AN ASSESSMENT OF THE PLANNING AND OPERATIONAL PERFORMANCE OF THE BUS RAPID TRANSIT SYSTEM IN ISTANBUL

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1. Abstract

Bus systems are the backbones of transportation systems in cities; all cities provide their mobility with bus systems either as their main public transportation system or a feeder service for rail transit. However, conventional bus operations have been suffering from a poor public image due to their slower and lower quality service provision. Thus there is a tendency to improve the quality of bus operations in recent years, and Bus Rapid Transit (BRT) systems are getting more popular throughout the world since they combine quality of rail transit service and flexibility of buses. Today there are more than 120 cities operating BRT and bus corridors in North America, South America, Asia, Europe and Australia. BRT operations in medium-sized cities and in certain corridors in large cities can carry the same amount and even more passengers than many of the LRT lines. Since BRT provides faster transit services, reduced travel times and high quality of service with good identity and image it is believed to increase transit ridership. Furthermore, recent experiences with certain systems, such as one of the best-practice cases of BRT in Curitiba, Brazil, show that when the planning of these systems are carried out in integration with metropolitan development plans as well as local neighbourhood plans, expected benefits can be significantly increased due to high land-use impact that can in turn increase ridership.

This paper provides an assessment of the Istanbul Metrobus, the only BRT system in Turkey, which opened in September 2007. Using the lessons learnt from a number of best-practice cases in the world (TransMilenio in Bogota, RIT in Curitiba and Metrobus in Mexico City), the paper will first attempt to answer what makes a BRT system successful, and then review the following aspects regarding the Istanbul case:

- Planning background: integration into urban planning; integration with other transport modes
- Physical characteristics of the system: location, design and other aspects that may have effects on ridership
- Operating characteristics: level of service, fare schemes, etc. that may have effects on ridership
- Marketing, advertising, identity and image-building policies: operator’s and/or local authorities’ efforts in promoting the system, which may have an effect on ridership

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It is intended to elaborate how the first four aspects, ie. planning, design, operation and marketing, may have affected the ridership performance of the BRT in Istanbul. Findings are to be generalized in comparison with the aforementioned best-practice cases, and a list of possible factors will be presented for a successful BRT implementation.

Key words: BRT, planning, implementation, operation

2. Introduction

Today, the boundaries of cities enlarged due to high economic activities and in metropolitan areas population increases, thus the mobility between residential areas and job, education and public services become fundamental. Cities throughout the world suffer from traffic congestion caused by high rate of private car usage and air and noise pollution due to gas emissions led by transportation activities. In order to deal with traffic congestion, air and noise pollution problems national and local authorities started to focus on integrated public transportation activities. With no doubt bus systems are the backbones of the public transportation systems, because of being cheaper and more flexible. Rail based transportation systems are applied in most of the cities in the world, but they are expensive to implement and require long construction time. Despite being the most common type of transportation mode, conventional bus operations suffer from poor public image, lower speed, reliability and safety issues. Bus Rapid Transit systems are getting more popular all over the world both in developed and developing countries, because of having flexibility, being easy and cheap to build, which are characteristics of bus operations, and having high service quality high capacity, being reliable and safe, the well-known characteristics of rail transit.

BRT includes many components; according to budget of the national and local governments it can be implemented either partially or as a whole. The benefit gained from operation increases when all the components are implemented. There are more than 120 cities that applied BRT in their public transportation network either as the primary mode or as a feeder service to the rail transport system.

BRT system is not a recently rising public transportation trend; especially in Latin American cities it has been implemented for decades. In Turkey too, there was a separated bus-lane operation in Ankara in the 1980s; however it was abandoned in favour of an underground light rail system. Currently, the only example of BRT in Turkey is in Istanbul which is the largest metropolitan area in the country. City officials are trying to deal with traffic congestion and problems caused by this situation.

Population of Istanbul is rapidly increasing due to economic development, thus urban area is expanding. Registered private car number has increased 6 times and reached over 1,7 million since 1958 in Istanbul. Also passenger mobility is very high. According to household survey conducted by Metropolitan Municipality of Istanbul, number of daily trips is 20,9 million, 10,3 million trips are pedestrian the rest is with motor vehicles. (İstanbul Ulaşım Ana Planı, 2010)

As it is discussed previously, rail transit investments require high investment and maintenance cost and also long investment time. Istanbul has a number of rail lines newly developed; but the city also needed a cheaper and quicker solution for transportation problem in the main arterial of the city. The corridor that BRT is implemented is one of the most important highways and surrounding areas are densely populated. One of the main objectives of the BRT project on this corridor was to provide fast, reliable and comfortable service to the users and attract especially private car owners.

Istanbul also suffers from high air pollution rates caused by transportation activities. While planning and implementing BRT in Istanbul, reducing greenhouse gas emissions was the other objective, by decreasing the number of private cars in the corridor and also reducing the number of other (low-capacity) public transportation vehicles which pollute the environment most such as low technology conventional buses and minibuses.

The first BRT corridor in Istanbul started operation in September 2007 between Avcılar-Topkapı corridor. The first phase became successful and fulfilled the objectives; reducing travel times, reducing private cars by attracting people with high quality service, via high technology buses and eliminating low technology conventional transportation modes from traffic BRT reduced CO_2 emissions.

The high ridership of the 18,2 km BRT route led new routes to be planned. Today three phases have been completed and in operation. After completion of Phase III two continents, i.e. the two sides of Istanbul, were connected through the Bosphorus with BRT line. Phase IV is under construction in the western part of the city from Avcılar to Beylikdüzü.

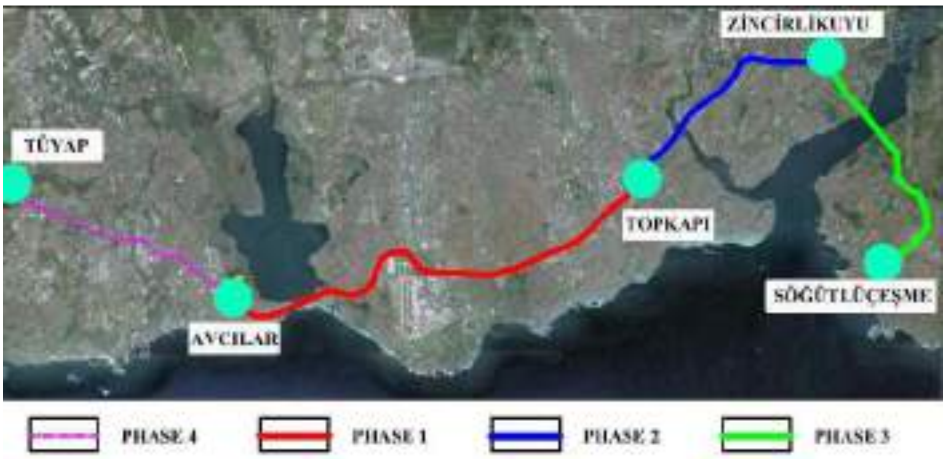

Figure 1: BRT System in İstanbul

3. Implementation

3.1. Phase I: Avcılar-Topkapı Corridor

The construction of the first BRT corridor started in 2007 between Avcılar and Topkapı corridor and started operation in September 2007. Total construction time of the corridor was 8 months. Total route length of the corridor is 18,2 km and total number of stations on the corridor is 16, 14 bus-stops and 2 turning point stations.

Açıklama [EBS1]: Bu aşamada olumlu değerlendirmelere girilmemeli. Daha tarafsız bir anlatım baş tarafta daha doğru olur.

Figure 2: Avcılar-Topkapı BRT Line

3.2. Phase II: Topkapı-Zincirlikuyu Corridor

One year after Phase I, Phase II started operation in September 2008. Phase II starts from Topkapı and ends in Zincirlikuyu station which is the last station in European side. Construction of Phase II was completed in 77 days. Total route length of the Topkapı-Zincirlikuyu corridor is 11,8 km and total number of stations are 12; 11 bus stops and 1 turning terminal.

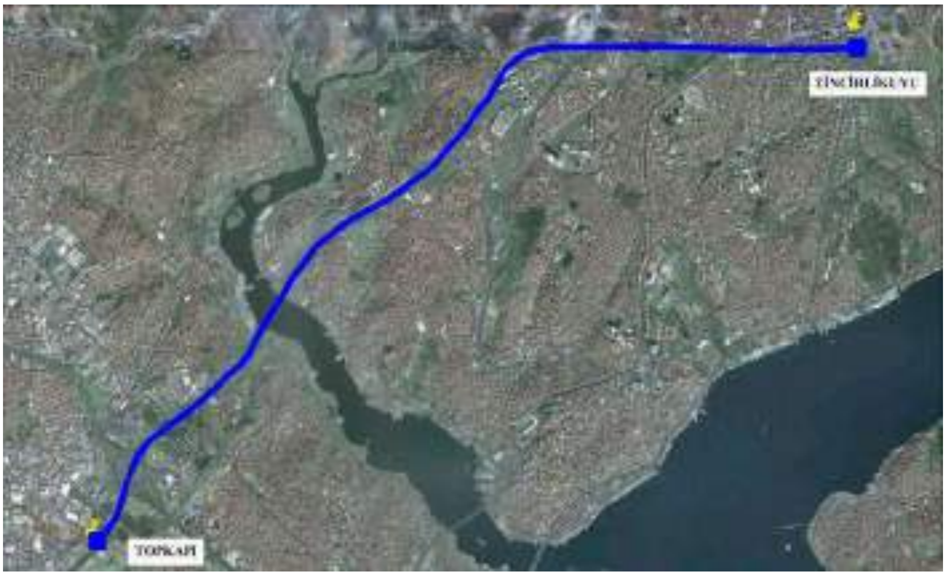

Figure 3: Topkapı-Zincirlikuyu BRT Line

3.3.Phase III: Zincirlikuyu-Söğütlüçeşme Corridor

Zincirlikuyu-Söğütlüçeşme line is the 3rd Phase of the Istanbul BRT. This phase of the system connects two continents over Bosphorus. This feature makes Istanbul Metrobüs first and only intercontinental BRT line in the world.

Figure 4: Zincirlikuyu-Söğütlüçeşme BRT Line

Total route length is 11,5 km, consisting of 7 bus stops and 1 turning terminal. This phase is constructed in 5 months and started operation in September 2009. The line starts from Zincilikuyu station from Europe and ends in Söğütlüçeşme station in Kadıköy District in Asian side.

The BRT line in Istanbul has a fully segregated route along the corridor. The only place where BRT buses flow in the mixed traffic (for 3 km) is on the Bosphorus Bridge. However, in order not to compromise the speed of the system buses enter and exit the bridge on dedicated lanes, and it is the approach to the bridges that feature the worst traffic congestion; therefore the system provides a significant advantage in journey time when crossing the Bosphorus.

4. Physical Characteristics

4.1. Running Ways

İstanbul Metrobüs is running on D-100 and O-1 Highways with fully segregated median busways with 40 km route length. There is one lane in both directions and it is segregated from general traffic with physical barriers and from other BRT lane with road markings. Since the doors of the vehicles located on the right side, buses run on the left side of the traffic and counter to the general traffic flow.

Photo 1: Fully Segregated Median Busways

4.2.Stations

There are 33 stations in Avcılar-Söğütlüçeşme BRT corridor. Since running ways are limited with total two lanes, there is no passing lane at stations. Platform length is 60 m which allows two 26 m long bus or three 18 m bus to serve at the same time in the stations. Since BRT corridor is located in the middle of the highway, passengers' access to the stations is provided via under or over passes. Platforms and vehicles have the same level of height.

Photo 2: Median Station

4.3.Fare Collection

Fare collection is off-board. In Istanbul fares are fixed both in rail and bus transportation independent from the travel length. In order to decrease waiting times of buses in stations and accelerate the boarding, BRT uses same fixed tariff with other public transportation systems.

Photo 5: Off-Board Fare Collection

4.4.Service Plan

There are three lines as described before, which are operated 24 hours stopping at every station. Since the line has one lane in the both directions, there is no overtake capability of buses in the stations, thus different service types, such as express service is not applicable.

4.5.Information Technologies

Visual and audio information is provided in every bus for passengers. Real time information is gathered in command and control center. Every bus is tracked with GPS technologies and any emergency situation can be detected quickly.

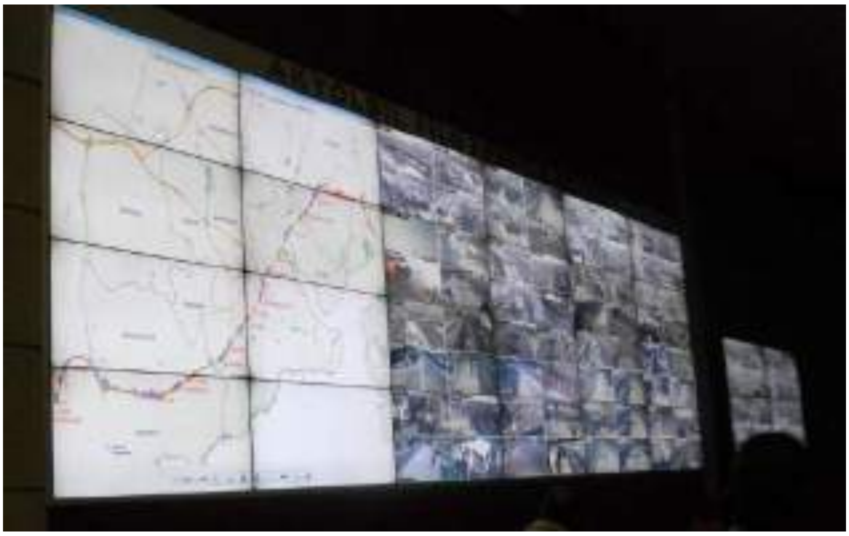

Photo: GPS tracking of buses

5. Analysis

BRT system in Istanbul has all the components of classical BRT systems in the world. In this part of the study BRT system in Istanbul will be compared with three other BRT systems in the world. First best practice case is Curitiba RIT system in Brazil. Reason for choosing this case is RIT is the pioneer BRT implementation attempt starting from the 1970s and has a great success in terms of ridership and system performance. The other system is TransMilenio in Bogota in Colombia. This system is implemented at the end of the 1990s but the system coverage, ridership and performance is admirable because of its planning background. Third case is the Metrobus system in Mexico City in Mexico. This system started operation two years before Istanbul Metrobüs and more or less has same ridership with Istanbul. The population of the city, its density and increasing car usage are also similar to Istanbul,

Comparison of the systems is made in 5 categories: planning background; physical characteristics; operating characteristics; marketing, advertising, identity and image-building policies; and finally the ridership on the systems.

5.1.Planning Background

Daily trip rate is very high in Istanbul due to high population and development pattern of the city. Since there is limited area for development, the city has a linear urban form but very strong Central Business District (CBD). Although about half of daily trips are made by walking, the remaining half represents long trips between homes and working places. Passenger mobility is provided in Istanbul with road, marine and rail transport, but most of the trips are done via roads. Private car ownership is low compared to Western European cities but car usage rate is high and combined with ever-increasing rates of mobility, this causes traffic congestion in many arterials. Rail investments are present in the city, with a number of metro, LRT and tram lines, but their coverage is still limited and the completion of the full network takes long time to construct. Therefore, city officials decided to implement BRT as a cheaper and quicker solution to traffic problem.

Since the decision to implement the BRT was linked to traffic congestion and the existing mobility needs, the local government focused only on traffic issues and aimed at starting the operation in the shortest time possible. This meant that urban development plans and future development patterns were not considered; and as a result the system does not have any integration with the urban master plan, which was actually being prepared and about to be finalized at the same time with the BRT decision. Meanwhile a comprehensive transport plan is also being prepared for the city, studies for which have been carried out since the mid-2000s, again during the same time with the BRT decision. The BRT is not integrated into the transport plan either.

After the high ridership of the first phase, other corridors were implemented again without any coordination with urban master plan and urban transportation plan.

The system operates in the middle of D-100 Highway, which has already turned to an urban arterial, and thus land use pattern is mostly integrated with the road. Some of the stations in the European side are partially integrated with important nodes, such as universities, shopping malls, dense residential areas and commercial uses. These uses existed before BRT implementation; they are not a planning decision because of the Metrobüs construction. In the Asian part, the highway preserves its highway features, thus integration with land uses seems more complicated here. Since important land uses do not exist close to BRT stations (because they are at a reasonable distance to the highway), integration becomes weaker.

BRT system is also only partially integrated with rail system in the European side of the corridor. The integration is related to proximity of Metro and BRT stations only. Many of the bus and minibus operations are removed from the corridor, since Metrobüs has a higher carrying capacity. But there is opportunity to transfer to bus and minibus systems; İETT tried to integrate conventional bus stops to BRT stations. Metrobüs system is operating in the middle of highway, thus bike lanes are not applied. Bike integration does not exist; and there are no bike parking areas on the corridor. There are Park and Ride facilities in some stations. Since pedestrian infrastructure is very weak in the whole of Istanbul in spite of high pedestrian trip rates, integration with pedestrian areas and streets is also limited.

Information about the best-practice case studies of Curitiba, Bogota and Mexico are given in less detail and summarized in Table 1. Important findings of the comparison to note are as follows: all systems initiated the BRT projects due to congestion problems and high car usage rates, and therefore to improve public transport. In Curitiba, an additional aim was to control development, which is important since this leads to one of the best-known examples of integration between land-use planning and BRT implementation. In other cities too, integration with urban plans existed; and this seems to be one important shortcoming in Istanbul. Integration with other transport systems also appears to be limited in the Istanbul case. Interestingly, all systems have somewhat neglected integration with cycling, perhaps due to the low rate of cycling in these cities.

Table 1: Planning Background Checklist

	Curitiba	**Bogota**	**Mexico City**	**İstanbul**
Reasons to implement	uncontrolled development high car usage	high traffic congestion high private car ownership	poor public transport high car usage	high travel times high congestion poor public transport
Aim	integrated public transport reduced private car usage	reduce private car usage	increasing mobility reduced gas emissions	fast & economic transport solution to corridor
Integration with urban plans	yes	yes	yes	no
Integration with land use	trinary system zoning & land development policies	support long-term urban renewal prioritize walking & cycling	yes	no

Integration with rail systems	Not applicable	yes	no	limited
Integration with bus systems	yes	yes	no	Yes
Integration with Bicycle	no	partially	no	no
Existance of bike parks	no	yes	no	no
Existance of Park&Ride			no	some
Integration with pedestrians	yes	yes	yes	partially

5.2.Physical Characteristics

An important aspect that affects ridership is the physical characteristics of the systems, including location and design of the system. In this part, analysis is done in three categories. First physical components, then busways and finally stations and vehicles will be compared.

Table 2: Physical Components Checklist

	Curitiba	**Bogota**	**Mexico City**	**İstanbul**
BRT System Covarage	405 km	310 km	67 km	42 km
BRT Busways	65 km	84 km	67 km	42 km
Number of Stations	127	114	112	33
Average Distance Between Stations	600 m	790 m	600 m	1210 m
Off-Board Fare Collection	yes	yes	yes	yes
Control Center	yes	yes	yes	yes
Located Top 10 Corridors	yes	yes	yes	yes

As Curitiba is the first city that applied total BRT system, its network coverage is the highest. This is also due the feeder service network. In Istanbul there is not an official BRT feeder, thus BRT busway can be observed as the coverage of the system. But in Istanbul BRT corridor is fed by İETT and private buses, thus total system coverage is more than 42 km. In terms of station numbers and average distance between stations; Istanbul represents a faster system with much higher distances between its stations.

While determining stations' location, being a trip attraction point is an important factor, and especially in Asian side distances between stations increase.

Another important feature of BRT systems is off-board fare collection. Since it is time consuming to pay to the driver, the most effective way to decrease time needed to validate the ticket is off-board fare collection. Smart cards are also very effective to decrease time losses while boarding to the vehicle, off-board fare collection allows passengers to board vehicle not only from first door but also from all doors, which in turn decreases time needed for buses to wait in the stations. All four systems have off-board fare collection to increase the performance of the systems. Existence of control center tracking buses with GPS technologies lead to interfere to buses quickly if an emergency situation occurs. Thus, whole system is not affected negatively from the interruption.

If the system is constructed along one of the top 10 corridors, it also increases the number of the passengers using it in daily trips. Same as all three best practice cases, BRT system in Istanbul is implemented on one of the most important arterials.

Table 3: Busways Checklist

	Curitiba	**Bogota**	**Mexico City**	**İstanbul**
Busways				
Segregated Right-of Way	fully segregated	fully segregated	fully segregated	fully segregated
Alignment	median	median	median	median
Intersection Treatment	yes	yes	yes	not applicable
Passing Lanes at Stations	%20 of total	%100 of total	no	no
Station Set Back from Intersection	yes	yes	no	not applicable
Center stations	yes	yes	yes	Yes

Segregated lanes are the distinctive characteristics of BRT systems when compared to conventional bus operations. It leads buses to move quicker and not to be affected by traffic congestions. All systems analysed here have fully segregated busways. BRT system in Istanbul crosses the Bosphorus Bridge, the only place where BRT buses flow in the mixed traffic is on the bridge: that is because the property of the bridge belongs to General Directorate of Highways, and this authority did not permit reserving one lane exclusively to BRT. But buses enter and exit the bridge in dedicated lanes, and since it is the approach to the bridge that suffers from worst traffic congestion, the BRT is not affected much by congestion.

All systems are located in the medium lane which prevents interruptions from other traffic. But Istanbul has the advantage since it runs on the highway that already has most junctions in grade-separation; and therefore the BRT does not have any at-grade intersections. There is no intersection where BRT buses have to stop for traffic lights.

Passing lanes at intersections is another feature of the system that increases the ridership. Passing lanes located at the stations prevent buses to wait for the other bus to move. Also it gives opportunity to operate express services which do not stop at all stations, just at those with higher passenger demand. Passing lanes may be one of the reasons that Curitiba and Bogota BRT systems have higher ridership than Mexico City and Istanbul BRT because this gives them an opportunity to provide higher service levels. Since the highway that the Metrobüs was implemented has a limited area, it was hard to implement passing lanes, thus system has only two lanes both in the corridor and at the stations that decreases the passenger numbers carried.

Access to the station has to be safe for passengers using the system, thus stations should be located at a distance to intersections not to conflict pedestrian movement with vehicle traffic. Since stations in Curitiba, Bogota and Mexico City are at grade intersection set back becomes crucial. Stations are located in Curitiba and Bogota at a distance from intersection to protect pedestrians from flowing traffic. But this type of treatment was not applied in Mexico City. This kind of precaution is not applicable for İstanbul BRT, because passengers can only access to stations via pedestrian overpasses.

While using median running-ways center station which serves both directions of BRT system makes transfers easier and it is also more cost-effective. All four systems have center stations.

In Istanbul buses and stations have same level, but drivers are afraid of crashing to the platform, thus they do not dock to the station. This sometimes leads passengers either to jump a long distance or step down and step up to access the vehicle. This also decreases the performance of the system. Safe and comfortable station design is the distinctive characteristics of BRT systems when compared to other bus operations. In RIT, TransMilenio and Metrobus systems, stations have safe and comfortable design. In RIT tube stations are used, in Bogota and Mexico City there are similar station design with Curitiba. This type of design provides total weather protection. Also they are safer, because they have sliding doors protecting people from stepping into the road. Despite having diverse severe weather conditions in Istanbul, weather protection is very limited, since stations have only roofs. Also neither sliding doors nor guard rails exist to protect passengers from flowing bus traffic. Especially in peak hours people wait for the bus standing on the road. Since BRT operations are very frequent in Istanbul, seating are not provided at the stations. Since off-board fare collection is a feature of BRT operation, the number of doors on buses becomes important. Passengers can use all doors, time losses decrease while boarding. In RIT system buses have 5 doors, the other three systems are using buses with 4 doors. Frequency of BRT operation is very high especially in peak hours, thus platform length should be long enough to accommodate more than one bus at the same time to decrease waiting times of buses in each stations. There are sub-stops and docking bays in three best practice cases. In Istanbul platform length is enough for 3 buses to stop. Sliding doors have another important mission, that is to define the exact place where buses will stop and this informs passengers to wait close to the doors. Also it helps handicapped users to know where to wait to board easily with wheelchair or with special pavements blind people can be directed to the doors. Mexico City and Istanbul BRT systems do not have sliding doors.

Table 4: Stations and Vehicles Checklist

	Curitiba	**Bogota**	**Mexico City**	**İstanbul**
Platform Level Boarding	yes	yes	yes	yes
Safe and Comfortable Stations	yes	yes	yes	yes
Number of Doors on Bus	5	4	4	4
Docking Bays and Sub-Stops	yes	yes	yes	yes
Sliding Doors in BRT Stations	yes	yes	no	No

5.3.Operation Characteristics

Having good feeder services is a very important determinant that increases ridership of systems. Curitiba and Bogota systems have feeder operations to support BRT system. Mexico City and Istanbul has only BRT corridor not including an official feeder system. But these two systems have conventional bus operations to support the system which is only based on proximity of stations. Istanbul has a good conventional bus feeder operation but vehicles cannot enter the corridor. Buses discharge people to a bus stop close to BRT stations.

BRT systems have higher commercial speeds then conventional bus operations, because like rail operations they have their own right-of-way. But especially intersections slow down vehicles when they meet mixed traffic and decrease commercial speeds. All three best practice cases have at grade crossings and intersections. Thus commercial speeds are 17,5 km/h for Curitiba, 18-28 km/h for Bogota and it is less than 20 km/h for Mexico City. Since Metrobüs in İstanbul is located in the middle of highway and intersections are eliminated from flowing traffic, commercial speeds are as high as 35-40 km/h, which results in faster and more reliable operations.

İstanbul Mertobüs has the highest frequency especially in peak hours among other cases. Also off-peak intervals between buses are very short which increases total ridership of the system. In peak hours every 15 seconds a bus leaves the station. 3 buses dispatch from terminal stations and in order to meet high demand on crowded stations some buses leave terminal stations empty. In day time, off-peak intervals are 1 minute. The system is operated 24 hours both in weekdays and weekends while this is not the case in any of the other comparison systems. It can be concluded that operating characteristics are quite superior in IstanbulMetrobüs, providing a high quality service level. On the other hand, as mentioned before, there is only one corridor in Istanbul and since there are no passing lanes it is not possible to operate express or limited services. Despite having only one corridor there are 3 different lines in the same corridor, defined by different lengths. Same electronic card is used in Istanbul for all transportation modes except for minibuses, which operate with cash payment. Same travelcards are used for Metrobüs also; this provides easy transfers between other transport modes.

Table 5: Operation Characteristics Checklist

	Curitiba	**Bogota**	**Mexico City**	**İstanbul**
Operational Mode	trunk-feeder	trunk-feeder	trunk-only	trunk-only
Commercial Speed	17,5 km/h	18-28 kım/h	<20 km/h	35-40 km/h
Peak Frequency		2 minutes	48 seconds	15 seconds
Off-Peak Frequency		6 minutes		1 minute
Hours of Operation	weekday 20 hours	weekday 5am-11pm	weekday 4:30am-0:30am	weekday 24 hours
	weekend 19 hours	weekend 6am-11pm	weekend 4:30am-0:30am	weekend 24 hours
Multiple Routes	yes	yes	yes	No
Express, Limited and Local Services	yes	yes	no	No
Multi Corridor Network	yes	yes	yes	yes
Express, Limited and Local Services	yes	yes	no	No

Fare Integration	yes	yes	yes	Yes
Automated Fare Collection & Fare Verification	yes	yes	yes	Yes

5.4.Marketing, Advertising, Identity and Image Building Policies

Stations and vehicles should be distinctive for BRT systems, because they show the customer that they provide different and higher-quality services than conventional bus operations. Since the idea behind implementation of BRT is “think rail, use buses”, it should provide comfortable, reliable and frequent services like rail systems, thus it should have different vehicle and station designs like tube stations in Curitiba or Bogota. In Istanbul, buses and stations are different than conventional bus operations, but unlike other cases, stations do not provide full protection for users like tube stations do. Also for increasing ridership branding of the systems by local private or public authorities is very important. Before starting the operation in Curitiba, Bogota and Mexico City a large campaign was made to introduce BRT systems to the users. Since planning and implementation was very quick in Istanbul branding was very limited initially. But now there are some commercials for the system.

Table 6: Marketing, Advertising, Identity and Image Building Policies Checklist

	Curitiba	**Bogota**	**Mexico City**	**İstanbul**
Stations	distinctive	distinctive	distinctive	distinctive
Vehicles	distinctive	distinctive	distinctive	distinctive
Branding	yes	yes	yes	Initially limited; improved today

5.5.Ridership on the System

After presenting the features that are likely to affect the ridership and performance of the systems, in the last part ridership on systems will be discussed. As it is stated before Curitiba is the pioneer BRT system and because of its integrated planning background and high coverage, total ridership is very high with 2.26 million passengers per day. Since there are 6 different corridors and multi centered urban pattern peak hour passenger/hour/direction are only 13.000. When the only BRT corridor of 65 km without the feeder services are taken into consideration, passengers carried per km is 34.770 in Curitiba. (Table 7)

TransMilenio in Bogota also appears to be a highly used system: 1.65 million passengers are carried daily on the corridor. In peak hours passenger/hour/direction is 34.000 on the 84 km BRT corridor. 19.047 passengers are carried per km of the BRT corridor.

Metrobus in Mexico City has ridership numbers close to Istanbul: total number of passengers is 620.000 daily on 62 km route. Approximately 9.250 passengers are carried per km. In peak hours, it carries 9.000 passenger/hour/direction.

Total number of passengers carried daily in İstanbul Metrobüs is 600.000. With 42 km route length, this amounts to 14.280 passengers carried per km. It carries 21.400 in peak hour passenger/hour/direction.

When the total ridership is compared Curitiba and Bogota has very high numbers but they have very extensive feeder services too. Despite using only existing conventional bus operations and having a rather limited integration based on proximity of stations, İstanbul BRT has a rather high ridership, higher than the BRT in Mexico City. Also Istanbul has shortest route length when compared to other systems. The reason to have high ridership for Istanbul is probably a combination of two factors: the corridor's location and high service level. It is located on one of the most demanded axis and it provides a rather fast journey with very frequent services and for 24 hours all days of the week. In addition, the system provides a relatively fast crossing across the Bosphorus, a major physical barrier for the two sides of the city. Also many of the conventional and minibus operations are removed from this corridor, thus people have to use the system. Despite having high frequency especially in peak hours, it is often reported that operation is inadequate to meet the demand.

Table 7: Ridership Checklist

	Curitiba	**Bogota**	**Mexico City**	**İstanbul**
Passenger Numbers	2,26 million/day	1,6 milion/day	620.000/day	600.000/day
Peak Hour Passenger/hour/direction	13,000	43,000	9,000	30,000
Passenger Per Km	34,770	19,047	9,000	14,280

6. Results and Conclusion

When compared to the three well-known best-practice cases of BRT, the Istanbul Metrobüs is found to have a mixed performance. Its major weakness is in its planning background: the system was developed without any integration into the urban development plan and the transportation plan of the city. This has two consequences:

- The Istanbul Metrobüs is developed with only existing passenger demand considerations; and therefore the corridor serves currently existing development areas that already have very high mobility needs. This maybe one of the reason for its high ridership. Such a strategy of serving the existing high-demand corridor may be beneficial indeed to establish the system as a success in its early years of operation. And Istanbul Metrobüs is a young system that proved to be successful in ridership figures. However, this lack of coordination between the system's planning and urban planning need to be overcome in the future in later stages since the urban plans will inevitably change demand patterns, that the Metrobüs will have to follow.
- Lack of integration into the transportation plan meant that the system was not integrated with existing metro and tram stations at all initially. No transfer stations were designed although some rail stations were in close proximity to the BRT. The same goes for conventional bus systems and stops. They were also poorly integrated although this improved in later years. The transfer stations with rail systems also improved although problems still exist. This is obviously a negative aspect in terms of planning; but it may have two very conflicting repercussions: had the system been better integrated with rail, the passenger numbers might be even higher; however, the opposite appears to be the case: the BRT system competes with the (Light) Metro system and it is stated by the Istanbul Rail Operating Agency that it attracted many passengers from the rail systems.

In spite of these apparent problems of integration, the system carries a reasonably high number of passengers. Its number of passengers per km of route is lower than the systems in Curitiba and Bogota, but higher than that in Mexico City. Furthermore, its number of passengers per km of route is higher than that of the two Metro systems of the city combined, which is about 13,500 passengers/km according to figures given by Özgür (2009). This high level of ridership shows that the level of service provided is a very important factor since this is the clear strength of this system when compared to the best-practice cases. The strong points of the Istanbul BRT can be listed as follows:

- Due to its design with higher distances between stations and full-segregation, it provides the highest speed of service when compared with the best-practice cases, and this is extremely important in a large city like Istanbul where commuting from outer suburbs to the CBD is the dominant mobility pattern.
- Furthermore, the system operates with very high frequency and 24 hour service – in both aspects, the system out-performs the best-practice cases as well as the Istanbul Metro systems.

- Moreover, the Bosphorus crossing, a condition specific to Istanbul, is a major advantage since there is no rail crossing yet and therefore this is the first rapid transit connection between the two sides of the city.
- Although it was noted that integration with other transport modes was limited, conventional buses and minibuses operating at the BRT corridor were reorganized and mostly removed, which made the BRT system the favoured choice in most cases.

Finally, the comparison with best-practice cases also provides some lessons to improve the Istanbul Metrobüs:

- Station design needs to be improved for both safety and weather protection.
- In future phases, passing lanes should be incorporated in order to allow for faster operation as well as express services.
- Integration of non-motorised modes, such as cycling and walking, should be improved.
- As already mentioned above, integration with rail systems need to be improved; and future phases must be planned in integration with the urban development plan of the city.

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