Bus Rapid Transit (BRT) in Touba, Senegal

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Mots-clés

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Introduction

Senegal is located in the western part of Africa's Sahel region and has a territory of 196,722 km². Senegal's population is estimated at 15.3 million as of 2016. According to the latest population census conducted in 2013, 23% of the population lives in the Greater Dakar region (0.3% of the territory), and 40% lives in other urban areas[1] Touba, the Muslim holy city founded by Shaykh Ahmadou Bamba Mbacké in 1887, is Senegal's second largest urban site and the capital of the country's powerul and popular Mouride order[2].

Since 1970, Touba has experienced a spectacular demographic growth from a small rural community of 30,000 inhabitants to a city with nearly 1 million inhabitants.

Today, transport system in Touba is considered a real problem. A chaotic circulation with almost 15,000 carts on the roads is the principal cause of accidents, overloads and recurrent traffic jams.

Outdated transport vehicles and a mediocre sector management system hasn't followed its population growth and had hindered the development of this field.

In order to address this issue, we propose to implement a BRT system (Bus Rapid Transit). It will improve the over-all performance of the urban passenger transport system in terms of quality, level of service, safety, and environmental efficiency.

1. The BRT project

1.2. Why a BRT Project?

Two transport systems were considered in this project: Bus Rapid transit and Tramway. These choices had to meet the requirements of capacity, reliability, cost-effectiveness and longevity. A system that includes a dedicated lane was chosen because it gua-

1. World Bank Group. *Senegal Overview* [En ligne]. Disponible sur http://www.worldbank.org/en/country/senegal/overview (Consulté le 16 février 2018).

2. ROSS Eric S. *Sufi City: Urban design and archetypes in Touba*. University of Rochester Press, 2006.

rantees they have right of way before other vehicles, thus a high commercial speed and a rapid transit between stations compared to the other transport systems.

BRT also provides flexibility to the network. Bus routes can change and expand when needed, for example during the four days of the Grand Magal. Also, buses can use existing roads and general traffic lanes can be converted into dedicated lanes. Regarding financial costs, in front of a tramway, the BRT requires a lower capital cost for initial infrastructure and rolling stock investment. Finally, it is used mostly by people who are transit dependent, so bus service improvements provide greater equity. Since the current situation needs a quick action, it can be phased in service, instead of waiting for an entire system to be finished. However, BRT has a shorter life span than a tramway, and at the end of its life span, the costs of maintenance increase considerably.

That's why BRT solution is the most appropriate choice for Touba's new transport system.

1.3. Travel demand and the transport system

In order to predict future demand and performance of the transportation system, a four step model was used.

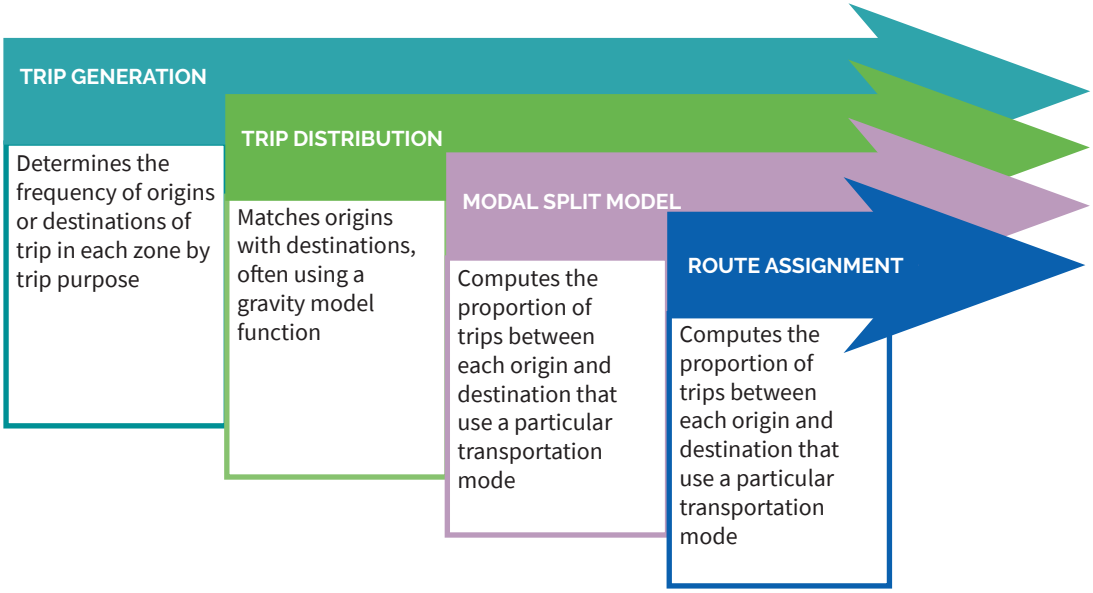


Diagram 1: four-step model.

1.3.1. Traffic demand

We divided the city into 140 areas according to the density of the population. The density was estimated to be high for areas closer to the mosque (city center and economic epicenter of the city) and decreases considerably outside the ring road.

The density and the surface allow us to calculate the population of each zone. The total population of the city was estimated at 894 500: 842 630 in Touba and 52 000 in Mbacké.

Using a gravity model, we were able to estimate the number of trips issued and received per zone and per day. Trip productions were distributed to match the trip attraction distribution. Then, the trip tables were factored to reflect relative proportions of trips by alternative modes. And finally, using all these data, we were able to calculate the population that gets on and off at each station of the principal line: from Mbacké to the mosque of Touba.

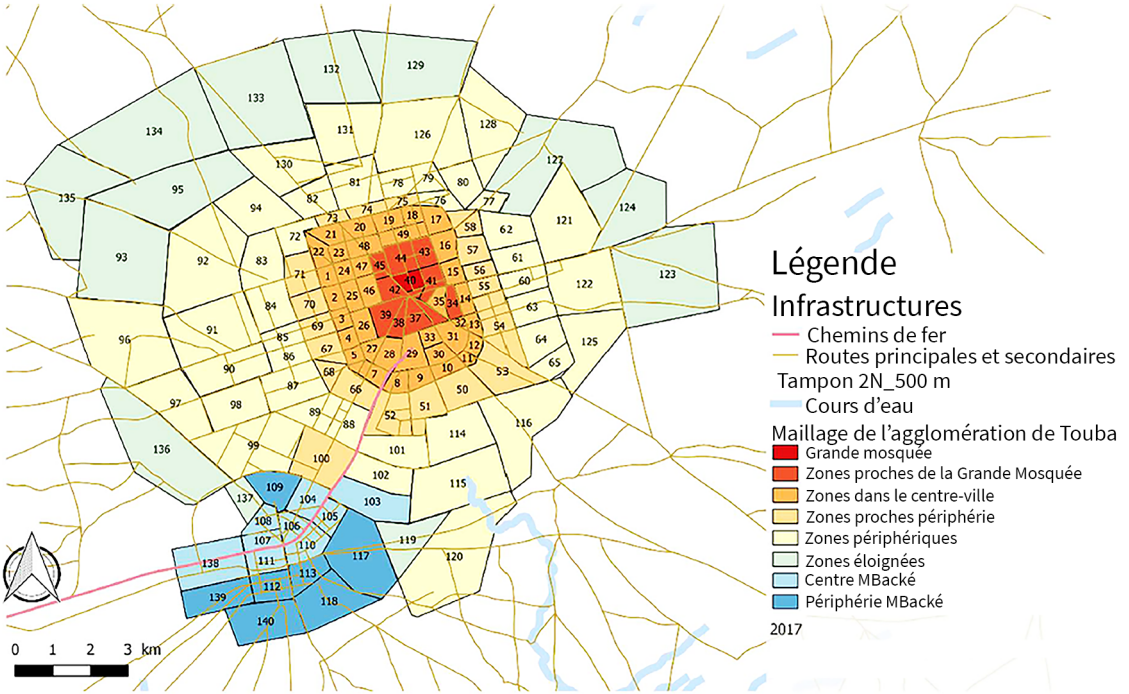
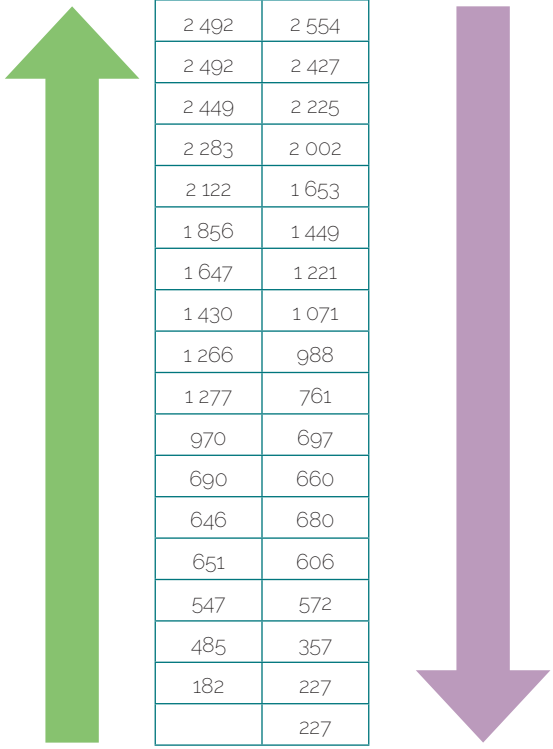


Figure 1: Density zones

For a total population of 894,500 (842,630 in Touba; 52,000 in MBacké), we obtained a traffic demand of 2,554 pphpd (passengers per hour per direction). This value was the starting point to dimension our transport system.



Towards Touba mosque	Towards Mbacké
2 492	2 554
2 492	2 427
2 449	2 225
2 283	2 002
2 122	1 653
1 856	1 449
1 647	1 221
1 430	1 071
1 266	988
1 277	761
970	697
690	660
646	680
651	606
547	572
485	357
182	227
	227

1.3.2. Proposed route

The new transport system will be composed of 4 BRT lines, with a common destination and correspondence: Touba mosque, the main activity point.

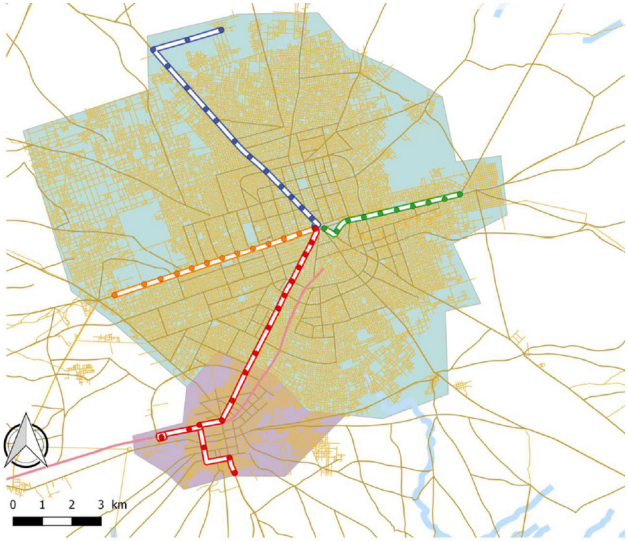


Figure 2: BRT lines for Touba's new transport system

Line 1-south: it connects Mbacké and Touba. The principal stations served by this line are: the local market next to the mosque, Touba University, the Islamic school, the heliport near Mbacké, the old bus station of Touba, the bus station of Mbacké and the mosque of Mbacké. The line 1 south will thus serve the existing railway station of Touba.

Line 2-north: it connects Darou Mousty and Touba. The principal stations served by this line are: the local market next to the mosque, the mosque, the French school, the Darou Mousty community, the Darou Mousty's new bus station, and will be the entry point for the maintenance site that will be located to the north of the city.

Line 3-East: it connects Ndindy and Touba. The principal stations served by this line are: the local market next to the mosque, the mosque, the main cemetery of the city, and the community of Ndindy

Line 4-West: it will connect the future Touba airport and the center of Touba. The principal stations served by this line are: the local market next to the mosque, the mosque, the future Ngabou road station, the Matlaboul Fawzaini hospital and the Dianatoul Mahwa police station.

1.4. Rolling Stock

We took several assumptions in order to find out which fleet suits more our BRT line number 1S. We have found out a peak load of 2554 pphpd (passengers per hour per direction) thanks to traffic expectations previously highlighted. Comparing different operating speeds from Africa to France thanks to a non-exhaustive database, we

advise an operating speed of 21 km/h. Such a speed seems realistic to begin the implementation of a real new public transport system from Touba's inhabitants' point of view.

Headway during peak hour should be of 4 min 30 s. A higher number will decrease the level of service dedicated to inhabitants, whereas an inferior one is allowed and will be used in order to suit the increasing demand if needed. Then, we sized our system giving it some flexibility, which might be very useful when lots of unknown factors remain about the demand.

We have set 3 min of dwell time at stations, justified by terminals operated with traffic roundabouts and a loop at Touba Mosque allowing buses to turn back. According to African common values, we have chosen a value of 6 p/m^2 for the comfort criteria within buses. This value will allow us to think about smaller and cheaper buses when time for purchase of such buses will come.

With these assumptions, we have chosen:

- a capacity of 192 seats per articulated bus;
- a roundtrip time of 60 min;
- a needed operating fleet of 14 buses.

Adding a small fleet of 3 buses supporting the operating one if needed and for maintenance, we finally get a total fleet of 17 articulated buses.

We advise to choose a type of bus based on 3 French existing BHLS systems. Firstly, an articulated bus (18 m × 2.55 m) can be chosen - non-full capacity of transport provided.

It will allow the authorities in charge to meet future needs (rise of the peak load) – by purchasing more buses and reduce headways if possible or purchasing other buses with an increased single-bus capacity.

1.5. BRT Operation

The operation of the new transport project has been done for the line 1-south. This line has a length of 9.6 km and the commercial speed that will be used is 21 km/h. The turnover time is set to 3 minutes, so the total time of the mission in both ways is 60 minutes. All of the previous data allow us to plan the operation of BRTs, during the week: from Sunday to Thursday, for Friday, national holidays and for Saturday. A special planning of operation has been done for the religious celebration of Grand Magal and will be used during 3 consecutive days. Hereby, an example of a week day:

	Time interval (minutes)	Block of time	Number of BRTs in operation per hour	Number of tripsfor the whole route during the block of time	Total distance done (km)
5h30-6h00	10	0h30	7	6	57.6
6h-8h30	4 min 30	2h30	14	65	624
8h30-16h30	7	8h	9	120	1152
16h30-18h00	4 min 30	1h30	14	39	374.4
18h00-22h	10	4h	7	40	384
	TOTAL	16h30		270	2,592

1.6. Maintenance

The BRT new transport project will undergo a cycle of maintenance operations planned throughout their life. The operations will be realized according to the kilometers reached. Four levels of maintenance will be applied in the new transport system.

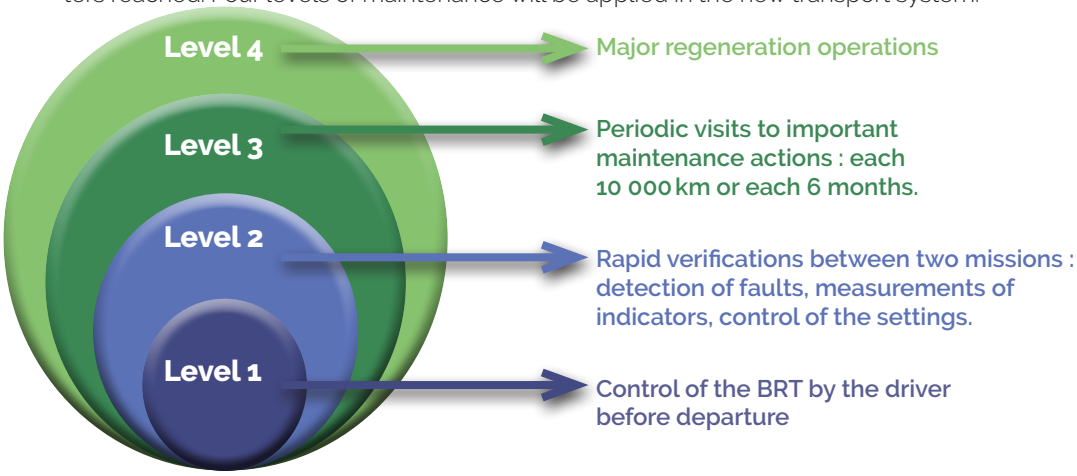


Diagram 2: Levels of maintenance.

2. Public transport Authority

For the implementation of the project, it is necessary to develop an organization that will be in charge of the management of the complete system. We propose two entities with different missions: an institutional entity and a technical entity.

The first one will operate in cooperation with the government and the religious authority of Touba. It will be in charge of the creation of road traffic regulations made for the provision of satisfactory transport services and better compliance with safety requirements of the lanes.

This entity will be supported by the CETUD (Executive council of urban transport of Dakar), which is the only organism in Senegal managing transport system. Every decision taken by the institutional entity will be transmitted to the technical entity.

The technical entity will be composed of: the operations director, maintenance director, infrastructure director, financial director and traffic management director. This entity will be in charge of guaranteeing the implementation of government policies, vehicles maintenance, planning of BRTs operations, pricing policies and road transport services.

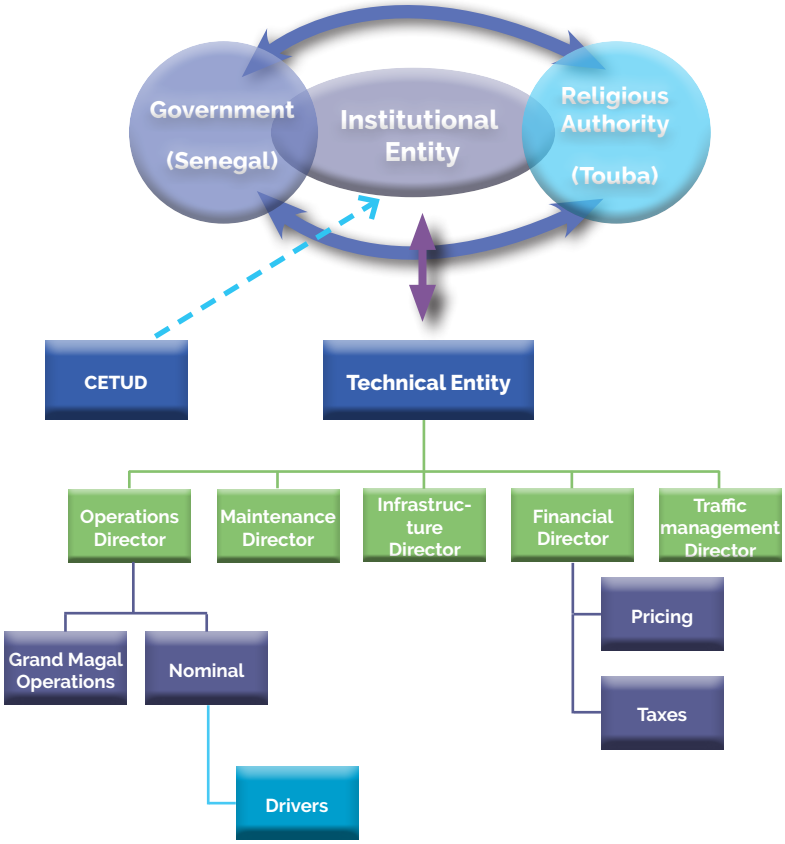


Diagram 3: Public transport authority organization

3. Social and economic balance of the project

3.1. Investment costs to develop the line 1 south

The table below shows the main costs[3]:

	Unit of measurement	Quantity	PU	Cost	Percentage
Assistance project	Unit	1	4 % of total cost	€573,130	4%
Rolling stock purchase	u	17	€250,000	€4,250,000	23%
Civil Engineering				€7,203,200	40%
Asphalt pavement	m²	60,760	€80	€4,860,800	27%
Rigid pavement	m²	5,040	€110	€554,400	3%
Station	u	36	€25,000	€900,000	5%
Giratory	u	7	€100,000	€700,000	4%
Crossroad signal	u	20	€9,400	€188,000	1%
Building				€6,000,000	33%
Park and maintenance site	u	1	€5,000,000	€5,000,000	28%
Control-command building	u	1	€500,000	€1,000,000	3%
Eletricity plant for low electric current	u	1	€500,000	€1,000,000	3%
Global cost	€18,112,000				

This cost applied to the length of the line, delivers €2.5 M/km. Compared to the cost of living and the cost of development in Senegal, it seems a fair price. The main risks are the building cost (estimated without a reliable source) and the civil engineering cost (because we don't know for sure the price of raw materials).

3. Based on Certu, Transitec and Setec costs.

3.2. Social and economic calculation

We made hypotheses regarding the demand per day, considering that the peak demand is:

2544 pphpd: demand per day = 3.65 × evening peak of demand = 41,020 people/day

The main operation cost for an articulated bus is €0.010 / p.km[4]
The actual ticket price is €0.11, and our aim is to keep that price, because an increase of its price may frighten people and prevent them from choosing to take buses, because of a low income per person.

The hypothesis is that the Organization Authority adds €1.09 per ticket. If so, we get a positive project balance, as followed:

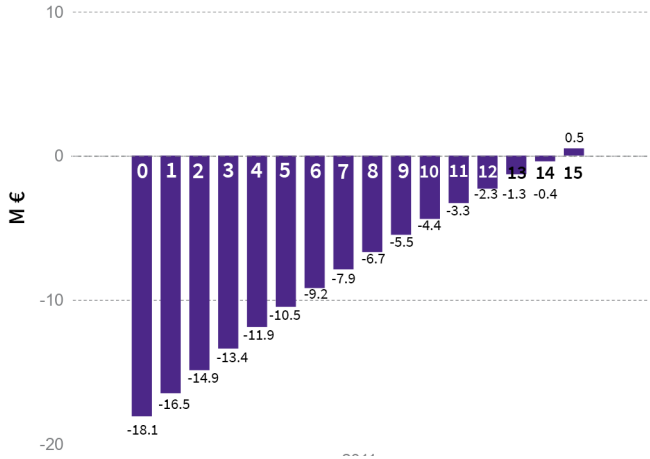


Diagram 4: Economic and social balance of the lane 1S during its life span (15 years)

3.3. Financial sources

In order to realize the project, we will need financial sources. Organisms from developed countries can participate. Thanks to the religious attractiveness of Touba, Islamic Banks can find interesting to invest in this project, such as the Islamic Bank of Development, in Saudi Arabia.

4. Transitec, *Étude de déplacements et d'aménagement urbains de Touba*, Transitec, 2008.

4. The future of the project

Even, if this transport project has not yet started, we wish to do consider the future of the project. From the current situation of the city, as well as its evolution in the last years, we can make some assumptions. With the implementation of the BRT transport network, Touba will have a better urban organization with a population density distributed more evenly, the dedicated lane transport will give access to new hubs, like Touba's airport, new bus stations and the railway station. If the city keeps on growing, the transport system is flexible enough to adapt to new travel demand.

By 2032 the rolling stock will be at the end of its life span and it will be necessary to ask whether a new concept of transport will be relevant. Today, Touba's population is unfamiliar with the use of motorized public transport, but as soon as the BRTs starts, we expect a progressive increase in the demand is expected.

In order to maintain comfort, reliability and attractiveness for passengers, a tramway solution may be more appropriate. The main advantage of the tram is that it is suitable for higher travel demand and higher daily traffic. Even if the investment is higher, the lifetime of this type of rolling stock is 30 years compared to the 15 years of the BRTs. The dedicated lanes will already be in place for the new tramway concept, so infrastructure costs will be lower compared to an initial solution.

This solution would be even better if Touba takes advantage of its climatic conditions that are particularly advantageous in terms of sunny weather and flat landform, like focusing on renewable energies such as photovoltaic solar panels or wind power. The development of a strong electrical network is also necessary to implement a tramway, or to develop electrical BRTs networks.

Conclusion

This project will bring many benefits to Touba. It will provide new economic opportunities and encourage community growth and revitalization. It will reduce congestion and traffic jam in the principal axes of the city. It will enhance personal opportunities, giving faster options to get to work, to school, to the mosque, etc.

However, in order to ensure the success of the project, there are some points that need to be taken into account. There has to be a strong institutional management to coordinate planning and regulation is critical. The life span of the rolling stock proposed is not very long, so new solutions have to be studied, like a tramway. Since the community has a high population growth, traffic management and travel demand have to be assessed again in order to see if the operations still remain valid.

The BRT would be a major step in terms of progress and modernization of the city. But the key to the development of this project is the patience and the strategic choices made by the religious authorities of Touba.