possible reduction of the ticket price in comparison with the present one - must no surprise: it is a logical and possible consequence of changing a highly inefficient present system with 5.000 buses in circulation, for a rational and efficient mass transport with about 800 low-floor buses (for 60 and 100 passengers), functioning with natural gas. (Moller, 2004, 2006)

In the case of Cali, despite the strong reduction of the ticket price for the passengers, the alternative with the low-floor buses produces daily utilities of about 45,000 US-Dollars for the mixed operation enterprise, according to our estimations.

Comparing the two models of (mass or BRT) public transport, only the alternative with low-floor buses can improve significantly the mobility of poor people, giving them the chance to leave poverty behind, and freeing parts of the family's incomes for the satisfaction of other basic needs.

### **Frequencies versus a time table in each bus stop**

In Bogotá and Cali, TransMilenio and MIO, work with frequencies defined for each of the bus lines in the exclusive bus lanes with its elevated bus stations. Its compliance is controlled by a satellite control system, which permits to know the position of each bus in circulation.

A massive transport service functioning with frequencies and not with a precise time table in each bus stop, causes deficiencies for the passengers which are worsened in case of the existence of different operation companies for the exclusive lanes ("troncales") and the feeder buses. In the case of Bogotá's TransMilenio and in Cali's MIO, the passenger is informed about the frequencies of the different bus lines in the interior of the bus stations. But he does neither know the time the bus needs to reach the destination bus station, nor the time he has to wait until the feeder bus leaves from there. Thus the TransMilenio model perpetuates one of the most serious problems of the present public transport: it is impossible for the passenger to calculate the total

time to reach his destination. This deficiency is not felt so strongly in rush hours with bus frequencies of less than 5 minutes in each bus line. But the problems grow in the low demand service hours, very early in the morning, in the nights, and especially for the persons who need a connection with a feeder bus. In this case it is possible that a passenger who does not know the exit hour of a feeder bus, has to wait 20 minutes or more, a fact that reduces drastically the attractiveness of a mass transport system. In the actuality, half of all TransMilenio passengers have to use a feeder bus.

In the case of Bogotá, the situation is worst by the existence of different operation enterprises without a coordination among them and for the different lines.

But another related and very important aspect is the profitability of the mass transport system. The existence of a few rush hours with high demand makes inevitable the existence of many daily hours with a low or very low passenger demand, especially in some of the feeder zones. In these hours with a low demand it is impossible to have circulate feeder buses frequently, because it would cause losses to the operation company.

To resolve this conflict between the financial viability of the operation company and the high quality of service for the passengers, we propose as a solution the definition of precise time schedules in each bus stop and for each of the bus lines. All of the mass transport systems in European cities function this way. The complete time schedule of all bus lines permits a passenger to calculate precisely the time he needs from one point of the city to whatever destination. In reality, some times the buses are a little bit late, but they never leave the bus stop before the scheduled hour.

An important argument in favor of a precise time schedule is that from the point of view of the passenger, more important than high frequencies, is the possibility to organize with precision his journey in bus. Generally it does not constitute a big problem to have a time schedule each 15, 20 or even 30 minutes, if the rapid connection with other bus lines is assured in the crossing points of the mass transport system.

A bus service with a precise time schedule has another economic and cost advantage: it permits the operation companies to define the needed passenger capacity of the buses, reducing costs with using smaller ones in low demand hours, what could be translated into a minor ticket price. A satellite control system is not necessary: the time schedule permits to know where each bus is in whatever moment of the day, and his position could be verified in direct contact with the driver. And it is always necessary to have a communication system between the operation center and each bus.

### **The environmental impacts**

The high-floor articulated buses of TransMilenio with its diesel engines contaminate the air significantly, despite the fact that the diesel sold in Bogotá is the best disposable in Colombia. In Cali, in the complete MIO system will be used about 1000 vehicles, among articulated high-floor and feeder buses. In the first phase of operation, all the buses work with diesel engines, despite of the existing incentives to use natural gas. (El Pais, 2004; Metrocali S.A., 2006). The permission of diesel means in Colombia to maintain a too high level of air pollution. It is to know that the Colombian diesel used outside the capital pollutes 50 times as much or more, as that for example used in the low-floor buses of the mass transit system in Santiago de Chile.

In this alternative, It is possible to prove that in Cali, with only about 800 low-floor buses for 60 and 100 passengers there could easily be mobilized more than 1.5 million passengers per day, without the necessity of heavy articulated buses, and using natural gas. (Moller, 2006) Thus, this alternative would create a better mass transit or BRT service for the passengers, with less vehicles, which are less heavy than high-floor buses, polluting less the air and producing minor noise due to its minor weight and the use of natural gas. Our alternative fulfills better the environmental criteria of sustainable development. (GTZ, 2005)

Additionally, the low-floor buses do not need the huge infrastructure obligatory for the high-floor buses: reconstructed exclusive bus lanes with its

high-floor bus stations and large pedestrian bridges, which characterize the TransMilenio model. The technology of the low-floor buses permits reduce dramatically the environmental impacts of the construction and maintenance of the infrastructure and the vehicles. In the cases of Bogotá and Cali the experience has shown, that during the construction period of the exclusive bus lanes rises seriously the total air pollution due to the resulting daily traffic chaos. This is very important due to the large construction period. In the case of Cali, the construction period was planned in 4 years: in reality the construction of all the infrastructure will last about 12. All these years with an elevated air pollution.

### **The infrastructure costs**

The infrastructure costs of TransMilenio in Bogotá and of the MIO in Cali are very high, and affect the financial sustainability of the cities despite the fact that the costs for this model of BRT are lower than that of a subway system of mass transit, which could neither be financed by nor is very useful in “underdeveloped countries”, because the majority of the passenger would always have to be mobilized in buses. The articulated high-floor buses, with its 32 tons of weight full of passengers, require the construction of a huge infrastructure, which includes the construction of gorgeous bus lanes, jointly with the reconstruction of the lanes for all other motorized vehicles, the construction of elevated bus stations and pedestrian bridges, among others. Below the exclusive bus lanes it is necessary to reconstruct at high costs the service system (water, wastewater, electricity, telephone). In Bogotá, the costs for the construction of the first 41 kilometers of exclusive bus lanes (“troncales”) between 1998 and 2002, with its 61 bus stations, ascended to 350 million US-Dollars. (Hidalgo, D. & Herrmann, G., 2004) The real present costs per kilometer of a TransMilenio exclusive bus lane in the III.

Construction period are about 40 million US-Dollars in 2009, when at the beginning the costs per kilometer were calculated in 5.2 million US-Dollars. (Hidalgo, 2006) It will simply not be possible to construct the projected 388 kilometers of bus lines of TransMilenio with the initially calculated budget. Thus the administration of

Bogotá and the Colombian government are already fighting about whom has to assume the higher costs, and, with the impossibility to finance the system, it is planned now in the Mobility Master Plan of the city to complement the TransMilenio bus lines with reorganized bus lines of the actual public transport, eliminating the “penny war” among the bus drivers in order to transform it into a good service.

In Cali, initially the public investment in the construction of all the related infrastructure for the MIO BRT was calculated in 345 million US-Dollars, including 49 kilometers of exclusive bus ways, the reconstruction of the roads with the exclusive lanes, the construction of elevated bus stations, pedestrian bridges, a few bridges for motorized vehicles, among others. Only for the financing of the initially calculated 345 million US-Dollars which later rose to more than 500 million (DNP, 2005) and in 2009 are calculated officially in 1281 million US-Dollars the national government, which covers 70 % of the total public system costs, had to look for a 200 million US-Dollar credit from the Interamerican Development Bank, BID. Cali has to sacrifice at least until the year 2019 about 70 % of a special tax on combustibles in order to finance the MIO. One of the consequences is that the city cannot realize the maintenance of its streets: the principal streets are very deteriorated, and cause additional accidents and traffic congestions. In reality, still at the end of 2009 the financing of the MIO BRT is neither clear nor sure. The MIO BRT project has all the characteristics to affect seriously the financial situation of the city during many years. In fact, the budget of the city is already controlled by the national government and the banks, due to the elevated level of public indebtedness of the city, and the city has no autonomy about its budget. Its very probable that the MIO project will eliminate the social investment capacity of the city during many years. The national government in the person of the Colombian president, Alvaro Uribe Vélez, obliged the city and its municipal service enterprise EMCALI to assume about 120 million US-Dollars of costs for the reconstruction of the service red (water, wastewater, electricity) below the exclusive lanes, expenses which were not included in the company's budget, and can now not be used to improve its services in the poor

neighborhoods. At the national level the indebtedness of the country is not that far away from critical levels.

In comparison with the total costs of (at least) 1.281 million US-Dollars (at the end of 2009) for the MIO version of the TransMilenio model, the alternative of a BRT with low-floor buses could be built with total costs of less than 30 million US-Dollars, according to our preliminary estimations. This is due to the fact that the low-floor buses do not need the construction neither of gorgeous exclusive bus ways, nor the reconstruction of the lanes for all other motorized vehicles, nor the construction of elevated bus stations and pedestrian bridges.

The low costs of the BRT project with low-floor buses is caused by the fact that low-floor buses of whatever size do not need especially prepared lanes. Inclusive, the articulated low-floor buses with a weight of about 27 tons (with passengers) can use whatever normal street with an even pavement, a fact that can easily be registered in all European cities, where nearly the totality of all public transport buses are low-floor and circulate in all the streets of the towns (inclusive articulated and bi-articulated buses). Instead of the expensive elevated bus stations, it would be possible to install the nice bus stops, already known in the city, constructed and administered by a private company. The creation of the exclusive bus ways is very cheap. The city has to invest simply and principally in the reparation and maintenance of the lanes at the right side of the streets used by the buses of the BRT system.

There have to be adapted the semaphores with special signals for the buses in order to allow its priority (“ola verde”). And it is necessary to install signals for pedestrians and cyclists, and to paint “zebras”, in all the intersections with bus stops.

About the cost aspect of the public investment in infrastructure for the massive transport system it is important to make emphasis in the fact that the relative success of TransMilenio in Bogotá does not depend on the technology of high-floor buses, but to have created exclusive bus lanes, to have eliminated the so called “penny war” with the

exclusiveness of the bus lines of TransMilenio in a road, to have organized the anticipated selling of the bus tickets and the rapid access of the passengers to the buses. The same basic elements of mass transport or BRT could easily be realized in a system with the technology of low-floor buses.

Additionally to the comparison of the costs of the two BRT models in the moment of the construction of the infrastructure, it is necessary to include its necessary maintenance which appears earlier or later, depending of the quality of the work done. In order to cover these future costs, the tickets had to be doubled in Bogotá, according to Sarmiento Palacio (2004), what would cause a social exclusion effect much more profound than the present one. In Bogotá, TransMilenio does not provide incomes for these future expenditures to the municipality. Thus the TransMilenio entrepreneurial model sacrifices the social investment and the financial health of the city at the expense of future generations.

In this alternative, it is previewed the participation of the city in the revenues of the massive transport system, which guarantees the financing of the necessary maintenance of the infrastructure, and possibly additional revenue for social municipal investment.

Using financial criteria of sustainable development, only in our alternative with low-floor buses neither the central government nor the city have to run into debt. We estimate that the costs of the creation of the mass transport system could be covered with the current income of the special tax on combustibles (“sobretasa a la gasolina”), and that very soon these incomes could be used for other purposes, for example the pavement of the about 30 % of the municipal streets in poor neighborhoods without pavement nowadays.

The comparison of the anterior aspects of a BRT system is directly related to the technology of low-floor or high-floor buses. The following themes of comparison are independent of the bus technology.

#### **The creation of the mixed operation company**

In the TransMilenio model, the entrepreneurial

organization of the mass transit system is the following: TransMilenio S.A. is the public municipal company of Bogotá, owner of the system. The city constructs the infrastructure. TransMilenio S.A. gives concessions to private operation companies which buy the buses, realize their maintenance and hire the drivers and other necessary personnel. The operation companies in the exclusive bus lanes (“troncales”) with its articulated high-floor buses receive 65 % of the total system incomes, those with a concession for the feeder lines 20%. The base for their remuneration is the total of kilometers circulated by each of their buses. Another company sells the bus tickets and receives 11 % for this service. TransMilenio S.A. receives 3 %, and 1 % of the total income goes to an investment fund. In Bogotá, the companies and the owners of the vehicles which realized the public transport service before in the roads with the now exclusive bus lanes of TransMilenio, were replaced by big consortium's.

Instead of five operation companies and one for the ticket sales in the massive transit MIO in Cali (including the companies which actually operate the public transport), in our alternative we propose for the administration and operation of the system the creation of a mixed private public company, based on shares, with a 28 % participation of the city of Cali (jointly with others from the metropolitan area), a 24 % participation of the operation companies of the present public transport, a 24 % participation of the present bus owners and another 24 % participation for new investors. The unified mixed private public enterprise would operate the mass transport system, buy the low-floor buses, employ the drivers and other staff, sell the bus tickets and remunerate the share holders based on the utilities produced by the whole system and the respective individual share participation. This entrepreneurial, administrative and operational organization would assure the optimal operation of the massive transit system, avoiding problems of coordination among various or multiple companies.

In the case of Bogotá for example have occurred already several times violent protests of the TransMilenio passengers due to the coordination

problems between the companies of the main and the feeder bus lines. In order to save money and to reduce costs, the feeder buses companies circulated only a small number of vehicles, and the passengers had and have to wait a lot of time until finding a free space in a bus.

For the optimal coordination of the time schedule in all of the bus lines it is better to have only a single operation company, similar to the situation in all of the large European cities and its metropolitan areas, which successfully coordinates the schedules of subways, regional and large distance trains, buses, ferries (if it is the case) and so on. An additional advantage of a single operation company is, that it is not necessary to finance the management and administrations of various or multiples operation companies. The existence of various operation companies and one for the ticket sales makes the whole BRT system more expensive and does not permit the reduction of the ticket price, maintaining the cost-factor of social exclusion in urban transport.

In the mixed operation company, the social interests of the population are represented by the cities, meanwhile the private shareholders assure the high entrepreneurial efficiency avoiding corruption and inappropriate political influence.

In the case of Cali, this preliminary estimations showed that the mass transit system could produce daily utilities (before taxes) of about 45.000 US-Dollars. (Moller, 2004; estimation adapted to the values of 2009), a high level of utilities compared with other economic sectors in Colombia. Of these utilities, a quarter (about 11.000 Dollars) would enter in the treasury of the city and could be used for the maintenance of the infrastructure or for social investment in housing, education and health.

### **The social solution of the transition process**

In the TransMilenio model of BRT were taken into account only marginally the interests and the future of the present public transport companies, the owners of the buses, and still less those of the drivers and other employees who worked or are still working today in the public transport. In this alternative, it is proposed, that the new public-

private operation company gives stable employment to all of those who are working now in this activity. Obviously, today exists an excess of staff in the highly inefficient public transport. It would be one of the management's tasks to reduce the staff number to a level really necessary for an efficient system of mass transit, gradually in a horizon of 5 years without “firing” anybody. Thus our alternative guarantees the social element of sustainable development, creating quality employment for a dignified life, and avoiding the deepening of local unemployment and poverty.

## **5. Other critics**

### **5.1. Lack of an integral solution for urban transport**

In Bogotá, the last five municipal administrations have shared the vision of a city for the people (and not for cars), with an approach towards an integral solution of urban transport problems, giving space to pedestrians, cyclists, and intending to reduce the private car use. (Peñalosa, E., 2002). In the case of Cali, and in other Colombian cities, who copy the TransMilenio model of public transport, a similar vision is completely absent.

But despite of the good intentions in Bogotá, unluckily, the realized solutions have not taken into account the special conditions of a so called “underdeveloped country”, with strong financial limitations for the central and municipal governments. Bogotá disposes in 2009 of about 350 kilometers of separated cycle lanes, which unfortunately represent security in only 5 % of all the roads in the town. While cyclists continue to risk their lives among the motorized traffic in 95 % of the town's roads, the bicycle can not convert itself in a daily mobility mode. The persons in charge for the design of the cycle lanes were obviously erroneous about the principal use of the bicycle when they constructed the cycle lanes principally in the center or in the border of main arterial roads. The bicycle rarely is used to cross all the city or for large distances; the bicycle needs security for short rides (a few kilometers), within the neighborhoods and between quarters.

Additionally, the costs of the constructed cycle

lanes were and are very high, and thus it is nearly impossible to amplify the cycle lane net under the permanent condition of 'public poverty' not only of Bogotá, but of all Colombian cities. It is necessary to create more cheap alternatives for cyclists and pedestrians, redistributing the disposable public space, which includes the lanes today used by the motorized vehicles. (Moller, 2006)

### **5.2. Encouragement of motorized private traffic**

The TransMilenio model and the MIO case encourage with the reconstructed infrastructure in reality the daily use of automobiles and motorcycles, in open contradiction with one of the most important functions of a mass transit system: to promote a reduction of the daily use of automobiles and motorcycles. In both cities more space is covered with pavement in the lanes for the private motorized traffic than in the exclusive bus ways for the high-floor buses. In Cali, according to its President, the public company Metrocali S.A, responsible for the MIO BRT, aspires to construct more than a dozen of new bridges for motorized vehicles in traffic intersections, with its principal function to guarantee the permanent flow of private vehicles, and without any utility for the buses of the mass transit system. (Moller, 2006)

The large period of infrastructure construction between 10 and 20 years in the cases of Cali and Bogotá are a reason for many to buy a car or a motorcycle. Because during the years of construction of the necessary infrastructure, the BRT systems with high-floor buses do only cover a small segment of the town, and the deficiencies of public transport persist. It is well that it very difficult to motivate drivers of cars and motorcycle to change to mass transit after being costumed to their motorized vehicles.

## **6. Conclusions**

Mass transit systems based on buses are the only realistic solution to satisfy the mobility necessities of the majority of the population in cities of the so called “third world”. But the TransMilenio model of BRT / massive transit / public transport has very



serious deficiencies: in the Colombian cases, it contaminates a lot, is slow and expensive for the passengers, excessively expensive for the public finance, maintains social exclusion because of the ticket price and the type of feeder bus with high steps, and thus is not capable to contribute to a reduction of poverty and to complete other Millennium Development Goals.

On the contrary, using the technology of low-floor buses in public transport or BRT systems permits fulfill all criteria of sustainable urban transport.

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