

Transportation System in Istanbul: Evaluation of Bus Rapid Transit (BRT) and Marmaray under Sea Subway

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Abstract

Modal integration and high balanced modal distribution are the key issues for metropolitan transportation solutions. Transport infrastructure is a vital social and economic asset; it influences trade flows, as well as industrial and residential locations. In this paper investments and the progress in Istanbul transportation system to have better model distribution is presented. Especially evaluation of bus rapid transit BRT public transport system and Marmaray under sea subway are presented. Evaluation results show that both BRT and Marmaray subway have benefit effect on reducing traffic congestion in the city. Furthermore, Metro bus feasibility studies show that converting general purpose freeway travel lanes to BRT use is viable, where there is high passenger demand and an existing high volume of surface public transport users.

Keywords: Bus Rapid Transit (BRT); Marmaray; Marine transportation; Daily trip; Rubber tyred; Modal share; Mode choice

Introduction

Transport infrastructure planning and financing are becoming controversial political topics at national and increasingly at international levels. Transport infrastructure planning is not only a political topic, it is also a central subject for research, where there are difficult conceptual and analytic issues. Infrastructure investments need to be rationalized, accepted standards adhered to, modern construction techniques utilized to reduce costs, and genuine budgets established for expenditure and revenue. Because, if these principles are seldom is followed, high costs are placed on the state, a situation that is aggravated by the high rate of inflation [1]. The situation has long been aggravated by the lack of a legal frame work that specifies the duties and responsibilities of those who administer and use road transportation, and defines the rules and regulations governing construction and maintenance of the motorways. Hence it should not be surprising that safety and maintenance standards are inadequate or that carriers operate in an essentially unregulated manner. Although, a recently enhanced

laws in Turkey has improved the situation by establishing a number of commissions to deal with such issues as safety, security, education, and communications and regulating the speed of buses. However, more than new a legislation is required for it is no simple matter to find and retain qualified personnel, who possess the necessary training to carry out the irresponsibilities effectively, and because of such weaknesses, as lack of job security. Transportation investments rapidly grow in Istanbul, but selection of the mode, line and integration between the local (partial) and the whole system has a vital role. For instance, Bosphorus Bridge and Fatih Sultan Mehmet Bridge has affected the urban area and transportation system considerably in Istanbul. On the other hand, Marmaray has a strong effect too. The location of Marmaray under sea tunnel and its cross section is shown in Figure 1. When the full system of Marmaray has started (ie. Gebze to Halkali), it starts to affect the general traffic situation in Istanbul. For the balanced modal distribution in Istanbul, urban railway system and marine lines are also very important and have determinant role. Also we can evaluate the railway system investments' increase and efforts

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for achieving a balanced modal distribution from sustainability perspective. At the national level, we see that planning methods may vary, that the traffic and economic forecasts on which they are based are different, that the evaluation techniques are not the same, that the consultative and legal processes differ widely, and finally that decision-making procedures may diverge. Despite the weaknesses, the procedures and processes in some countries have resulted in what are generally regarded as good systems [1].

Istanbul and Its Transportation System

Istanbul is one of the largest cities in the world with a population of almost 15 million inhabitants in 2015. Similar to New York City and other megacities in size and complexity, Istanbul's metropolitan area is even larger.

The Bosphorus sea channel divides the city into two parts and connects the Black Sea and the Mediterranean Seathrough the Marmara Sea. It also forms the natural boundary between Europe and Asia. Despite the Bosphorus' positive impact on the city's landscape and historic development, it concentrates and complicates access within the city. The two sides of Istanbul are connected by two highway bridges (Bosphorus and Fatih Sultan Mehmet) and by maritime transportation (ferries, passenger boats). The demand for maritime transportation is limited, since it serves only certain waterfront locations. Modal distribution on accesses on Bosphorus for different years are summarized (Table 1).

The transit points or nodes of the public transport system connect road, rail and water seamlessly. The payment system should not interfering with changes between lines or modes of transport. The traveler plans the trip without reflecting on whether it goes on road, rail or water. This concept branch is developed by focusing on the waterborne part and the land-sea interface. The following are prerequisites for this concept branch:

- Year-round operation of the land based part of the public transport system.
- The terminal is a node integrated to the local main flow of the public transport system. A possibility to reach the terminal by, for instance, a low frequency bus or tram link is not recommended for being considered as an integrated node.
- Ticket notification should not obstruct the embarkation or the departure times.
- The waterborne part of the public transport system is based on a certain volume so that the organizational and material resources to provide infrastructure maintenance (e.g. ice clearance and traffic management) and vehicle maintenance (servicing and replacement units) can be efficiently used in cost effective manner.

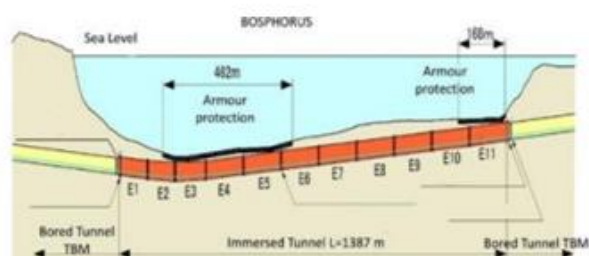
Based on the performance drivers and the differences in practice between city traffic and suburban service, the concept branch is split into two. The suburban service is characterized by pronounced rush hours in the morning and afternoon with more or less

unidirectional passenger flow, while the city traffic is characterized by short distances, high departure frequency and short time durations at sea. This leads to the conclusion that the transport unit, the city boat, for city traffic should be smaller but with a generally high departure frequency compared to the Suburban shuttle which will be serving more remote, and less populated parts of the city. This is similar of course to city busses and articulated or bi-articulated busses used in bus rapid transit schemes. The city boat is the waterborne complement to city buses, trams and underground system (metro). It is intended for distances less than 3 nautical miles (5.5 km) with the most common distance between the terminals to be less than 1.5 nautical miles (corresponding to the distance between 3 bus stops or 1-3 underground stations [2-4]. The travel time is typically varying from a few to 10 minutes. The passenger compartments are inspired by subway cars, but with a slightly lower proportion of standing passengers, approximately 1.5 standing per seated one, which is a normal rate for city buses. The two envisaged City boat concepts are both sketched for max of 125 passengers, 50 seated, corresponding to common capacity of 18 m articulated busses. Passenger compartments are at one level. To fit into the urban pace, the departure frequency must be less than approximately 10 minutes (Stockholm the departure frequency of the major bus lines during rush hours are around 5 min). High frequency plays an important role. The time at the terminal including mooring is considered to be a performance driver that is strongly influenced by embark/debark time and docking. To keep this time down the city boat moor alongside the dock and the passenger flow is through several sets of sliding door for underground and commuter trains. The time to embark/debark is estimated to be around 1.5 minutes per 100 passengers (pax) and 25 bikes [3]. The city boat is lighter than the traditional passenger ships. The city boats operate between the two embark/debark terminals or in a round-trip service for three terminals. Shuttling and round-trip services can of course be combined for instance using 4 vessels in a round trip during the peak hours (one departure every 11 min with a capacity of 4000 pax/hour) turning to shuttle service with 3 units during off peak hours (departure at every 12th to 19th minute with a capacity of 3100 pax/hour). The suburban shuttle is intended for distances between 3 to 10 nautical miles (5.5-18.5 km). While the city boat is the capillaries of the public transport network, the suburban shuttle is the arteries with larger transport units and an acceptance for lower departure frequency. A guideline value is a departure at every 20 minutes, compare with the departure frequency for buses in suburban Stockholm during rush hour being this amount to departures at the travel planner. The shuttle bus capacity is typically twice the city boats and providing seats for all the passengers (the concepts also refer to standing passengers but that is indicative showing on flexibility depending on route [3]. The service has pronounced rush hours and the low departure frequency, demands good timekeeping and reliability, as

well as possibilities for the commuters to spend the waiting time in a valuable way. The travel time is strongly dependent on speed at sea and the concept pallet is more varied in this respect, in relation to the city boat concept.



a. *Marmaray under sea tunnel location:*



b. Marmaray tunnel Profile.

Figure 1: Marmaray Project [2,10].

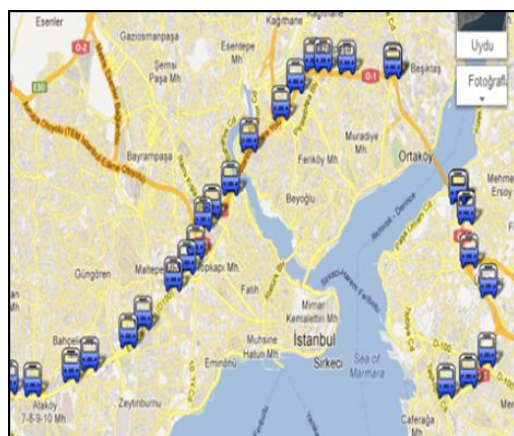


Figure 2: Istanbul Metrobüs Stations Map [2].

The time between terminals should in any case be less than approximately 45 minutes. The longer journey typically also requires added comfort values such as conditions to work, having a meal, WC, lounge, etc. Energy consumption is mainly driven by the vessel speed. So from an economic and environmental perspective it is important also to find solutions with a lower speed where will be an attractive complement in the public transport system. Although embark/debark time is a smaller part of the travel

time, compared to the city boat, boarding is done alongside at similar, and often the same, terminals as for the city boats. The sea lift concept is a line ferry that could be driven by the passengers themselves (after having taken a so called driver's license) which enables lower costs and increased flexibility and frequency. In a sense the sea lift could be seen as a prolonged piece of road or bike lane crossing over shorter water distances in order to increase density and accessibility as well as enabling less total number of personal kilometers. Mass transport does not have enough composition in all transportation modes. The Table 2 refers to lack of traffic safety, lack of time savings, punctuality, comfort, costs and also economic-social-cultural integration [4]. High balanced modal distribution and inter modal integration are indispensable specialties of transportation system's reliability functionality. In Turkey, the non-balanced high ratio of highways effect on modal distribution and the insufficient ratio of presence a mass transport on highways and any other modes are continuing problem in the reducing last ten years. Car ownership ratios are very high in our country. Thus, the naturel result of consumption culture practices, national producing degrees and political canalizes in the last decades. Transportation in Istanbul mainly relies on road-based transportation (92.3%) followed by rail (5.5%) and water (2.2%). The city's residents have a strong dependence on the city's comprehensive public transportation system. Overall, 53% of the population uses one or more forms of public transportation, including commuter rail, metro, light rail and extensive networks of bus and minibus services. Table 2 shows that Istanbul's rapidly increase values in transportation system and modal distribution estimations for 2018 and 2023 years. In this meaning, presence a well-balanced and functional transportation system is also an argument and supply of healthy implementation of all social-cultural, geographical, technical, economic connections and distributions. Turkey is surrounded by seas on three sides, has also unique waterways 'Marmara Sea' and the straits, located in the middle of Black Sea-Caspian Sea-Mediterranean Sea and any other feeding water lines, has used this potential very limitedly up till today.

However, it is possible that to travel from Bulgaria, Romania to Netherlands by Inland Waterway due to triteness of Tuna River and Rehn River. The true investments and interventions to Marines and Inland Water Lines have the potential of formatting ability of a geography's strategic location and also effect deeply the transportation capacity of peripheral areas.

BRT and Modal Distribution

In the Recent Past Periods, in this method, with the construction of Panama Canal and Suez Canal, improves the progress of history-battles-economic-strategy. Sustainability was issued by the Western Countries that experienced the technical developments in the last 30-40 years. We have seen their radical precautions in this

subject. The reflections of sustainability to transportation system are increasing gasoline variety, improving renewable energy possibilities, inserting alternate transportation modes, intermodal integration etc. In specialty for our country; it can be read that extension of subways in mass transport system, supplying active and integrated marine transportation (producing demand and

satisfying), inserting cableway systems, popularization of bicycle usage, extension and standardization of bicycle ways, canalizing the car ownership to the healthy degrees and levels by education-awareness methods and realizing enormous investments by brief steps, are seminal and human focused [4-8].

Table 1: Modal Distribution of Istanbul at the Bosphorus Bridge Existing Period [2].

Transportation Mode	1987 (%)	1996 (%)	2006 (%)
Private Car	19,30	19,20	26,34
Taxi+ Dolmush	10,20	9,40	4,75
Shuttle Vehicle	10,40	11,50	21,48
City Buses (İETT+ Private Public Buses)	35,20	34,10	24,12
Minibuses	19,00	19,60	16,71
Railway Systems	3,80	3,60	4,60
Marine Transportation	2,10	2,60	2,00

Table 2: Daily Trip Values of Istanbul [4].

YEAR 2010 DAILY TRIP VALUES			YEAR 2014 DAILY TRIP VALUES		
Transportation Mode	Passenger/Day	Ratio (%)	Transportation Mode	Passenger/Day	Ratio (%)
RubberTyred	5.541.466	78,4(%)	RubberTyred	10.715.595	67,7(%)
Railways	1.335.372	18,9(%)	Marmaray	1.170.178	7,4(%)
Marine Transport	195.056	2,8(%)	Railways	3.745.397	23,7(%)
Total	7.071.894	100(%)	Marine Transport	186.575	1,2(%)
YEAR 2018 DAILY TRIP VALUES			Total	15.817.745	100(%)
Transportation Mode	Passenger/Day	Ratio (%)	YEAR 2023 DAILY TRIP VALUES		
RubberTyred	8.427.620	50,7(%)	Transportation Mode	Passenger/Day	Ratio (%)
Marmaray	1.312.880	7,9(%)	RubberTyred	7.739.228	26,5(%)
			Marmaray	1.673.092	5,7(%)

Railways	6.722.825	40,4(%)	Railways	19.530.944	66,9(%)
Marine Transport	170.071	1,0(%)	Marine Transport	240.034	0,8(%)
Total	16.633.396	100(%)	Total	29.183.298	100(%)

Table 3: Factors Affecting Metrobus Mode Choice [3].

Reasons for using Metrobus (BRT)	Frequency (Multiple Selection)	Percent (%)
Fast	731	35.9
No traffic congestion	730	35.9
Comfortable	149	7.3
Economic/Cheap	44	2.2
Frequent service	132	6.5
I have to	201	9.9
Runs 24 hours	44	2.2
Safety/Security	3	0.1
Total	2034	100.0

As we look onto the marine transportation history, we see that its dominant role for geographic expeditions and sustaining, its usage area, either for passenger or freight transport. In our country, marine transportation was the most efficient instrument for providing the interaction with North Africa and Black sea Regions on the political and social point of view on Ottoman Empire. High levels of traffic congestion in urban areas and constrained resources require public agencies to fund timely and effective solutions, preferably with low initial costs. Istanbul's famous Metrobusor bus rapid transit (BRT) line is one of such solution (Figure 2). The line, which was first opened in 2007 and progressively expanded, carries a large number of riders and dramatically reduces travel times over the previous situation.

Bosporus Bridge (also known as the First Bridge) was completed in 1973 and has become increasingly congested in the subsequent years. Fatih Sultan Mehmet Bridge (the Second Bridge) project has started in 1986 and was completed in 1988. The two bridges accommodate only highway vehicles – cars, trucks and buses. The Marmaray project, an underground rail tunnel, was constructed and also connected the European and Asian sides of Istanbul. At present, passenger transportation between the residentially heavy Asian side and the business oriented European side only can be performed using the two existing bridges over the Bosporus straight that are congested for many hours each day [3]. Light rail systems are an interesting case study from several points of view. Many countries abandoned light rail or trams in the recent years. After the Second World War. All UK cities except Blackpool did so, as did France, the Netherlands and the United States, where

only seven remained at the end of the 1970s. Germany and Switzerland were the main exceptions, where many cities maintained their trams. Metro (subway) construction has been protracted over the years. This results from the historic nature of the city, the desire to protect artifacts that are often uncovered by the subway construction and limits to available funding. Therefore, emphasis was placed on less expensive alternatives, light rail lines and later, Metrobus (BRT) to reduce the long journey times. The Istanbul Public Transportation Authority in Istanbul (IETT) has opened its first BRT system, Metrobus, for service in 2007. A median busway with the center island stations was built within the median of the freeway-D100 by removing a travel lane in each direction. Bus operation is counter flow to reduce costs and implementation times and use conventional buses with right hand doors. The entire Metrobus system has a dedicated right-of-way except for the mixed traffic operations on the Bosporus Bridge. Metrobus has started with about 3,250,000 monthly riders in January 2008 and in May 2011 it served 17,300,000 passengers. These ridership numbers represent a 530% increase in less than 3.5 years. Then IETT estimates that the capacity of Metrobus as 30,000 persons per hour per direction in the peak direction. This value is based on 150 buses per hour and for about 200 people capacity per 26-meter bus (a crush load). On the other hand, Hidalgo (2008) has estimated that the maximum ridership is at about 18,000 persons per hour in the peak direction [3]. These ridership volumes make Metrobus to be one of the most utilized BRT systems in the world. Reasons for riding Metrobus are shown (Table 3). High operating speed and congestion free travel account for about 40 per cent of

the reasons cited for choosing Metrobus. Metrobus connects with the regular IETT bus, subway, and light rail systems. IETT encourages multi-modal trips by offering free transfers between the Metrobus and any other modes. Metrobus also provides accessibility to the Ataturk International Airport (Istanbul's largest airport) by connecting with a light rail system that goes directly to the airport. A large share (37%) of Metrobus riders walks to and from Metrobus to reach their destinations. Most walking takes less than 10 minutes, and the share of walking is higher for exiting from Metrobus. The second highest access mode is the dolmuş/minibus, followed by regular IETT buses.

Conclusions

The long history of civilization in Istanbul raises the challenge of dealing with the built environment for transportation planning purposes. For instance, construction of the Istanbul's Marmaray subway was stopped several times by the discovery of new archeological sites during excavations. The slow progress of the subway construction has led to placing more emphasis on at grade, surface public transport like LRT and BRT (Metrobus) and when new light rail lines were constructed [8,9]. From transportation planning and operations perspective, Metrobus feasibility studies show that converting general purpose freeway travel lanes to BRT use is viable, where there is high passenger demand and an existing high volume of surface public transport users [8,9]. Modal distribution trends in Istanbul evolve with time. But it may not exactly reach its full capacity in a short term. In this case, consumption culture and governing of it is significant points by the related parts of the transportation system and decision makers play an important role. Transportation point of view in 2013 vision of Turkey has a vital role for planning and Strong-Weakness-Opportunities-Threats (SWOT) analysis of the system. Vision 2023 has interurban, local, national, regional and international scales. In achieving of the targets, at all these scales necessitate substantial coordination and integration between the related disciplines and parts. Especially in Istanbul and generally in Turkey and the region is very suitable for cable way systems, maritime lines, railways and water ways investments as a result multi modal transportation by the way of land characteristics, geography, location, population characteristics, economy, culture and similar features. Ensuring of a balanced modal split and intermodal integration, has a significant point by the phases of energy saving, sustainable transportation, enhancing of service parameters, reducing of traffic congestion related problems and providing of increased high way traffic safety [8,9].

References

1. T.C. Development Plan Transportation and Traffic Safety O.I.K. Report (Turkey Republic 10th Development Plan). 2012.
2. Kiziltas MC. Transportation Investments, Expectations and Estimations, Transportation World Newspaper. 2013.
3. Mustafa I. Effects of Bosphorus Bridges to Istanbul and Marmaray Investment-3. 2013.
4. Kiziltas MC. Transportation Investments and Marmaray. 2014.
5. Ilicali M, Yazici M, Levinson H, Camkesen N, Kamga C, A Bus Rapid Transit Line Case Study: Istanbul's Metrobus System, J Public Tran. 2013; 16: 153-177
6. Kiziltas MC. Global Scaled Developments In Railway Systems and Istanbul-2. 2016.
7. Kiziltas MC. European Union and Transportation Policies-2. 2016.
8. Engel-Yan J, Passmore D. Assessing alternative approaches to setting parking requirements. ITE J. 2010; 80: 25-30.
9. Gossling S. Integrating e-scooters in urban transportation: Problems, policies, and the prospect of system change. Transportation Research Part D: Transport and Environment. 2020; 79: 102230.