Chapter 18 Railway Network Development Plan

18.1 Network Configuration

18.1.1 The Master Plan Network

The Master Plan network was formulated from the Maximum Network (Chapter 14) considering the economic evaluation, prioritization, and financial constraints (Chapter 15 and 16). In course of the network determination, the railway lines for Bosporus crossing were reorganized taking into account of the detail analysis of the route alternatives (Chapter 19). The Master Plan network consists of 27 lines with a total length of 512.2km. The number of lines and the length by the system type is shown in Table 18.1.1.

Table 18.1.1 Summary of Master Plan Network

System	No. of lines	Total length (km)
Suburban	2	138.5
Metro	8	228.6
Light Metro	4	78.1
Tramway	4	44.3
Nostalgic Tram	2	4.2
Monorail	3	16.5
Funicular	2	1.2
Teleferik	2	0.7
Total	27	512.1

Source: Study Team

Figure 18.1.1 shows the Master Plan network by line (the line code is tentative) in the center area of Istanbul and Figure 18.1.2 shows the network in the west area.

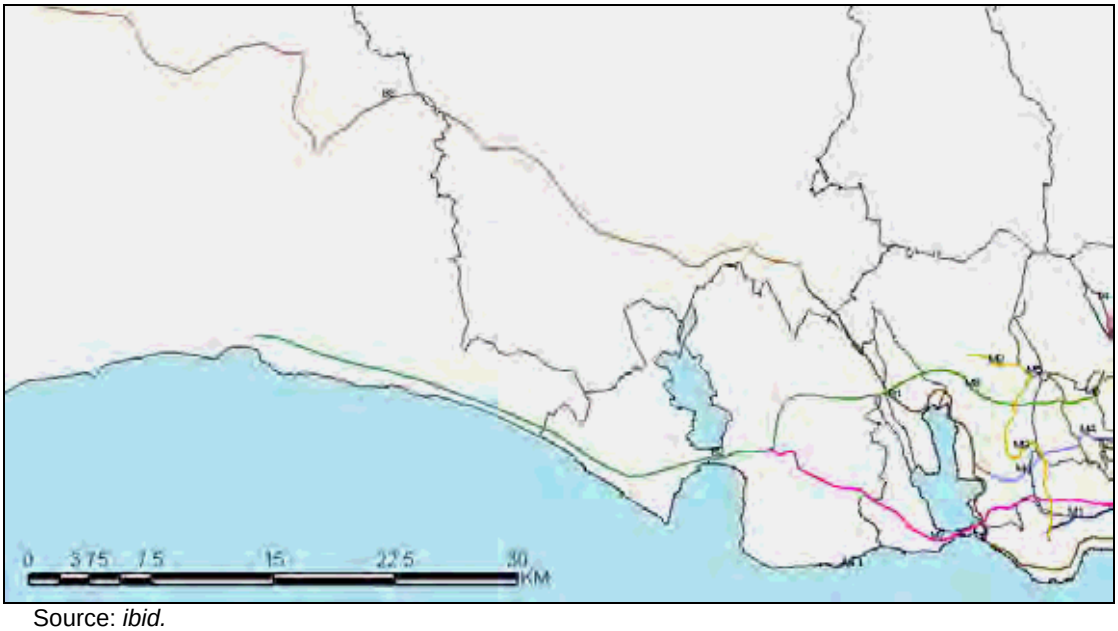
Source: *ibid.*

Figure 18.1.1 Master Plan Network (Center Area)

In Asian side, the Marmaray Commuter and M3 (Kadikoy – Kartal) run parallel along the seaside, while M6 (Uskudar–Cekmekoy) forms the east and west corridor in Uskudar and Umraniye.

In European side, the network is a form of the grid style. Along the seaside, the east and west corridor is formed by Marmaray Commuter, the Metro (M2), the tramway (T1) and the

Light Metro (M1) M9 (Olimpiyat Koyu–Yesilkoy–Atatulk Airport) runs north to south connecting these east-west lines. In the northern part of the urbanized area, M8 (Kabatas–Besiktas–Sisli–Giymkent–Tekstilkent–Istoc–Ispartalule) forms the east and west corridor along TEM. Between the two corridors, M4 (Otogar– Bagchilar–Halkali) connects Otogar and Halkali east and west. On the other hand, M1 forms the north and south corridor between Yenipaki and Sariyer, running through the business and commercial center of Istanbul. Other north and south corridors are T5 (Eminonu–Alibekoy), M2, T2 (Zeytinburnu–Bagchilar), M5 (Bakirkoy–Bachelieler–Ikitelli– Altinsehir), and M4 in order from east to west.



Source: *ibid.*

Figure 18.1.2 Master Plan Network (Western Area)

The Marmaray Project will connect the both sides by the railway tunnel under Bosporus Straight, and this will significantly promote public transport, integrating railway system in Istanbul. However, the demand analysis shows that the future demand in public transport between European side and Asian side will be far larger than the capacity of the Marmaray Project.

To deal with the future demand, the master plan network includes a metro system over the new bridge (M10) and the Metrobus line on the 1st Bosporus Bridge.

In European side, M10 connects Seyrantepe (M2) and Kazlicesme (B1), running the outer side of the Golden Horn like an arc shape, crossing five other railway lines. In Asian side, the line connects Sogutlucesme (B1), crossing M3, M6 and M11 (Umranie - Bostanci).

The idea of constructing a new railway tunnel under the straight is not adopted in the master plan because of the high construction cost and the long distance between stations at both sides of tunnel. The distance of the section without station will be long because the vertical difference between the tunnel section and the underground section of the land in European side and Asian side is very large.

18.1.2 Railway Line Profile

Currently, railway lines that are operated by Ulasim A.S. have line codes such as M1, M2, T1, T2, T3, T4, and F1. The station name at both ends of lines forms the name of lines such as Taksim–4.Levent Metro, Aksaray–Airport Light Metro, Kabatas–Zeytinburnu Tramway, etc. This naming system brings confusion when a line is extended and the new stations become the both ends of the line; and this change will occur so often.

Table 18.1.2 shows the list of railway lines with code name and line name. Figure 18.1.3 shows the route locations and profiles of the first 18 lines from M1 to B2 in Table 18.1.2 except T3 and T6 lines.

Table 18.1.2 List of Master Plan Network

Code	Line Name	Section	Length (km)
Metro & Light Metro			
M1	Aksaray Line	Aksaray-Ataturk International Airport	20.0
M2	Taksim Line	Bakirkoy-Yenikapi-Taksim-4Levent-Cayirbasi	22.9
M3	Kadikoy Line	Kadikoy-Kartal-Tuzula	39.3
M4	Otogar Line	Otogar-Bagcilar-Halkali	13.1
M5	Bakirkoy Line	Bakirkoy-Bahcelievler-Bagcilar-Ikitelli-Basaksehir	20.5
M6	Uskudar Line	Uskudar-Cekmekoy	19.0
M7	Beylikduzu Line	Bakirkoy-Buyukcekmece-Beylikduzu	26.0
M8	Sisli Line	Kabatas-Besiktas-Sisli-Giyimkent-Tekstilkent-Ispartakule	41.7
M9	Olympic Stadium Line	Olimpiyat Koyu-Yesilkoy-Ataturk Airport	18.7
M10	Bosporus Ring	Zeytinburnu-Seyrantepe-3rd Bridge-Bahcelievler-Sogutlucesme	34.7
M11	Bostanci Line	Umraniye-Bostanci	14.0
M12	Sultanbeyli Line	Ibrahimaga-Sultanbeyli- North Tuzla	36.8
Tramway & LRT			
T1	Kabatas-Zeytinburnu Line	Kabatas-Zeytinburnu	14.1
T2	Zeytinburnu-Bagcilar Line	Zeytinburnu-Bagcilar	5.1
T3	Kadikoy-Moda Tram	Kadikoy-Moda	2.6
T4	Topkapi Line	Topkapi-Edimekapi-Sultancifligi	15.5
T5	Golden Horn Line	Halic-Cevresi	9.6
T6	Istiklar Line	Istiklal Street	1.6
Suburban Railway			
B1	Marmaray Commuter Line	Hadimkoy-Kalkali-Yenikapi-Ibrahimaga-Gebze	96.5
B2	Silivri Line	1st Phase: Ispartakule-Kirac-Celaiye-Silivli-	42.0
Monorail and Other Railway System			
H1	Beyoglu Monorail	Shishane-Kulaksiz-Cemal Kamaci Guzergahi	5.8
H2	F1 Monorail	Sabiha Gokcen Airport-Formula 1	7.7
H3	Kartal Monorail	Kartal D100-Kartal IDO	3.0
F1	Taksim-Kabatas Funicular	Taksim Kabatas	0.6
F2	Tunnel	Tunel-Karakoy	0.6
K1	Taksim-Macka Teleferik	Taksim- Macka	0.3
K2	Eyup-Piyer Loti Teleferik	Eyup-Pier Loti	0.4
		Total	512.2

Source: *ibid.*

M1: Aksaray Line (Yenikapi–Aksaray–Ataturk International Airport

Length: 20.0 km Type: Light Metro No. of Stations: Traction System: 750 V DC Overhead Line Source: Study Team	M1 is Aksaray–Airport Light Metro (existing) and its extension to Yenikapi. This line connects important transfer points such as Ataturk International Airport, Otogar, and Yenikapi. Through trains between M1 and M7 (Bakirkoy–Buyukcekmece–Beylikduzu) will be operated to connect Buyukchekmece and the center of Istanbul.

M2:Taksim Line (Bakirkoy–Yenikapi–Taksim–4.Levent–Cayirbasi)

Length: 22.9 km Type: Metro No. of Stations: Traction System: 750 V DC 3rd Rail Source: Study Team	M2 is the expansion of Taksim–4.Levent Metro, running through high demand corridor. This line receives passengers from the Marmaray Commuter at Yenikapi.

Figure 18.1.3 Railway Line Profile

M3: Kadikoy Line (Kadikoy–Kartal–Tuzla)

Length: 39.3 km Type: Metro No. of Stations: Traction System: 1500 V DC Overhead Line Source: Study Team	M3 runs parallel with the Marmaray Commuter, connecting the east districts such as Maltepe, Kartal, Pendik, and Tuzla to the center of Asian side in Kadikoy and Uskudar. The end of this line is the industrial area in Tuzla. This line has a direct access to Sabiha Gokcen Airport. The first phase of this line (Kadikoy- Kartal) is under construction.

M4: Otogar Line (Otogar–Bagcilar–Halkali)

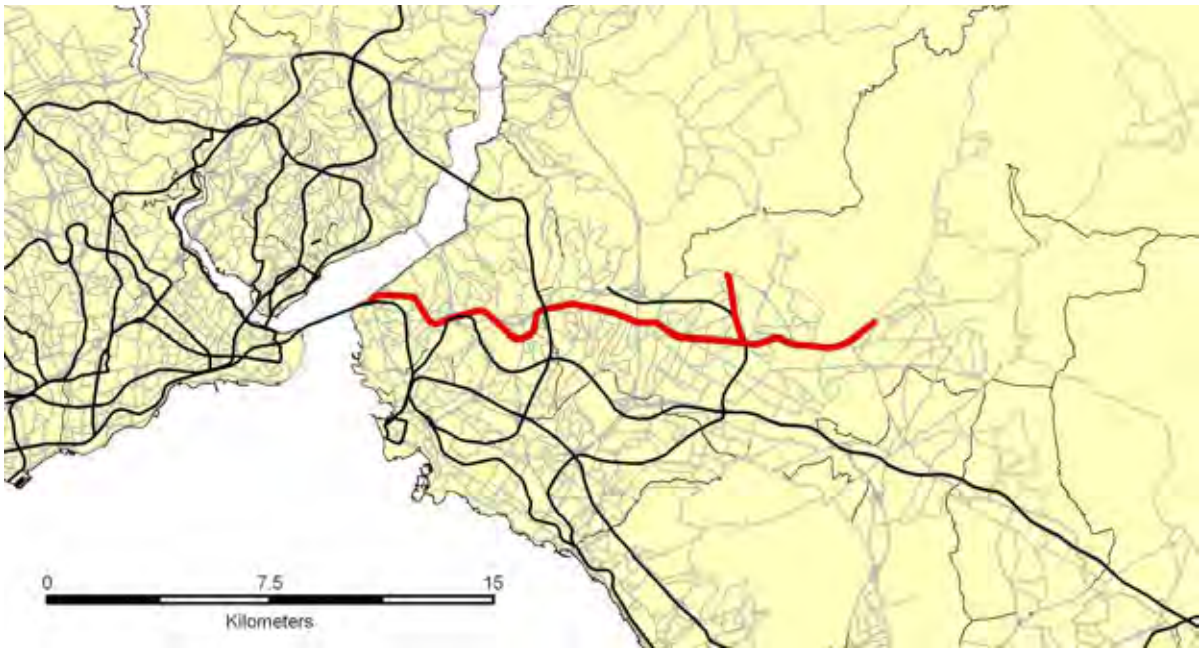
Length: 13.1 km Type: Light Metro No. of Stations: Traction System: 750 V DC Catenary Source: Study Team	M4 runs through the residential area in Kucukcekmece and Bagcilar east and west between M2 (Cayirbasi–Levent–Taksim–Yenikapi) and M8 (Kabatas–Tekstilkent–Ispartakule), connecting Otogar, Bagcilar, and Halkali. This line can go through M1 from Otogar to Yenikapi. The section between Otogar and Bagchilar is under construction and will opened soon.

Figure 18.1.3 Railway Line Profile (continued)

M5: Bakirkoy Line (Bakirkoy–Bahcelievler–Bagcilar–Ikitelli–Basaksehir)

Length: 20.5 km Type: Metro No. of Stations: Traction System: 1500 V DC Overhead Line Source: Study Team	M5 is the north-south corridor crossing Zeytinburnu, Bahcelievler, Bagcilar, and the north in Kucukcekmece. This line will improve accessibility to the northern area in Kucukcekmece. There are transfer stations with B1, M1, M2, M4, and M8 for the access to the center of the city.

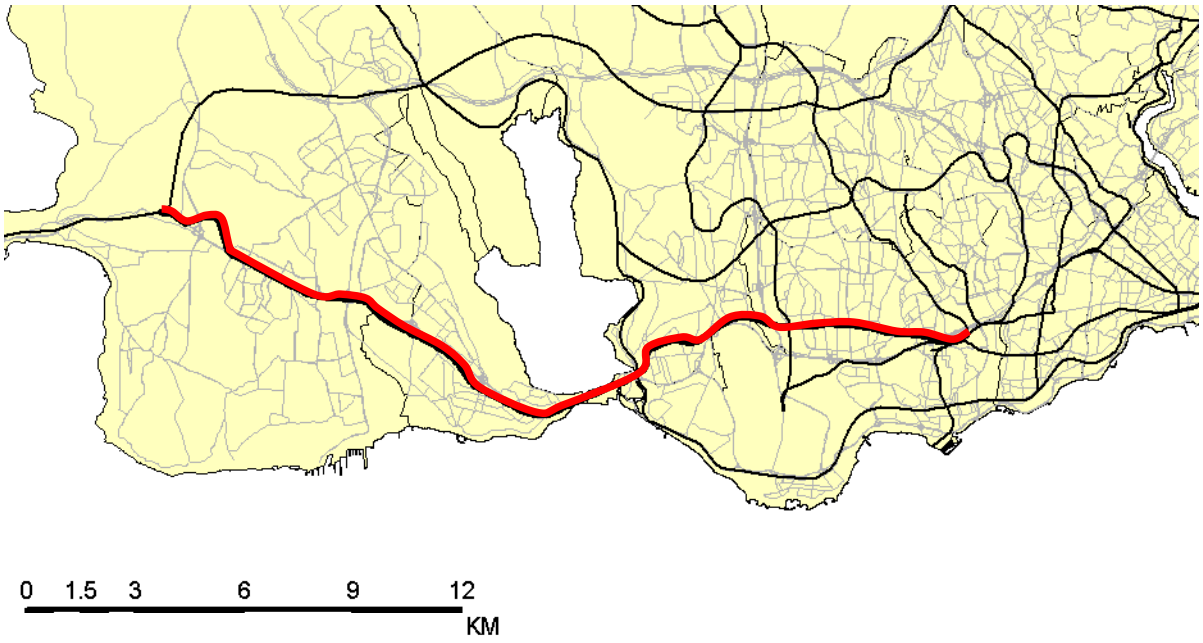
M6: Uskudar Line (Uskudar–Cekmekoy)



Length: 19.0 km Type: Light Metro No. of Stations: Traction System: 1500 V DC Catenary Source: Study Team	This is the line of Uskudar–Cekmekoy Light Rail project which is under tendering stage. M6 runs east and west through high density residential areas of Uskudar District and Umraniye District in Asian side. The terminal station at Uskudar connects this line to the Marmaray Commuter.

Figure 18.1.3 Railway Line Profile (continued)

M7: Beylikduzu Line (Bakirkoy–Buyukcekmece–Beylikduzu)



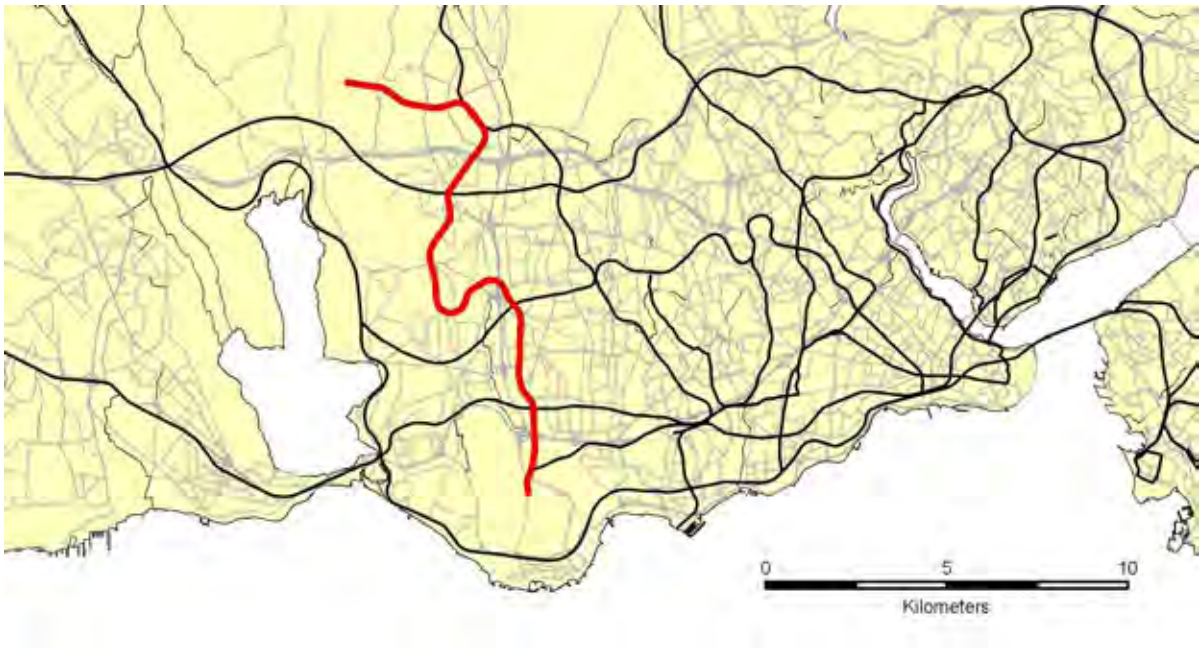
Length: 26.0 km Type: Light Metro No. of Stations: Traction System: 750 V DC Overhead Line Source: Study Team	M7 is a light metro which connect Buyukchekmece and Bakirkoy, passing through Avcilar and Kucukcekmece. This line runs along D-100 where Metrobus is currently operated. The project of this line is under tender stage. Through trains going through M1 will be operated. The end station at Tuyap will be extended to the Silivri Line (B2) so that the western area can be connected to the railway network in the center of Istanbul.

M8: Sisli Line (Kabatas–Besiktas–Sisli–Giyimkent–Tekstilkent–Ispartakule)

Length: 41.7k m Type: Metro No. of Stations: Traction System: 1500 V DC Catenary Source: Study Team	M8 runs through European side east and west with a long distance of 41.7 km. There are eight transfer stations with railway lines of north-south direction. This line is connected to the Silivri line (B2) at Ispartakule and through trains will be operated between the two lines. It is expected that the train operation will promote the urban development in Silivri and Buyukcekmece.

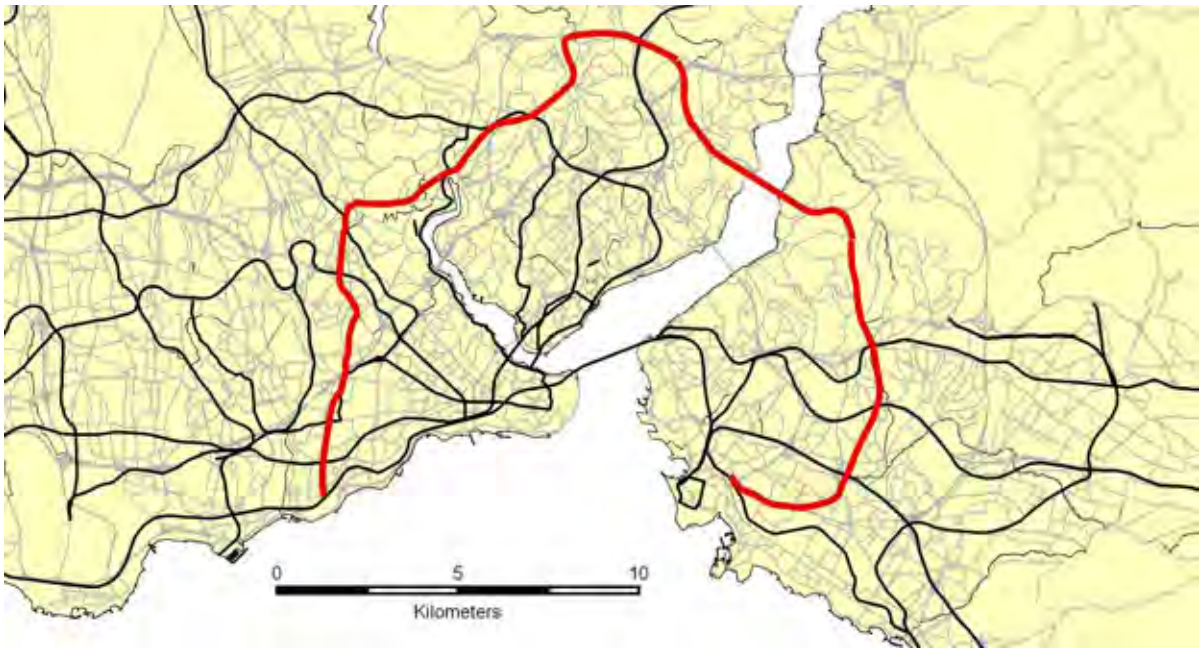
Figure 18.1.3 Railway Line Profile (continued)

M9: Olympic Stadium Line (Olimpiyat Koyu–Yesilkoy–Ataturk Airport)



Length: 18.7 km Type: Metro No. of Stations: Traction System: 1500 V DC Overhead Line Source: Study Team	M9 runs north and south through the residential area in Bahcelievler and Kucukcekmece, connecting Ataturk Airport and the new development area around Olympic Stadium. M9 is connected to M5 (Bakirkoy – Bahcelievler – Ikitelli – Altinsehir) at Ikitelli station and the through train operation from Olimpiyat Koyu to M5 is possible.

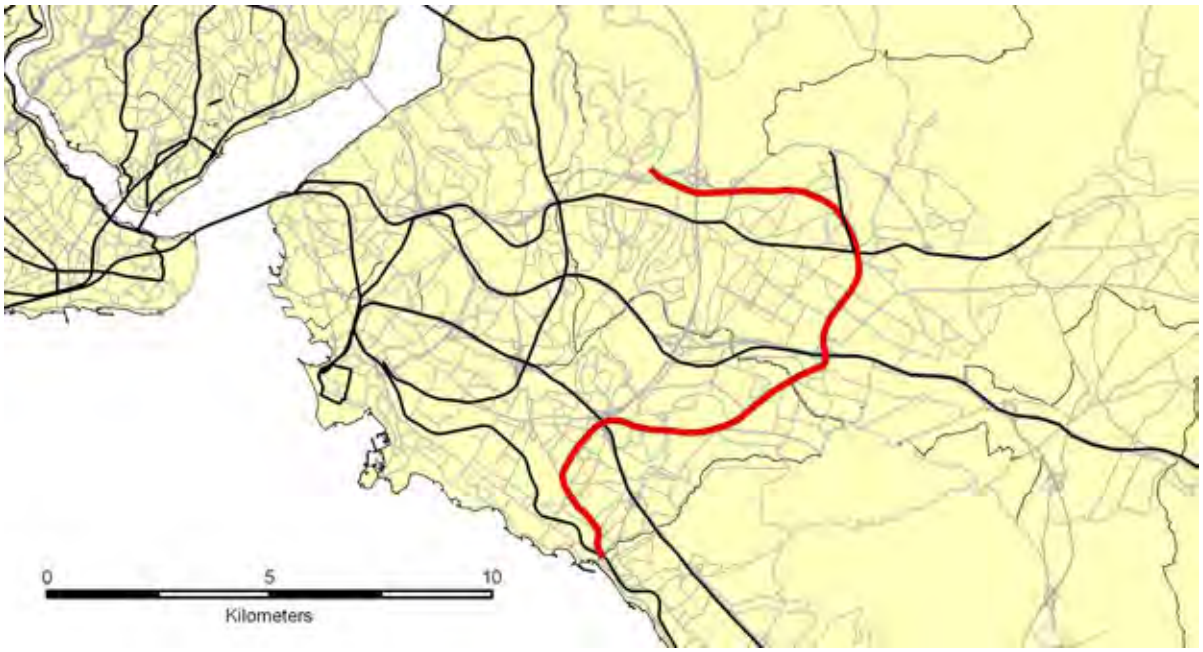
M10: Bosporus Ring (Zeytinburnu–Seyrantepe–3rd Bridge–Bahcelievler–Sogutlucesme)



Length: 34.7 km Type: Metro No. of Stations: Traction System: 1500 V DC Catenary Source: Study Team	This is an important railway for the Bosporus Crossing. M10 crosses Bosporus Straight by the new bridge between the 1st and 2nd Bosporus Bridge. In European side, this line connects Seyrantepe (M2) and Zeytinburnu (B1), running the outer side of the Golden Horn like an arc shape, crossing five other railway lines. In Asian side, this line connects Sogutlucesme (B1) and the bridge crossing M3, M6, and M12.

Figure 18.1.3 Railway Line Profile (continued)

M11: Bostanci Line (Umraniye-Bostanci)



Length: 14.0 km Type: Metro No. of Stations: Traction System: 1500 V DC Overhead Line Source: Study Team	M11 connects Bostanci (B1) and Umraniye (M6), crossing M3 (Kadikoy – Kartal) and M12, as the outer circular route in Asian side. This line will provide railway access to the residential and industrial area in Umraniye.

M12: Sultanbeyli Line (Ibrahimaga–Sultanbeyli– North Tuzla)

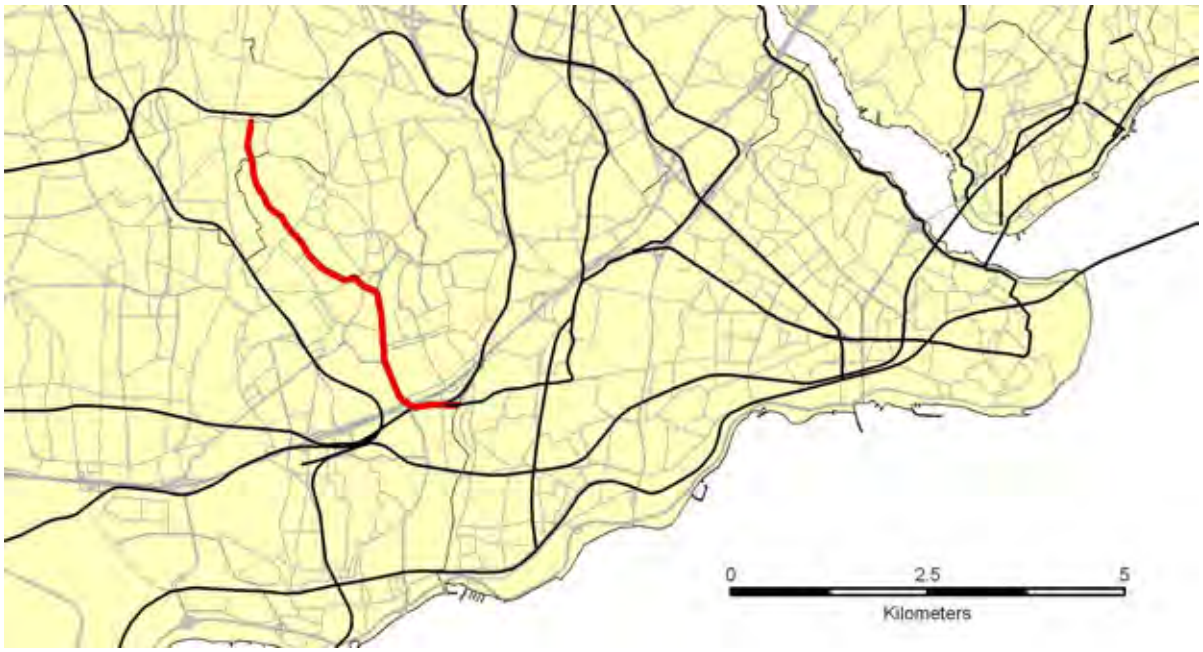
Length: 36.8 km Type: Metro No. of Stations: Traction System: 1500 V DC Catenary Source: Study Team	M12 runs along Ankara Highway (O-4) in parallel with M3 (Kadikoy–Kartal –Tuzla) through Uskudar, Umraniye, Kartal, Sultanbeyli, Pendik, and Tuzla. This line passes through the water reserve area in Sultanbeyli without any station to avoid unexpected development.

Figure 18.1.3 Railway Line Profile (continued)

T1: Kabatas–Zeytinburnu Line (Kabatas–Zeytinburnu)

Length: 14.1km Type: Tramway No. of Stations: 24 Traction System: 750 V DC Overhead Line Source: Study Team	T1 is a modern type tramway now under operation, running on the streets through commercial, business, educational, and tourism areas between Kabatas and Zeytinburnu. The tramway vehicle running on the streets is a part of the beautiful city landscape.

T2: Zeytinburnu–Bagcilar Line (Zeytinburnu–Bagcilar)



Length: 5.1km Type: LRT (Tramway) No. of Stations: 9 Traction System: 750 V DC Catenary Source: Study Team	This is the existing Zeytinburnu- Bagcilar Tramway. This line runs north and south in the industrial and residential area in Gungoren, having the connection with other lines at Zeytinburnu.

Figure 18.1.3 Railway Line Profile (continued)

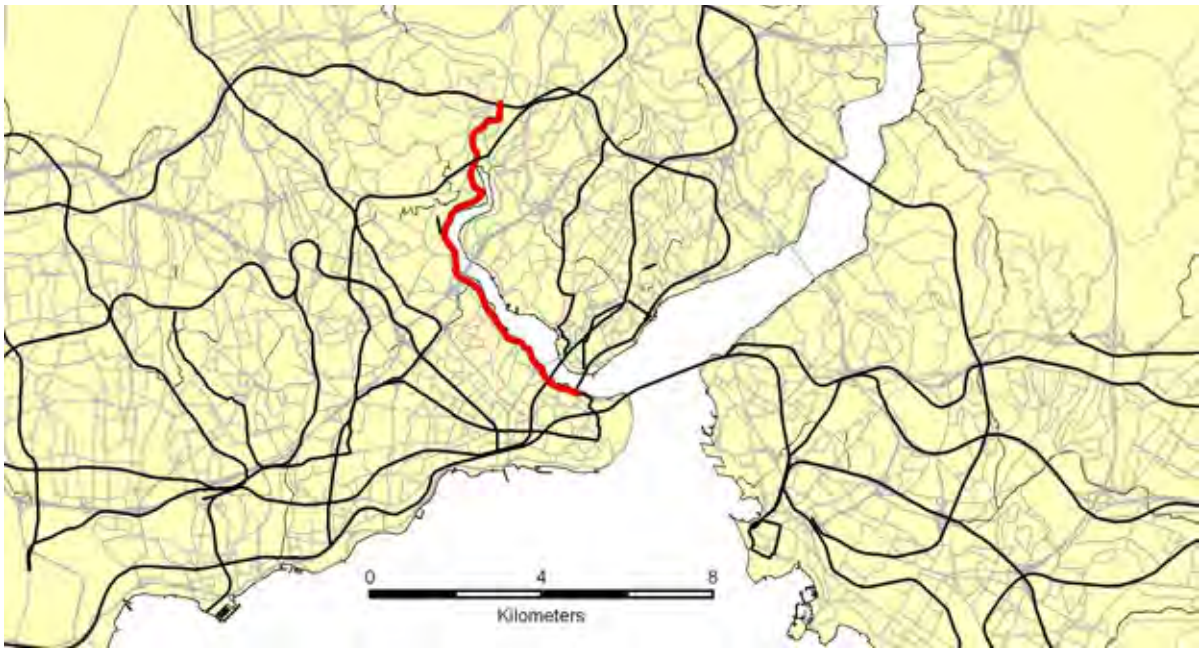
T4: Topkapi Line (Topkapi- Edirnekapi- Sultanciftligi)

Length:	15.5km
Type:	Light Metro
No. of Stations:	20
Traction System:	750 V DC Catenary

Source: Study Team

This line is currently operated as Edirnekapi- Sultanciftligi Tramway (T4) and the section between Topkapi and Edirnekapi is under construction. T4 runs north and south through business, commercial and residential area in Eyup, Bayrampasa, and Gazismanpasa.

T5: Golden Horn Line (Halic-Cevresi)



Length:	9.6km
Type:	Light Metro
No. of Stations:	13
Traction System:	750 V DC Overhead Line

Source: Study Team

T5 runs along the Golden Horn, connecting Eminonu and Eyup, providing access to educational institutions along the route. This line has the connection with T1, Kabatas–Zeytinburnu Tramway, at Eminonu station and with future lines of M2, M8 and m10.

Figure 18.1.3 Railway Line Profile (continued)

B1: Marmaray Commuter Line (Hadimkoy–Halkali–Yenikapi–Ibrahimaga–Gebze)

Length: 96.5km Type: Suburban No. of Stations: 50 Traction System: 2.5kV AC Catenary Source: Study Team	The Marmaray Commuter Line connects European and Asian side by railway through the tunnel under Bosporus Straight. This line runs along the existing TCDD line, and goes further from the end stations. Having triple tracks, both rapid and local stop trains will be operated in addition to inter-city trains. Yenikapi station will be the largest transfer station in Istanbul. This line is now under construction.

B2: Silivri Line (1st Phase: Ispartakule–Kirac–Celaiye–Silivri)

Length: 42km (1st Phase) Type: Suburban No. of Stations: Traction System: 1500 V DC Overhead Line Source: Study Team	This is an important transport infrastructure to promote the development in Silivri. B2 connects Tekirdag and the north in Buyukcekmece, running through Buyukcekmece and along the seaside of Silivri with a total length of 72km. The first stage between Silivri and Ispartakule is included in the master plan. This line has four tracks for the operation of rapid trains and local trains. Trough trains will be operated with M8.

Figure 18.1.3 Railway Line Profile (continued)

18.2 Development of Transfer Point

18.2.1 Necessity of Easy Transfer at Station

The advantage of railway is rapid and accurate operation. However, railway passengers sometimes need to use two or more railway lines to arrive their destination station, which requires transfer from one train to another at a station or stations. This is the disadvantage compared to other transportation mode. Since the smoothness of the transfer is one of the key points for passengers to select the transportation system, the short and easy movement from one train to another is very important to make use of the advantage of the railway system.

18.2.2 Transfer Type

There are various types of railway transfer points.

1) Through train operation between different railway lines

This does not require transfer between two lines and is convenient for passengers. However, this is usually difficult due to the railway alignment and it is impossible when the two lines are different such as tramway and metro.

2) Transfer through one platform

Passengers transfer from a train of one side of the platform to another of the other side. Transfer is very convenient for passengers.

3) Transfer via platform and concourse

Passengers transfer from a train to another train which uses a different platform through concourse without going out the ticket gate. The two lines should be connected by concourse.

4) Transfer at a station

Passengers exit a railway line and enter another line which uses the same station. In most cases, passengers need to pass the ticket gate.

5) Transfer between two stations

Passengers exit a railway line, go out from the station, and enter another line in the different station.

6) Transfer to another mode

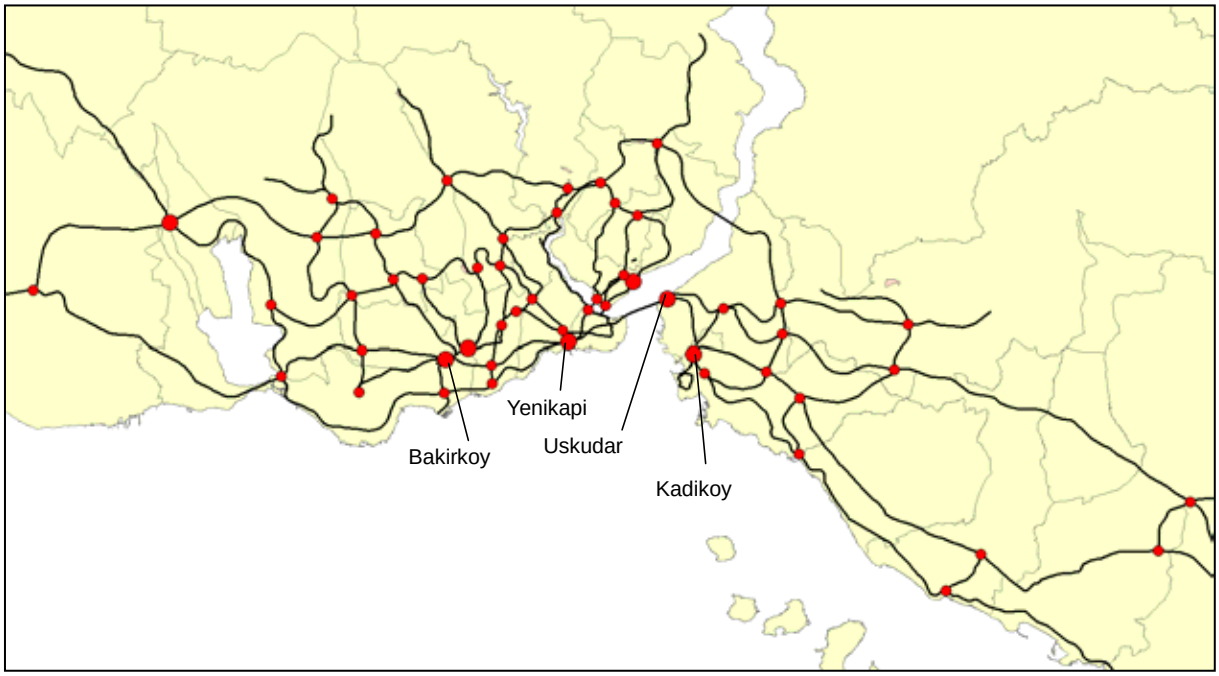
Passengers transfer from a transport system to another type of transport system, such as between rail and bus, rail and taxi, rail and private car.

18.2.3 Commercial Development at Terminal Stations

A terminal station is the potential area for commercial development when passenger demand is high because it has a large market area along the railway line. Shopping, cafe, restaurant and other commercial services in a terminal station are attractive for passengers. The commercial building itself at a terminal station can be a destination of railway passenger and will increase passenger volume which increases the railway revenue. At major terminals, commercial development should be promoted.

18.2.4 Transfer Point in the Master Plan

The figure below shows the transport points among railway lines in the master plan.



Source: *ibid.*

Figure 18.2.1 Transfer Points of Railway Lines

1) Yenikapi Station

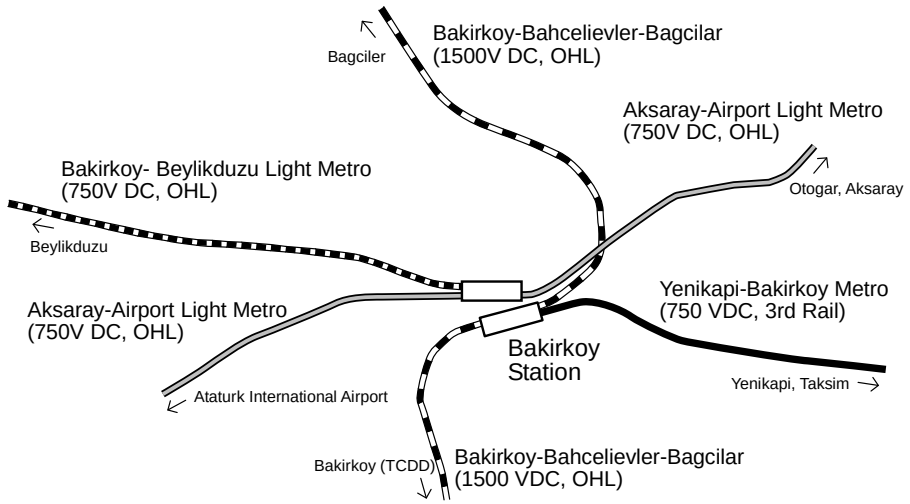
This is the transfer point of the Marmaray Commuter from Asian side to other railway lines in European side. M1 (Yenikapi–Ataturk International Airport), M2 (Cayirbasi–Levent–Taksim–Yenikapi–Bakirkoy), Marmaray Commuter will use this station. In future, beyond this master plan period, this station will also be the terminal station of the high-speed railway in European side.

This station will be developed as a station complex with commercial facilities such as shopping, restaurant, and other commercial services.

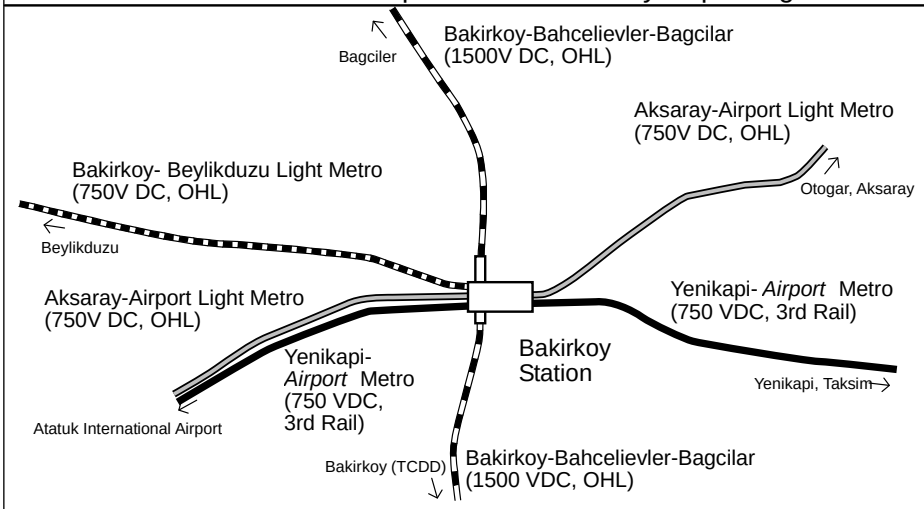
2) Bakirkoy Station

Currently, this is a station of Aksaray-Airport Light Metro, and will be the terminal station of the tender state project of Bakirkoy–Beylikduzu Light Metro (M7). In addition, M5 (Bakirkoy– Bahcelievler–Bagcilar–Ikitelli–Basak Konutlari) and M2 will use this station in the future. To provide the direct access between Atatulk International Airport and the business and commercial center in Beyoglu, Sisli, and Besiktas, M2, the extension of the existing Taksim–4.Levent Metro, should be connected to the airport. For the access route between Bakirkoy and the airport, this master plan remains two options: one is construction of a new line in parallel with the Yenikapi–Airport Light Metro (M1), and the other is conversion of the corresponding section of M1 to M2. In the second option, M1 will be connected to T1. Figure 18.2.2 illustrates these options. Platforms of M1 and M2 (and T1) will be parallel, while that of M5 will cross over or under them. In any case, the platforms of these lines should be connected by a common concourse.

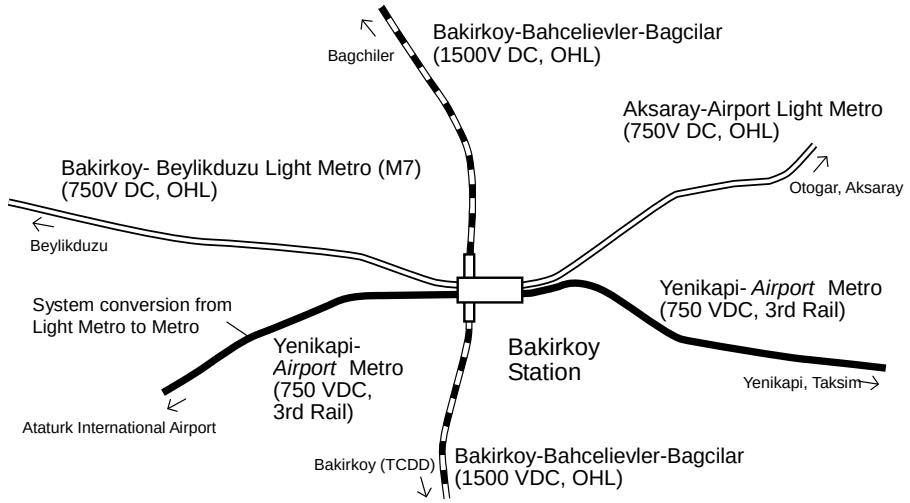
Present Plan



Alt-1: Construction of Metro in parallel with Aksaray-Airport Light Metro



Alt-2: System Conversion of Aksaray-Airport Light Metro to Metro (750V DC 3rd Rail) & Connection of M7 to the Light Metro



Source: *ibid.*

Figure 18.2.2 Alternatives of Railway Connection at Bakirkoy Station

3) Uskudar Station

Uskudar station will be the transfer point among Marmaray railway, M6 (Uskudar–Cekmekoy), buses, and ferries.

In the station, the platforms should be close one another and connected to the common concourse and underground walkway to access to the bus terminal and the ferry terminal should be constructed.

4) Ibrahimaga Station

Ibrahimaga is the central area in Asian side, and the major transfer point of sea transport. To promote railway transport in Asian side, development of convenient transfer among railway lines and inter-modal transfer is very important.

In this master plan, Ibrahimaga Station is used by the Marmaray Commuter, M3, and M12 (Ibrahimaga–Sultanbeyli– Sabiha Gokcen Airport), and the transfer from M3 and M12 to the Marmaray Commuter is expected to be high.

Ibrahimaga Station should have the common concourse for railway lines, buses and ferries for smooth inter-modal transfer, and be developed as a large scale station complex with commercial buildings.

18.3 Project Formulation

The master plan network has 12 metro and light metro lines, two suburban lines, four tramways, two nostalgic tramways, three monorails, two funiculars, and two teleferics, in which 13 lines are completely new, four lines are the extension of the existing lines, and others are the existing lines.

18.3.1 Completion of the On-going Construction Projects

Currently, eight railway projects are under construction as shown in the table below. The under construction projects include the extension of Taksim- 4.Levent Metro for both ends (C1 and C4), the extension of Aksaray- Airport Light Metro from Esenler and Aksaray (C5 and C8), and the extension of Edirnekapi- Sultanciftligi Tramway[1] (C2). The Marmaray project is the largest project including tunnel construction under Bosporus Straight. Bagcilar- Ikitelli- Olimpiyat Koyu Metro and Kadikoy- Kartal Metro are new underground lines with the traction system of DC1500V. These construction projects include civil work, E&M (electrical and mechanical) work, workshops construction, and procurement of rolling stocks. The project code beginning *C* represents under construction project.

[1] The system of Edirnekapi- Sultanciftligi *Tramway* is regarded as Light Metro in this report.

Table 18.3.1 Railway Projects under Construction

Project Code	Line Code	Project Section	Type	Traction System	Length (km)	Completion Year
C1	M2	Taksim - Yenikapi	Metro	DC750V 3rd Rail	5.2	2010
C2	M11	Topkapi- Edirnekapi	Light Metro	DC750V Catenary	3.0	2009
C3	M3	Kadikoy- Kartal	Metro	DC1500V Catenary	21.7	2013
C4	M2	4. levent–Ayazaga–Haciosman	Metro	DC750V 3rd Rail	8.0	Mar-2009
C5	M4	Otogar - Bagcilar (Kirazli)	Light Metro	DC750V Catenary	5.6	Dec-2009
C6	M5	Bagcilar- Ikitelli- Basaksehir	Metro	DC1500V Catenary	11.5	Dec-2009
	M9	Ikitelli- Olimpiyat Koyu	Metro		4.4	Dec-2009
C7	B1	Marmaray project	Suburban	AC25kV Catenary	76.5	Mar-2012
C8	M1	Aksaray- Yenikapi	Light Metro	DC750V Catenary	0.7	2010
		Total			136.6	

Source: Transportation Department. of IMM

18.3.2 New Construction Projects

New railway construction includes metro, light metro, suburban rail, monorail, and tramway. The list of the new construction projects is shown in Table 18.3.2, Table 18.3.3, and Table 18.3.4. The project code beginning with *T* means that the project is under tender stage, while *D* means the project is under design stage. The project code beginning with *P* or *PP* means that the project is planning stage.

In case that the length of a line is too long as a project, the section of the line is divided into several projects like M2, M5, M8, and M10 in order to make it easy to plan a stage construction.

Table 18.3.2 New Construction of Metro and Light Metro

Line Code	Line Name	Project Section	Length (km)	Project code
M2	Taksim Line	Bakirkoy–Yenikapi	7.0	D3
		Haciosman–Cayirbasi	2.7	P2-4
M3	Kadikoy Line	Kartal–Tuzla	21.7	P1-4
M4	Otogar Line	Bagcilar–Halkali	7.5	P1-1
M5	Bakirkoy Line	Bakirkoy–Bagcilar (Kirazli 1)	8.9	D1
M6	Uskudar Line	Uskudar–Cekmekoy	19.0	T1
M7	Beylikduzu Line	Bakirkoy–Buyukcekmece–Beylikduzu	25.0	T2
M8	Sisli Line	Kabatas–Besiktas–Giyimkent–Tekstilkent	24.5	D2
		Tekstilkent–Ispartakule	16.7	P1-2
M9	Olympic Stadium Line	Olimpiyat Koyu–Yesilkoy–Ataturk Airport	18.7	D5
M10	Bosporus Ring	Zeytinburnu – Seyrantepe	16.3	P2-1
		Seyrantepe – Bahcelievler	9.8	PP-1
		Bahcelievler – Sogutlucesme	8.6	PP-2
M11	Bostanci Line	Umraniye–Bostanci	11.6	P1-3
M12	Sultanbeyli Line	Ibrahimaga- Sultanbeyli- North Tuzla	36.8	PP-3

Source: Study Team

Table 18.3.3 Construction of Suburban Railway

Line Code	Line Name	Project Section	Length	Project code
B1	Marmaray Commuter	Hadimkoy–Halkali	20.4	PP-4
B2	Silivri Line	Ispartakule–Celayie	25.8	P2-8
		Celayie–Silivri (Phase-I)	18.9	PP-6

Source: *ibid.*

Table 18.3.4 Construction of Monorail and Tramway

Line Code	Line Name	Project Section	Length (km)	Project code
T2	Golden Horn Line	Halic–Cevresi	9.6	D4
H1	Beyolgu Monorail	Shishane- Kulaksiz- Cemal Kamaci Guzergahi	5.8	D6
H2	F1 Monorail	Sabiha Gokcen Airport- Formula 1	7.7	P2-3
H3	Kartal Monorail	Kartal D100- Kartal IDO	3.0	P2-2

Source: *ibid.*

18.4 Short-, Medium-, and Long-term Project

18.4.1 Construction Period

A railway project needs a long time to be implemented including planning, project formulation, and construction. Especially, a typical underground railway project stretches over a period of 10 years. The construction of an underground station takes five years according to the world experiences, although the period depends on the condition such as station depth and the location. Construction of a tunnel also takes time. The table below shows the schedule of a typical tunneling work by a single track TBM. The period by open-cut method is different.

Table 18.4.1 Typical Schedule of Tunnel Construction by TBM

Year	1	2	3	4	5
Preparation of TBM	■				
Construction of TBM base	■	■			
Construction of tunnel		■	■	■	
Track works				■	■

Source: *ibid.*

Key Assumption: Line length = 5km (all underground), No. of stations = 5,
Tunneling speed = 10m/day in average, Working days = 25 days per month,
Contract type = Design build

Construction of underground railway involves many works: site survey, land acquisition, preliminary design, preparation of tender documents, and tendering in preparation stage, and detailed site survey, detailed design, tunnel construction, station construction, E&M works, and test running in implementation stage. The table below shows the construction schedule of a typical 5km underground metro. In this case, the total time is about 10 years.

Table 18.4.2 Typical Schedule of a 5-km Tunnel Construction

Year	1	2	3	4	5	6	7	8	9	10
Preparation work										
Site survay										
Land acquisition										
Preliminary design										
Preparation of Tender Document										
Tendering										
Implementation										
Detailed site survey										
Detailed design										
Tunnel construction										
Station construction										
E&M works										
Test runing										

Source: *ibid.*

The construction period can be shortened by setting up several construction sites and constructing several sections simultaneously. For example, a 15km underground metro can be constructed in almost the same period as a 5km underground metro when the 15km section is divided into three sections and three construction works are done at the same time.

The construction period of elevated railways is shorter than that of underground metros if the length of the section is the same, although it becomes longer when land acquisition takes time.

For the schedule of the railway projects in this master plan, the following durations are assumed.

Table 18.4.3 Railway Construction Period for the Master Plan Schedule

	- 5km	-10km	-15km	-20km	-30km	-50km
Metro	9	9.5	10.5	11.5	12.5	15
Light Metro	6.5	7		7.5	8	-
Tramway		8	-	-	-	-
Monorail	7	7.5	7.5	7.5	8	-
AGT	7	7.5	7.5	7.5	8	-

Source: *ibid.*

18.4.2 Railway Construction Schedule

In this study, a short-term project is defined as such a project which will be completed by year 2013 and in the same way, a medium-term project by year 2018 and a long-term project by year 2013 regardless of its starting year of construction.

The construction schedule of the master plan railway network is shown in Table 18.4.4. There are nine short-term projects, 10 middle-term projects, and 11 long-term projects. Only the under construction projects fall into the short-term projects, while tender stage projects and design stage projects are the middle-term projects. Most planning stage projects fall into long-term projects. The construction work of almost all of the new projects should be initiated in the short-term period. There are only two projects whose construction work will be started in middle-term period.

Table 18.4.4 Construction Schedule of the Master Plan Network

	Code	TYPE	Length (km)	Years	Short-term						Middle-Term					Long-Term				
					2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Short-Term Projects	C-1	Metro	5.2	5																
	C-2	LRT	3.0	1																
	C-3	Metro	21.7	5																
	C-4	Metro	8.0	5																
	C-5	LRT	5.6	2																
	C-6	Metro	15.9	2																
	C-7	Suburban	76.5	5																
	C-8	LRT	0.7	5																
Middle-Term Projects	T-1	LRT	19.0	7																
	T-2	LRT	25.0	8																
	D-1	Metro	9.0	7																
	D-2	Metro	25.0	11																
	D-3	Metro	7.0	9																
	D-4	TRAM	9.6	7																
	D-5	Metro	14.3	10																
	D-6	Monorail	5.8	8																
	P1-1	LRT	7.5	7																
	P2-4	Metro	2.7	7																
	PP-5	LRT	1.0	6																
Long-Term Projects	P1-2	Metro	12.0	11																
	P1-3	Metro	14.0	11																
	P1-4	Metro	18.1	13																
	P2-1	Metro	16.3	11																
	P2-2	Monorail	3.0	6																
	P2-3	Monorail	7.7	7																
	P2-8	Metro	25.8	12																
	PP-1	Metro	9.8	10																
	PP-2	Metro	8.6	8																
	PP-3	Metro	36.8	13																
	PP-4	Suburban	20.4	8																
	PP-6	Metro	18.9	15																

Source: *ibid.*

18.4.3 Railway Construction in Silivri

Railway construction in Silivri is an important infrastructure development to achieve the future land use plan in Silivri. Since the area is large, the railway system should be developed stage by stage. The development stage of the railway system in Silivri is summarized as follows.

1st stage: Construction of the section between Silivri and Tuyap of the Silivri Line (B2). Passengers from Silivri area to the center of Istanbul transfer from this line to the Beylikduzu Line (M7: Bakirkoy–Beylikduzu Light Metro) at Tuyap Station.

2nd stage: Construction of the section between Ispartakule and Tuyap of B2. This line will be connected to M8 by through train operation. The section between Ispartalule and Silivri is the 1st Phase of the Silivri Line which is included in the master plan.

3rd stage: Construction of the section between Silivri and Gumusyaka as the 2nd Phase of the Silivri Line. This project is a super-long term project after the master plan period. This line will be connected to M8 by through train operation.

4th stage: Construction of the section between Gumusyaka and Tekirdag. The Siivri Line will be completed at this stage. This line will be connected to M8 by through train operation.

18.4.4 Review of Master Plan and Schedule

The master plan network is formulated based on the land use plan, demand forecast, and the various factors of the present conditions. As a nature of planning and demand forecast, the future conditions for railway development will not necessarily be the same as expected in the planning stage due to unexpected developments and socioeconomic situations. To incorporate the changes in the surrounding conditions, the short term construction plan should be reviewed and revised every 3 to 5 years.

18.5 Project Cost Estimate

1) Method of the Cost Estimate

There is no standard price for a railway project. The cost of a railway project can only be determined based on the local and specific conditions of the project individually. In the master plan stage, only a rough estimation is possible. The construction cost including civil work and E&M per route kilometer and the procurement cost of rolling stock per car by system type are assumed to estimate the project cost in this master plan. The composition of structure type is assumed for each system type.

Table 18.5.1 shows the unit costs of the project cost estimate for the railway projects.

Table 18.5.1 Unit Cost of Railway Project

System	Civil works + E&M (million USD per km)	Rolling Stock Per Car	Remark
Metro	60	1.7	Underground: 100%
Light Metro	50	1.7	Underground: 70% Elevated: 30%
Tramway	20	1.7	At grade: 100%
Suburban	45	1.7	Underground: 50% Elevated: 50%
AGT	20	1.5	Elevated: 50% At Grade: 50%
Monorail	25	1.5	Elevated: 100%

Source: *ibid.*

2) Summary of Project Cost Estimate

The total cost is estimated as 27.1 billion USD for the railway projects including under construction railway projects as shown in Table 18.5.2. Of the total, construction cost is 22.0 billion and rolling stock cost is 5.1 billion USD. A part of the cost of the under construction projects has already been spent. The cost excluding the under construction projects is 20.1 billion USD. The project cost does not include land acquisition cost.

Table 18.5.2 Summary of Project Cost Estimate for Railway Project

	Total Length	Cost (Billion USD)		
		Civil and E&M	Rolling Stock	Total*
Under Construction	135.6	5.5	1.5	7.0
Tender Stage	44.0	2.2	0.6	2.8
Design Stage	74.4	3.7	1.0	4.8
Planning Stage	115.4	6.1	1.1	7.2
Additional Plan	90.8	4.5	0.8	5.4
Total*	461.1	22.0	5.1	27.1

*: The total does not necessarily equal to the sum of the breakdown due to rounding of the first digit
Source: *ibid.*

3) Project Cost List

Table 18.5.3 is the list of the project cost by project.

Table 18.5.3 List of the Project Cost

Project Code	Line No.	Project Section	Type	Length (km)	No. of Rolling Stock	Cost (Million US$)		
						Civil + M&E	Rolling Stock	Total
Short-Term Project								
C-1	M2	Taksim - Yenikapi	Metro	5.2	92	312	156	468
C-2	T4	Edirnekapi - Topkapi	Tram	3.0	0	62	0	62
C-3	M3	Kadikoy - Kartal	Metro	21.7	144	1,302	245	1,547
C-4	M2	4. Levent - Ayazoga - Darussafaka	Metro	8.0	0	480	0	480
C-5	M4	Otogar - Bafcilar (Kilazli)	Light Metro	5.6	20	324	34	358
C-6	M5	Bagcilar - Ikitelli - Basaksehir	Metro	11.5	49	690	83	773
C-6	M9	Ikitelli - Olimpiyat Koyu	Metro	4.4	19	264	32	296
C-7	B1	Marmaray Project	Suburban	76.5	440	2,000	1,000	3,000
C-8	M1	Aksaray - Yenikapi	Light Metro	0.7	0	42	0	42
		Total		136.6		5,476	1,551	7,027
Middle-Term Project								
T-1	M6	Uskdar - Cekmekoy	Light Metro	19.0	214	950	364	1,314
T-2	M7	Bakirkoy - Beylikduzu	Light Metro	25.0	126	1,250	214	1,464
D-1	M5	Bakirkoy - Bahcelievler Bagacilar	Metro	9.0	100	540	170	710
D-2	M8	Kabatas - Besiktas - Sisli - Giyimkent - Bagcilar	Metro	25.0	260	1,470	442	1,912
D-3	M2	Yenikapi - Bakirkoy	Metro	7.0	36	420	61	481
D-4	T5	Eminonu - Alibekoy	Tram	9.6	30	192	51	243
D-5	M9	Yesilkoy - Ataturk Airport - Ikitelli	Metro	14.3	160	858	272	1,130
D-6	H1	Sishane - Kulakasiz - Cemal kamaci Guzergahi	Monorail	5.8	26	250	39	289
P1-1	M4	Bagcilar - Halkali	Light Metro	7.5	26	450	44	494
P2-4	M2	Haciosman - Cayirbasi Metro	Metro	2.7	19	162	31	193
PP-5	M7	Bakirkoy - Beylukzudu Extension	Light Metro	1.0	3	60	6	66
		Total		125.9		6,602	1,694	8,296
Long-Term Project								
P1-2	M8	Tekstilkent - Istoc - Olimpiyat Koyo - Ispartakule	Metro	12.0	115	1,002	195	1,197
P1-3	M11	Umraniye - Bostanci Metro	Metro	14.0	117	1,026	199	1,225
P1-4	M3	Kartal - S. Gokcen Airport - Tuzla	Metro	18.1	121	1,056	205	1,261
P2-1	M10	Zytinburnu - Seyrantepe	Metro	16.3	114	993	194	1,187
P2-2	H3	Kartal D-100 - Kartal IDO	Monorail	3.0	13	75	19	94
P2-3	H2	S. Gokcen Airport - Formula 1	Monorail	7.7	33	193	50	242
P2-8	B2	Ispartakule - Kirac - Buyukcekmece - Celayie	Metro	25.8	114	1,125	194	1,319
PP-1	M10	Seyrantepe - Bosphorus Crossing - Umraniye	Metro	9.8	61	755	61	816
PP-2	M10	Bahcelievler - Sogutlucesme	Metro	8.6	75	654	122	776
PP-3	M12	Kadikoy-Ibrahimaga-Esensehir-North Tuzla	Metro	36.8	226	1,980	385	2,365
PP-4	B1	Halkali - Hadimkoy	Suburban	20.4	80	400	136	536
PP-6	B2	Celayie - Silivri	Suburban	18.9	68	843	147	990
		Total		191.4		10,102	1,908	12,009
Grand Total				453.9		22,180	5,152	27,332

Source: Estimated by Study Team

18.6 O & M Plan and Cost

18.6.1 Operation and Maintenance Plan

1) Public Transport Organization

Organization of public transport should be formulated to satisfy the following needs of users, the citizens of Istanbul, operators, IMM and other authorities.

- The public transport network covers populated area in Istanbul as designed in this master plan.
- The public transport system provides passengers with the convenient services such as

fare, transfer, information, reservation, and other services by the integration of the services.

- The public transport service is also convenient for people with the handicap in mobility due to income-level, disability, or both of them.
- The public transport operators are financially sustainable and able to provide attractive services.
- The cost burden of the public transport development and operation is acceptable to IMM in view of the available budget.

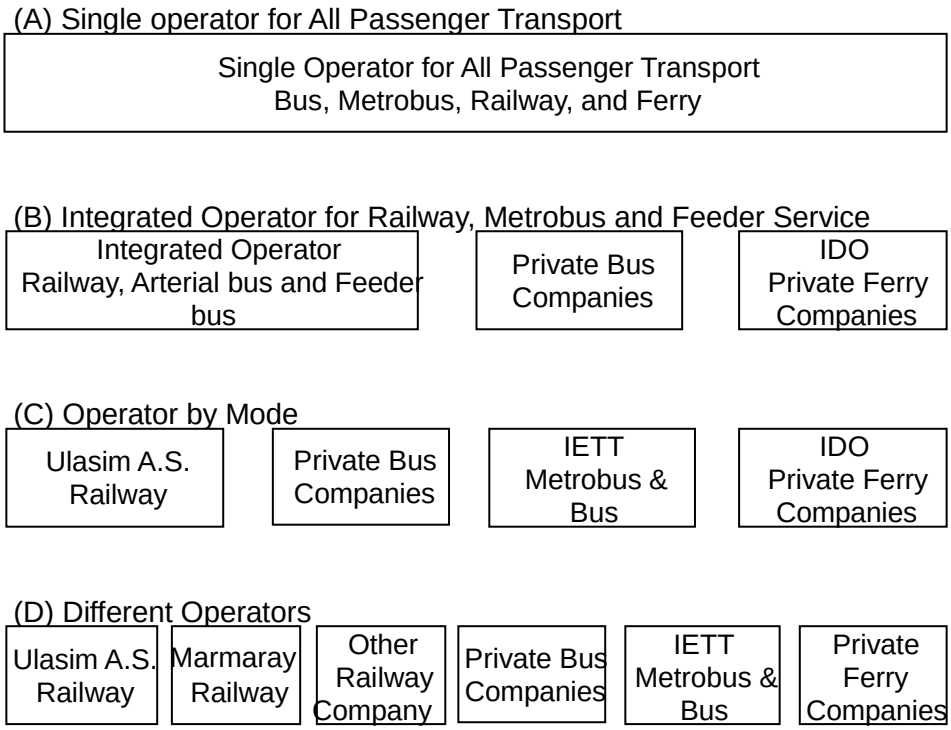
Currently, the railway network is operated by Ulasim A.S. and TCDD, bus network is operated by IETT and private companies, and water transport is operated by IDO and private companies. The integrated ticket system is operated by BELBIM. UKOME is responsible for the coordination among the operators, and the decisions of fare, route, and schedule. IETT and UKOME are agencies under IMM, while Ulasim A.S and IDO are semi-public companies owned by IMM. Since UKOME can define the level of public services such as fare, route and schedule, the service integration is secured at IMM level even though rail, bus and water transport are operated by different operators.

However, the future network will affect the present framework. First, the operation of Marmaray tunnel will involve complex coordination among commuter train, inter-city passenger train, domestic freight train, and international freight train. Second, the future railway network, more than three times the present network, will be too large for UKOME to cope with the coordination of the service integration. Third, the present fixed fare system will not be suitable for the large network in the future. It will be necessary to review the organization of public transport in Istanbul.

Figure 18.6.1 shows the alternative scenarios of public transport operators in Istanbul.

The service integration will be best achieved when the public transport service is provided by a single operator (scenario A). On the other hand, the single operator will be too large to cope with all modes in efficient manner. In addition, the monopoly in public transport has many potential problems in terms of user's benefit. For the efficient operation as an integrated system, establishment of an integrated operator for railways and feeder buses is another alternative (scenario B). This will enable the smooth inter-modal transfer between feeder buses and railway lines at railway stations. In this case, transparency of the railway investment and operation tends to be unclear. The possible scenario is that Ulasim A.S. will operate all the railway lines in Istanbul. However, this will narrow the alternatives for the implementation framework. For example, railway development in Silivri will need another approach than the present railway development and some monorail lines will not necessarily require high integration with other railway system.

The most likely scenario is that the public transport in Istanbul will be operated by different operators (scenario D). To ensure the service integration is the major issue In this case, and the role of the coordinating agency (UKOME) will be very important.



Source: Study Team

Figure 18.6.1 Alternative Scenarios of Public Transport Operator in Istanbul

2) Train Operation Plan

The specification of trains for new lines is not defined in the Master Plan. Instead, it will be determined in detailed feasibility studies.

The Master Plan simply assumes the specification as follows:

Table 18.6.1 Assumed Specification of Trains in Master Plan

	Length of car (m)	Car capacity (pax/car)	No. of cars per train	Length of train (m)	Train capacity (pax/train)
Suburban	20	220	4 – 10	80–200	880–2200
Metro	20	220	4 – 10	80–200	880–2200
Light Metro	20	220	4 – 6	80–120	880–1320
Tramway	30	340	2 – 3	60–90	680–1020
Monorail (normal)	15	170	4	60	680
Monorail (small)	10	70	4	40	280

Source: *ibid.*

Although the minimum headway of two minutes is possible, the Master Plan assumes the standard headway of four to five minutes in the peak hours and 7.5 to 15 minutes in the off-peak hours. For the commuter train of Marmaray, the minimum headway of two minutes will be necessary in the future.

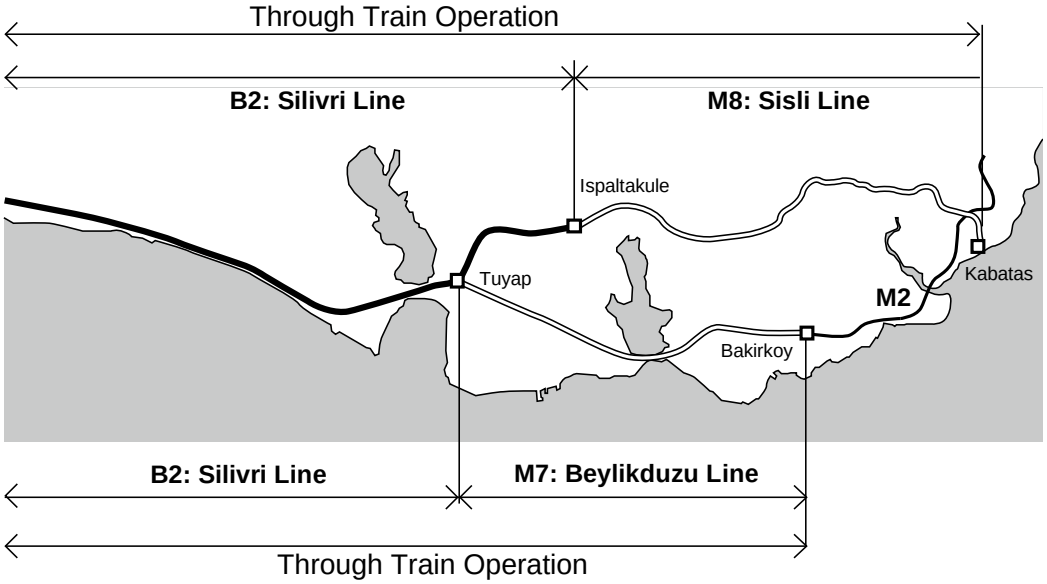
The scheduled speed ranges 30 to 40 km/h in average considering the distance of 0.8 - 1.5 km between stations. For the commuter trains of Marmaray, the scheduled speed is planned as 45 km/h for the rapid train operation, while the higher scheduled speed of 55km/h is planned for the rapid trains on the Silivri Suburban Rail Line.

3) Through Train Operation

The Silivri Line (B2), connecting the new development area in Silivri and the center of Istanbul, is planned as a suburban railway system. This does not necessarily mean that the line should apply the same system as TCDD (AC 25kV) although alternate current (AC) system is generally feasible for suburban rail while direct current (DC) system is generally feasible for urban rail system. In the case of B2, the connection between Silivri and the center of Istanbul is very important. B2 will be connected to Beylikduzu Line (M7) at Tuyap and Sisli Line (M8) at Ispartakule. Through trains should be operated from B2 to M8 going to Kabatas, and to M7 going to Bakirkoy. To enable the through train operation with the railway network in the center of Istanbul, B2 should apply the same system as M8 (DC 1500V). Since M7 is under tendering stage as a Light Metro (DC 750V), the composition of the through trains will be limited and dual-voltage trains will be necessary for the trough train operation. Such trains with a small number of cars will be operated along the Silivri Line because it is also expected to serve as an urban railway system within the new urbanized area in Silivri.

In the future after the master plan period, upgrading project of M7 for the higher voltage will be proposed.

Figure 18.6.2 shows the location of B2, M7, and M8.



Source: *ibid.*

Figure 18.6.2 Through Train Operation between Silivri and the Central Istanbul

Through train operation will be also introduced to M7 and M1 with a total length of 44.9km. Bakirkoy station will be the intermediate station. M1 will have another trough train operation with the Otogar Line (M9). Due to these through operations, scheduling of M1 will become complex and the number of trough trains will be limited in peak hours.

Bagcilar–Ikiteli–Olimpiyat Koyu Metro has a branch line from Ikiteli Sanayi 4 station to Olimpiyat Parki station. The section between Kirazli 1 station and Basak Konutlari station of the metro will be a part of M5 Line. Although the branch section and Yesilkoy–Ataturk Airport– Ikitelli Metro will form M9, through trains will be operated from Olimpiyat Parki station to Bakirkoy station of M5.

4) Operation of Rapid Train

Rapid trains will be operated on the Marmaray Commuter (B1) using its three tracks and the Silivri Line (B2) using its four tracks. The Silivri line will have a double-track line for the rapid train operation with a station interval of about 5km and another double-track line as an urban railway in Silivri area with a station interval of 1–2km. Ispartakule will be the transfer station of the rapid trains on B1 and B2. The scheduled speed of the rapid trains will be 55km/hour and with the maximum speed will be 100km/ hour.

5) Fare System

Currently, railway passengers pay a fixed fare of 1.3 YTL (1.25 YTL for Akbil users) for a ride with discounts for transfers to other lines. With the expansion of the railway network, the setting of the adequate fix cost become difficult because the same fare for those who travel in short distance and those in long distance is not fair in terms of cost burden. If the fare is set to cover the operation and maintenance cost, the short distance travelers have to pay very high fare.

A distance-based fare structure will be introduced by 2013 when Maramaray commuter train and other metro in the short-term projects will begin operation. Although a distance-based fare structure usually increases the cost of ticket selling system, the emerging information technology will reduce the cost.

The policy for the fare level is:

- The willingness-to-pay of Istanbul's citizen should be considered.
- The fare level is competitive enough to achieve the master plan's goals such as the promotion of public transport and decongestion of roads.
- The fare level of each line should consider fairness and integrity of the railway network system.
- Maximizing the revenue will not be necessarily required. However, at least the operation and maintenance cost should be compensated by the fare revenue.

The fare system will be integrated in the railway network, while the currently integrated fare system with bus will be changed.

18.6.2 Operation and Maintenance Cost

1) Key Assumption for O&M Cost Estimate

The operating and maintenance (O&M) cost of a rail line is calculated as:
O&M Cost = (No. of Staff × Average Salary) + (E × Car-kilometers)
Average Salary is assumed at YTL 2500 per month.
No. of Staff =(S_G × Route-kilometers) + (S_S × No. of stations)
+ (SO × 1000 Car-kilometers per day)
Where, E = Unit expenses other than personnel cost
(See Table 18.6.2, Expenses per Car-km)
S_G = Unit no. of general administration staff
S_S = Unit no. of station staff
S_o = Unit no. of other staff

These unites are shown in Table 18.6.2.

Table 18.6.2 Unit Number and Unit Expenses for O&M Cost Estimate

	No. of Staff			Expenses (YTL)
	General Administration Staff	Station Staff	Other Staff	
	Per route-km	Per station	Per 1000 car-km/day	Per car-km
Metro	3.0	10.0	6.7	3.34
Tramway	3.0	8.3	25.0	13.6
Suburban	3.0	9.9	3.4	2.07
Monorail	3.0	3.4	7.2	2.85

Note: refer to table 14.5.6, 14.5.7 and 14.5.8
Source: *ibid.*

Using the units, O&M cost is estimated by line as shown in Table 18.6.3. The total O&M costs of the all lines are estimated as 1,437 million YTL per year. The personnel expense of the all lines is estimated as 334 million YTL per year with the total number of staff of 12,400, while other expenses will be 1,102 million YTL per year.

Table 18.6.3 O&M Cost Estimate by Line

Line Code	Line Name	System	Length (km)	Car-km per day in 1000	No. of stations	No. of staff	Cost (Million US$) per year		
							Personnel Expense	Other Expense	Total
M1	Aksaray Line	Light Metro	20.0	25.0	18	417	11	25	36
M2	Taksim Line	Metro	22.9	78.4	22	839	23	78	100
M3	Kadikoy Line	Metro	39.3	98.1	30	1,075	29	97	126
M4	Otogar Line	Light Metro	13.1	16.1	10	247	7	16	23
M5	Bakirkoy Line	Metro	20.5	51.2	16	564	15	51	66
M6	Uskudar Line	Light Metro	19.0	23.7	17	386	10	24	34
M7	Beykikduzu Line	Light Metro	26.0	32.4	20	495	13	32	46
M8	Sisli Line	Metro	41.7	102.8	26	1,073	29	102	131
M9	Olympic Line	Metro	18.7	46.7	12	489	13	46	59
M10	Bosporus Ring	Metro	34.7	94.6	27	1,018	27	94	121
M11	Bostanci Line	Metro	14.0	42.7	13	467	13	42	55
M12	Sultanbeyli Line	Metro	36.8	82.4	17	821	22	82	104
T1	Kabatas-Zeytinburnu Line	Tram	14.1	13.2	24	571	15	53	69
T2	Zeytinburnu-Bagchilar Line	Tram	5.1	5.1	9	220	6	21	27
T4	Topkapi Line	Tram	15.5	19.3	20	444	12	31	43
T5	Goldern Horn Line	Tram	9.6	9.0	13	361	10	36	46
B1	Marmaray Commuter	Suburban	96.5	282.3	50	1,745	47	174	221
B2	Silivri Line	Suburban	42.0	91.4	23	845	23	77	100
H1	Beyoglu Monorail	Monorail	5.8	9.4	10	131	4	8	11
H2	F1 Monorail	Monorail	7.7	12.0	4	123	3	10	13
H3	Kartal Monorail	Monorail	3.0	4.7	3	53	1	4	5
	Total		506.0			12,384	334	1,102	1,437

Source: *ibid.*

Here, annual O&M cost is assumed to be constant by year and one year is 330 days.Table 18.6.4 shows the estimated O&M cost from 2009 to 2023. The total cost in the master plan period will be 10,625 million YTL. The O&M cost will increase with the expansion of the railway network of Istanbul. It is estimated the O&M cost would be 561 million YTL in 2013, 806 in 2018, and 1,333 in 2023.

Table 18.6.4 O&M Cost Estimate from 2009 to 2023

Unit Million US$

Line	Section	Yearly Cost	Year															Total Cost
			09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	
M1	E-2	34.7	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	520.1
	C-8	1.4			■	■	■	■	■	■	■	■	■	■	■	■	■	17.6
M2	E-1	27.2	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	407.9
	C-1	16.7					■	■	■	■	■	■	■	■	■	■	■	184.0
	C-4	25.4					■	■	■	■	■	■	■	■	■	■	■	279.6
	P2-4	8.4											■	■	■	■	■	42.0
	D-3	22.7									■	■	■	■	■	■	■	158.8
M3	C-3	69.6					■	■	■	■	■	■	■	■	■	■	■	765.7
	P1-4	56.7														■	■	113.5
M4	C-5	9.4		■	■	■	■	■	■	■	■	■	■	■	■	■	■	131.9
	P1-1	13.2										■	■	■	■	■	■	79.2
M5	C-6	50.8		■	■	■	■	■	■	■	■	■	■	■	■	■	■	711.3
	D-1	29.0							■	■	■	■	■	■	■	■	■	260.7
M6	T-1	33.9							■	■	■	■	■	■	■	■	■	305.5
M7	T-2	43.7								■	■	■	■	■	■	■	■	350.0
	PP-5	1.8											■	■	■	■	■	9.1
M8	D-2	78.8											■	■	■	■	■	394.2
	P1-2	52.1														■	■	104.3
M9	D-5	45.7										■	■	■	■	■	■	274.3
M10	PP-1	27.9														■	■	55.7
	P2-1	58.2														■	■	116.5
	PP-2	35.2													■	■	■	105.7
M11	P1-3	55.0														■	■	109.9
M12	PP-3	103.9																0.0
T1	E-3	68.7	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	1,031.0
T2	E-4	26.7	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	401.0
T4	E-12	24.0	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	360.2
	C-2	18.9		■	■	■	■	■	■	■	■	■	■	■	■	■	■	265.1
T5	D-4	46.1							■	■	■	■	■	■	■	■	■	414.5
B1	C-7	187.0					■	■	■	■	■	■	■	■	■	■	■	2,056.8
	PP-4	33.7													■	■	■	101.1
B2	P2-8	69.3											■	■	■	■	■	346.7
	PP-6	30.2															■	30.2
H1	D-6	11.5								■	■	■	■	■	■	■	■	91.8
H2	P2-3	13.5															■	13.5
H3	P2-2	5.4													■	■	■	16.2
Total (year)			181	261	262	262	561	561	670	725	747	806	965	965	1,039	1,289	1,333	10,625.2
Total (5 years)			1,526					3,509					5,590					

Source: *ibid.*

Chapter 19 In-Depth Study on Selected Railway Corridor

Based on the planning works from the previous chapters, the following three railway line were identified to have the highest potential for development and selected for Pre-feasibility study.

P2-1: Seyrantepe – Alibeykoy – GOP – Kazlicesme Metro

P1-3: Umraniye – Bostanci Metro (Option: 2nd Bosporus Bridge – Goztepe AGT Route, part of PP-2 route)

PP-1: Seyrantepe – Bosporus Crossing – Umraniye Metro

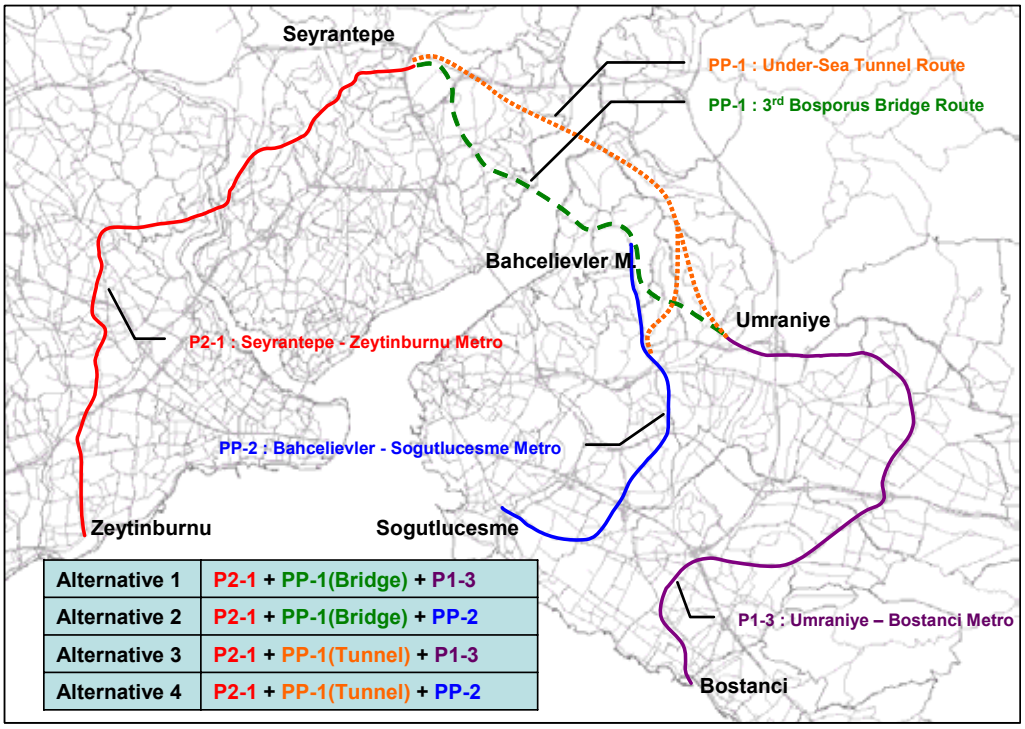
The alignment and the location of the stations of above lines are reviewed and rerouted during the pre-feasibility study considering the topographic condition, train operation efficiency with passenger convenience, comfort and location of transfer stations of other connecting lines.

Result of the realignment of the route, the Study Team renamed the above three railway line as follows;

(1) P2-1: Seyrantepe – Zeytinburnu Metro

P1-3: Umraniye – Bostanci Metro (Option: PP-2: Sogutlucesme – Bahcelievler Mahallesi Metro)

PP-1: Bosporus Crossing (Under-sea Tunnel or 3rd Bosporus Bridge) Route



Source: Study Team

Figure 19.1.1 Location Map of the Pre-FS Route

19.1 Outline of Project

P2-1 & PP-2 or P1-3 lines are important to provide railway access to the commercial and residential area as well as to promote along the railway line where rapid growth of population is expected in the land use master plan. Moreover, it is necessary to have a railway link between Asian and European side through Bosporus strait to satisfy the growth of public transport demand in future. In this context, PP-1 line is proposed to connect P2-1 line and PP-2 or P1-3 line as Bosporus crossing by either under-sea tunnel or bridge. The major function of this route is to connect urbanized area in European side and densely populated area in the Asian side, which will be an arterial alternative route of Marmaray project.

P2-1 line is located north-south direction in European side, total length of 18.1 km with 13 stations. PP-2 and P1-3 lines are located north-south direction in Asian side, total length of 10.9 km with 9 stations and 17.1 km with 13 stations, respectively. PP-1 line has studied both under-sea route and bridge route. There are four alternative route can be considered as whole project connected into one line.

Alternative 1: P2-1 route + PP-1 (Bridge) + P1-3

Alternative 2: P2-1 route + PP-1 (Bridge) + PP-2

Alternative 3: P2-1 route + PP-1 (Tunnel) + P1-3

Alternative 4: P2-1 route + PP-1 (Tunnel) + PP-2

On the occasion of complete the whole project into one continuous line, it will be the one of the efficient and effective route for future railway network in Istanbul. The total length of this route will be in the range of approximately 33 km or 43 km, and will be implemented in several phases. The whole system will be completed by 2022.

The following tables are the summary of outline and the operational phases of the proposed route by each alternative.

Table 19.1.1 Outline and Development Phasing for Each Alternative

	Project Code	Length (km)		No. of station		Operation Year
			Total		Total	
Alternative 1	P2-1	16.3	42.9	13	32	2022
	PP-1(B)	12.6		6		
	P1-3	14.0		13		
Alternative 2	P2-1	16.3	33.8	13	26	2022
	PP-1(B)	8.9		4		2021
	PP-2	8.6		9		
Alternative 3	P2-1	16.3	43.3	13	26	2022
	PP-1(T)	13.0		0		
	P1-3	14.0		13		
Alternative 4	P2-1	16.3	37.9	13	20	2022
	PP-1(T)	13.0		0		
	PP-2	8.6		9		2021

Source: Study Team

19.2 Location of Route and Stations

For the design of route alignment and station location, the following general criteria have been adopted:

- The route alignment shall take into account proposed IMM network plans in terms of future transport systems, residential, commercial and mixed use integrated developments to avoid potential impact with such developments.
- Minimize the number of buildings which require relocation or demolition to accommodate construction of the tunnels, viaduct and stations, in other words, to minimize the land acquisition.
- Minimize the extent of potential damage to existing buildings and infrastructure.
- To facilitate the latter above criteria, it is proposed the route alignment to be kept within public space such as main roads, parks etc., as much as possible. Tunnel is kept more than 2.0 times the tunnel diameter below ground level to the roof of the tunnel at residential area, and 1.5 times the tunnel diameter at under the road.
- Station locations shall needs to connect existing and planned transport systems as transfer station. Stations shall be generally located at about 1.0 km to 1.5 km intervals.
- Minimum curve radius is 300m and maximum gradient is 3.5% between the stations. Stations shall be straight and level.

19.2.1 P2-1: Seyrantepe – Zeytinburnu Metro

1) Route Alternative and Station Location

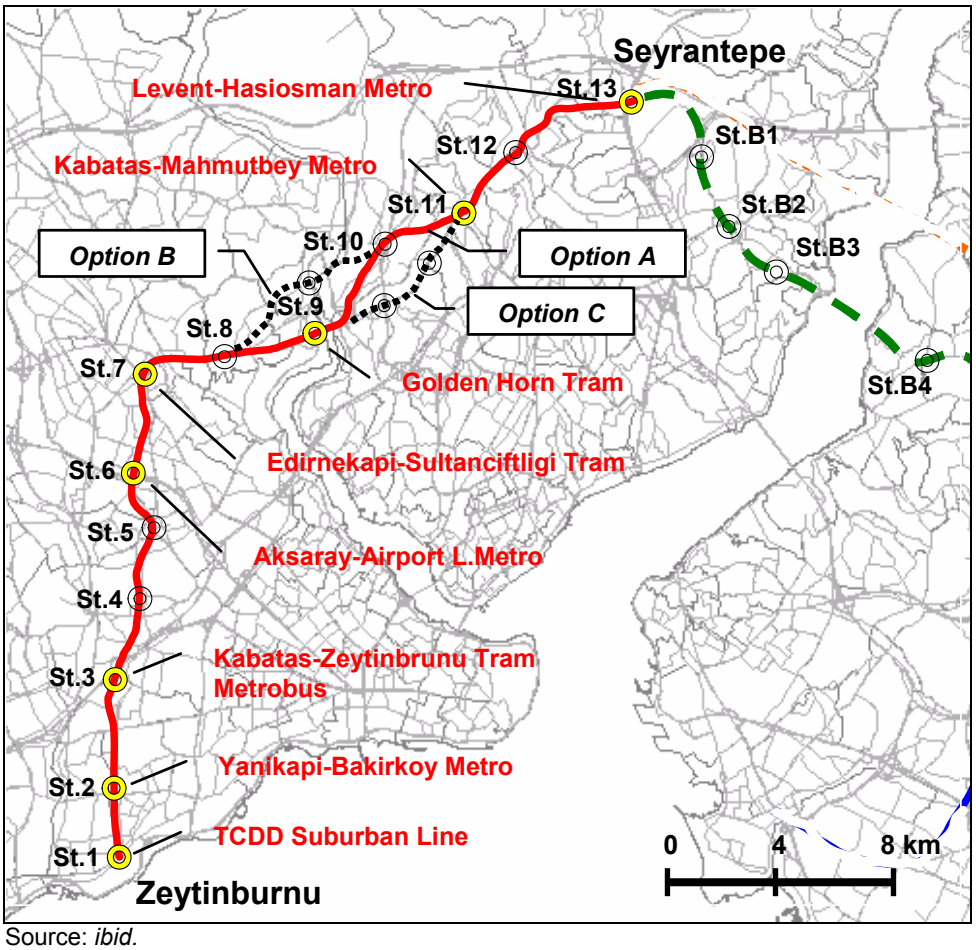
(1) General

This line is connects between Zeytinburnu and Seyrantepe passing through central area and industrial zone of Zeytinburnu District, commercial area of eastern part of Bayrampasa District, then running along the Gazi Muhtar Pasa Street in Gazi Osmanpasa District, and residential area of Eyup District and Kagithane District. Total length of this route is 16.3 km with 13 stations. The original IMM route was discussed and examined with Ulasim A.S. and IMM, and made a several modifications as follows;

- Terminal station (St.1) in Zeytinburnu District is sifted from Kazlicesme (TCDD) to Zeytinburnu (TCDD) station to attract more passengers and their convenience. Moreover, next station (St.2) can be located center of the Zeytinburnu District and possible to connect Yanikapi – Bakirkoy Metro (D-3).
- St.3 is also sifted about 400m further west along the D100 from the original location, because of existing Zeytinburnu – Kabatas Tramway (E-3) has a plan to reroute and construct new station at this location.
- Proposed route is connected at Sagmalcilar St. (E-2: Aksaray – Airport Light Metro) and Uluyol St. (E-12: Edirnekapi – Sultanciftligi Tramway).
- Last station at northern part was changed to Sanayi from Seyrantepe depot of 4.Levent – Haciosman Metro (C-4).

In addition, from the preliminary investigation based on the IMM original route plan, three

alignment options have been proposed and examined between St.8 to St.11, shown in the following figure.



Source: *ibid.*

Figure 19.2.1 Route and Station Location of Seyrantepe – Zeytinburnu Metro

(2) Route Option and Comparison

There are three options has been studied between St.8 and St.11. Option B is following original IMM route. It has three transition points from underground to elevated or vice versa with three tight curves and three steep gradients. At all three transition points are residential area where needs to have land acquisition. Option A is alternative route to reduce tight curve, steep gradient and land acquisition. Even though, it has still one tight curve and two steep gradients with two land acquisitions. Option C is minimized disadvantage of above options as well as reducing construction cost by selecting elevated structure running along the river. Elevated section will be start from St.9 up to St.12. According to the information from IMM, there is a historical building reconstruction project along the river (Kagithane Deresi) and hardly to construct elevated structure from the view point of landscape. Following table is a comparison of three options. The Study Team is selected Option A as optimum route for this section.

Table 19.2.1 Alternative Route Comparison

Items	Option A		Option B		Option C	
Alignment	2 steep gradient 1 tight curves	○	3 steep gradient 3 tight curves	△	1 steep gradient	◎
Structure	2 UG Station 2 ELV Station 2 tunnel section 2 elevated section	○	2 UG Station 2 ELV Station 2 tunnel section 2 elevated section	○	1 UG Station 4 ELV Station 1 tunnel section 1 elevated section	◎
Const. Cost (ratio)	1.00	○	1.03	○	0.86	◎
Land acquisition	2 locations	○	3 locations	△	1 locations	◎
Others					Historical building reconstruction project	X
Evaluation		◎		○		○

Source: *ibid.*

(3) Stations

Station No.1 (Zeytinburnu): Located on end of 58.Bulvar Street with connection of existing TCDD Zeytinburnu station. Underground station with two line and one island type platform is proposed.

Station No.2: Located on the cross point of 58.Bulvar Street and Prof. Muammer Aksoy Street with connection of Yanikapi – Bakirkoy Metro (D-3) station. Underground station with two line and one island type platform is proposed.

Station No.3: Located at D100 Osmaniye Junction with connection of rerouting Kabatas – Zeytinburnu Tramway (E-3) and Metrobus station. Underground station with two line and one island type platform is proposed.

Station No.4: Located on Gumussuyu Street in the middle of the Maltepe industrial zone. Underground station with two line and one island type platform is proposed.

Station No.5: Located near the Bayrampasa dist. office and Bayrampasa Merkez Mosque. Underground station with two line and one island type platform is proposed.

Station No.6 (Sagmalcilar): Located at northern side of Aksaray – Airport Light Metro (E-2) Sagmalcilar station. Underground station with two line and one island type platform is proposed.

Station No.7 (Uluyol): Located on Salihpasa Street with connection of Edirnekapi – Sultanciftligi Tramway (E-12) Uluyol station. Underground station with two line and one island type platform is proposed.

Station No.8: Located on the cross point of Ordu Street and Sinema Street. Underground station with two line and one island type platform is proposed.

Station No.9: Located on the cross point of Silahtaraga Street and Karadeniz Street near Derne Park with connection of Golden Horn Tramway (D-4). Elevated station with two line and one island type platform is proposed.

Station No.10: Located on Sokullu Street in Nurtepe area next to the Fatih Sultan Mehme Tkoprusucevre Highway. Underground station with two line and one island type platform is proposed.

Station No.11 (Kagithane): Located on Hurriyet Street with connection of Besiktas –

Mahmutbey Metro (D-2) Kagithane station. Elevated station with two lines and two side platform is proposed.

Station No.12: Located on the cross point of Cendere Street and Kagithane Street. Elevated station with two lines and two side platform is proposed.

Station No.13 (Sanayi): Located on Eski Buyukdere Street with connection of 4.Levent – Haciosman Metro (C-4) Sanayi station. Underground station with two line and one island type platform is proposed.

Following table is the summary of P2-1 Seyrantepe – Zeytinburnu Metro Station

Table 19.2.2 Seyrantepe – Zeytinburnu Metro Station

Station No.	Type	Distance (km)	Position (km)	GL (m)	RL (m)	Connection
St. 1	UG	0.000	0.000	12	-13	TCDD Zeytinburnu Station
St. 2	UG	1.220	1.220	35	5	Yanikapi - Bakirkoy Metro (D-3)
St. 3	UG	1.920	3.140	52	29	Kabatas - Zeytinburnu Tramway (E-3), Metrobus
St. 4	UG	1.540	4.680	77	57	
St. 5	UG	1.090	5.770	95	70	
St. 6	UG	0.900	6.670	92	55	Aksaray - Airport Light Metro Sagmalcilar Station (E-2)
St. 7	UG	1.660	8.330	115	85	Edirnekapi - Sultanciftligi Tramway Uluyol Station (E-12)
St. 8	UG	1.350	9.680	104	69	
St. 9	ELV	1.630	11.310	5	20	Golden Horn Tramway (D-4)
St. 10	UG	2.080	13.390	83	48	
St. 11	ELV	1.330	14.720	5	20	Besiktas - Mahmutbey Metro Kagithane Station (D-2)
St. 12	ELV	1.270	15.990	10	25	
St. 13	UG	2.110	18.100	125	95	4.Levent-Haciosman Metro Sanayi Station (C-4)
Total		18.100				

Source: *ibid.*

2) Structure and Construction Methods

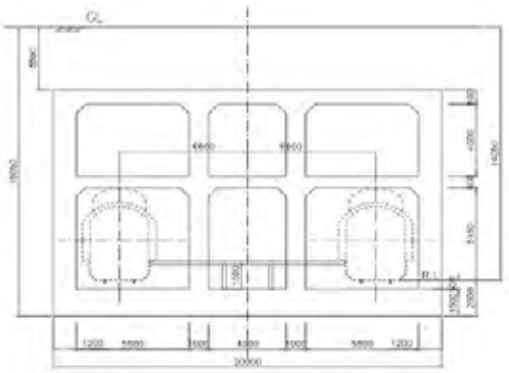
(1) Underground Structure

Under ground section will be from St.1 to St.8, after St.9 to before St.11 and after St.12 to the St.13. Underground station is 2 to 4 floors box type structure. The number of floors will depend upon the depth of the tunnels and physical constraints imposed on the station structure. The lowest floor is for track and platform and upper floor is for concourse and station utilities. A third and fourth intermediate floor may be used passenger circulation and for rail systems and/or station facilities/equipment/plant rooms. Where surplus space, earth covering section, is available such space could be used for public use such as parking, pedestrian road or commercial tenancies.

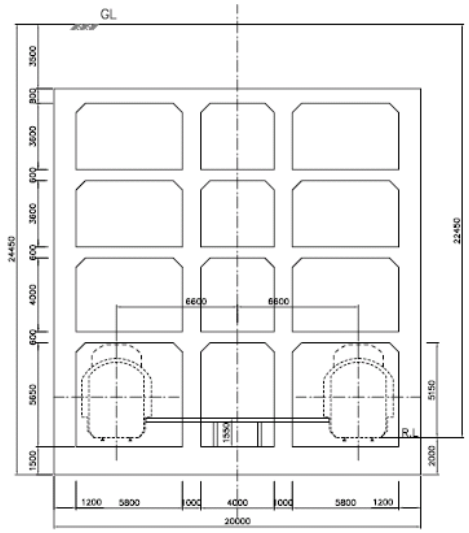
The station structures and the transition structures from elevated to underground will be constructed by using cut and cover methods. The tunnels will be constructed by NATM (New Austrian Tunneling Method) or TBM (Tunnel Boring Machine) methods. For tunnel section, in generally it has two options. One is single track twin tunnel, i.e. one track for each tunnel, and other is double track single tunnel.

Taking into account of other railway construction project in Istanbul, twin tunnel method is familiar, and in general, construction cost is lower than the double track single tunnel. Therefore, the Study Team will propose twin tunnel for the bored tunnel. However, for the next stage, more detailed analysis should be undertaken to confirm the best option and

construction methods. Following drawings are the typical cross section of station and tunnel type.



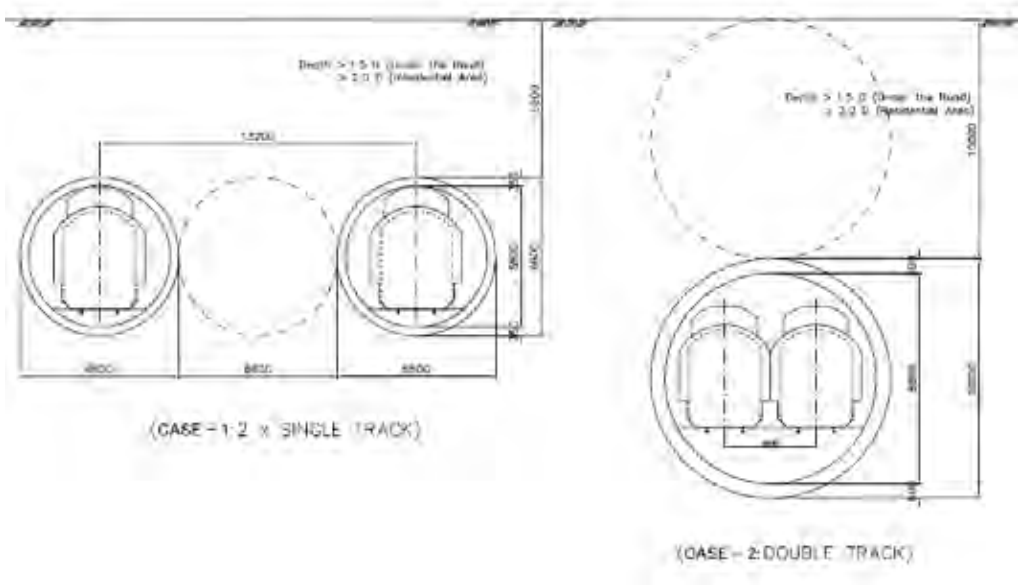
Two Floor Box Type Station
(Reference Only)



Four Floor Box Type Station
(Reference Only)

Source: *ibid.*

Figure 19.2.2 Typical Cross Section of Cut & Cover Tunnel



Type of TBM Tunnel (Reference Only)

Source: *ibid.*

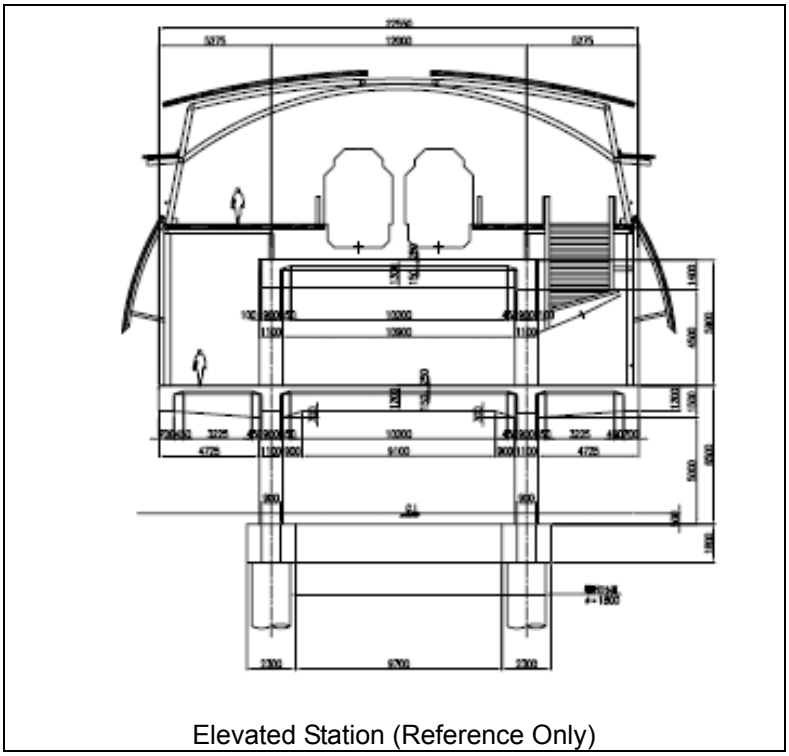
Figure 19.2.3 General Comparison of TBM Tunnel

(2) Elevated Structure

Elevated section will be before and after the station No.9 and from No.11 to No12 station.

The viaduct structure will be designed to have standard spans of 30m to 50m depending on the site conditions (for transportation of pre-cast bridge beams or segmental blocks), availability of contractor's equipment and total construction costs including substructure. In

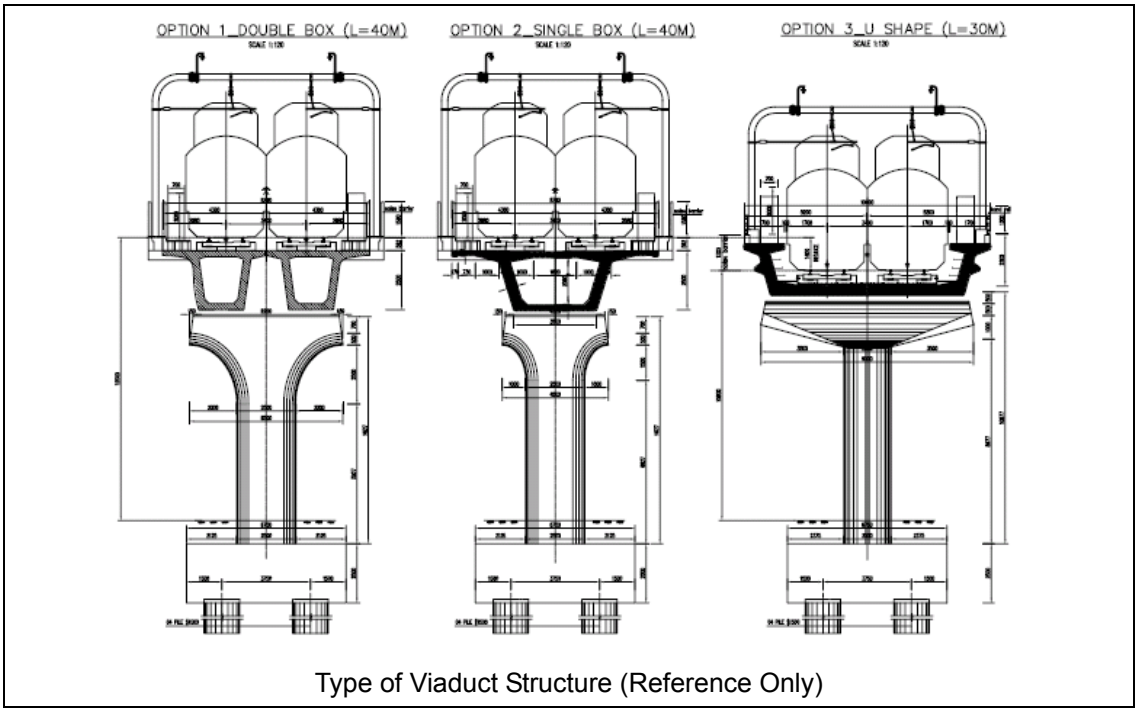
general, viaduct structure with more than 30m spans, box girder with single cell, box girder with twin cell or U-shape girder are widely constructed around the world. The viaduct can be constructed either by a “span-by-span” or a “balanced cantilever” erection method, both of which facilitate quick construction. For the next stage, more detailed analysis should be undertaken to confirm the best structure and construction methods. Following drawings are the typical cross section of station and type of viaduct structures.



Elevated Station (Reference Only)

Source: *ibid.*

Figure 19.2.4 Typical Cross Section of Elevated Structure



Type of Viaduct Structure (Reference Only)

Source: *ibid.*

Figure 19.2.5 General Comparison of Typical Viaduct Structure

3) Depot Location

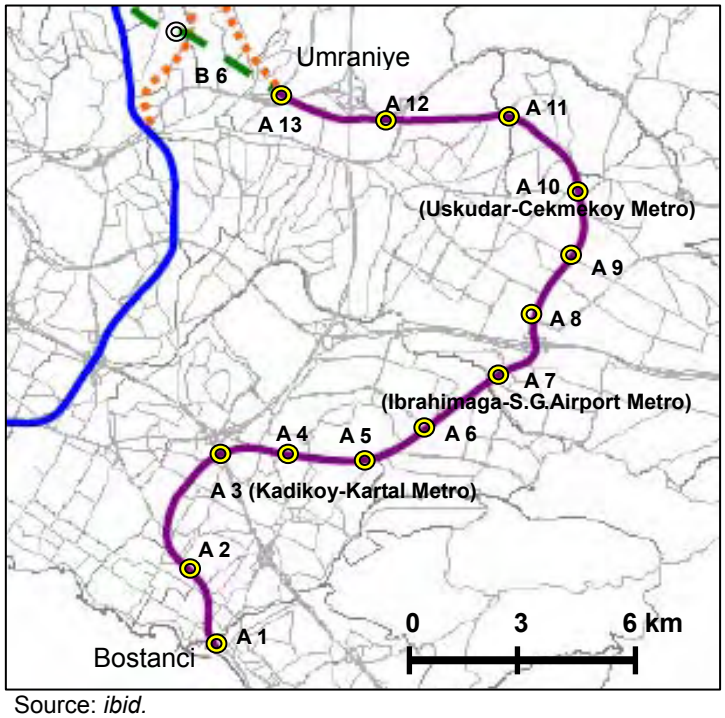
Study Team proposed to use Alibeykoy Triyaj Alani Depot which has been planned by IMM for Besiktas - Mahmutbey Metro (D-2). It will be necessary to expand to accommodate both Seyrantepe – Zeytinburnu Metro and Besiktas - Mahmutbey Metro's rolling stock.

19.2.2 P1-3: Umraniye – Bostanci Metro

1) Route and Station Location

(1) General

This line is connects between Bostanci station and northern part of Umraniye District passing through north-south direction of Kadikoy District, industrial area and residential area of Umraniye District. Total length of this route is 17.1 km with 13 underground stations. There are four transfer stations connecting with TCDD Suburban Line, Kadikoy-Kartal Metro (C-3), Ibrahimaga-Sabiha Gokcen Airport Metro (PP-3) and Uskudar-Cekmekoy Metro (T-1).



Source: *ibid.*

Figure 19.2.6 Route and Station Location of Umraniye – Bostanci Metro

(2) Stations

Station No.1 (Bostanci): Located on parking area of Bostanci harbor with connection of existing TCDD Bostanci station. Underground station with two line and one island type of platform is proposed.

Station No.2: Located on the crossing point of Semsettin Gunaltay Street and Avsar Street near Genel Mud Post Office. Underground station with two line and one island type of platform is proposed.

Station No.3: Located at D100 & O-2 Kozyatagi Kavsaglk10 Junction with connection of Kadikoy – Kartal Metro (C-3) station. Underground station with two line and one island type of platform is proposed.

Station No.4: Located on the crossing point of Kayisdagi Dudullu Street and Kucukbakkalkoy Street. Underground station with two line and one island type of platform is proposed.

Station No.5: Located on just before the crossing point of Kayisdagi Dudullu Street and Bostanci Street. Underground station with two line and one island type of platform is proposed.

Station No.6: Located on the Bostanci Street in front of the Track depot terminal. Underground station with two line and one island type of platform is proposed.

Station No.7: Located on the Bostanci Street in Yenicamhca residential area with connection of Ibrahimaga-Sabiha Gokcen Airport Metro (PP-3) station. Underground station with two line and one island type of platform is proposed.

Station No.8: Located on the Bostanci Street next to the Kucuk Sanayi Sitesi (Industrial zone) in Esensehir Underground station with two line and one island type of platform is proposed.

Station No.9: Located on the crossing point of Bostanci Street and Nato Street. Underground station with two line and one island type of platform is proposed.

Station No.10 (Dudullu): Located on the crossing point of Bostanci Street and Alemdag Street with connection of Uskudar – Cekmekoy Metro (T-1) station. Underground station with two line and one island type of platform is proposed.

Station No.11: Located at middle of the Ihlamurkuyu new residential area. Underground station with two line and one island type of platform is proposed.

Station No.12: Located at Cakmak area in between Ikea market and Highway D020. Underground station with two line and one island type of platform is proposed.

Station No.13: Located on the crossing point of Kucuksu Street and Drfazil Kucuk Street in Inkilap area. Underground station with two line and one island type of platform is proposed.

Following table is the summary of P1-3: Umraniye – Bostanci Metro Station

Table 19.2.3 Umraniye – Bostanci Metro Station

Station No.	Type	Distance (km)	Position (km)	GL (m)	RL (m)	Connection
St. 1	UG	0.000	0.000	4	-16	TCDD Bostanci Station
St. 2	UG	1.650	1.650	37	12	
St. 3	UG	1.920	3.570	67	37	Kadikoy - Kartal Metro Station (C-3)
St. 4	UG	1.000	4.570	82	57	
St. 5	UG	1.000	5.570	103	83	
St. 6	UG	1.270	6.840	120	100	
St. 7	UG	1.490	8.330	113	88	Ibrahimaga – Sabiha Gokcen Airport Metro Station (PP-3)
St. 8	UG	1.130	9.460	150	115	
St. 9	UG	1.120	10.580	157	135	
St. 10	UG	0.930	11.510	147	117	Uskudar – Cekmekoy Metro Station (T-1)
St. 11	UG	1.860	13.370	109	89	
St. 12	UG	1.980	15.350	145	125	
St. 13	UG	1.710	17.060	123	99	
Total		17.060				

Source: *ibid.*

2) Structure and Construction Methods

This route is all underground. Underground stations as well as tunnel structure and construction methods are described in Section 19.2.1, 2), (ii).

3) Depot Location

Depot will be located at Cekmekoy in Umraniye District, namely Cekmekoy Triyal Alani Depot. This depot location has been planned by IMM with applox 18 ha for Umraniye – Bostanci Metro (P1-3) and Uskudar – Cekmekoy Metro (T-1). According to the information from Ulasim A.S., it can be accommodate around 170 cars. For the next stage, more detail analysis is required to calculate necessary size of depot considering number of cars for each metro.

19.2.3 PP-2: Sogutlucesme – Bahcelievler Mahallesi Metro

1) Route and Station Location

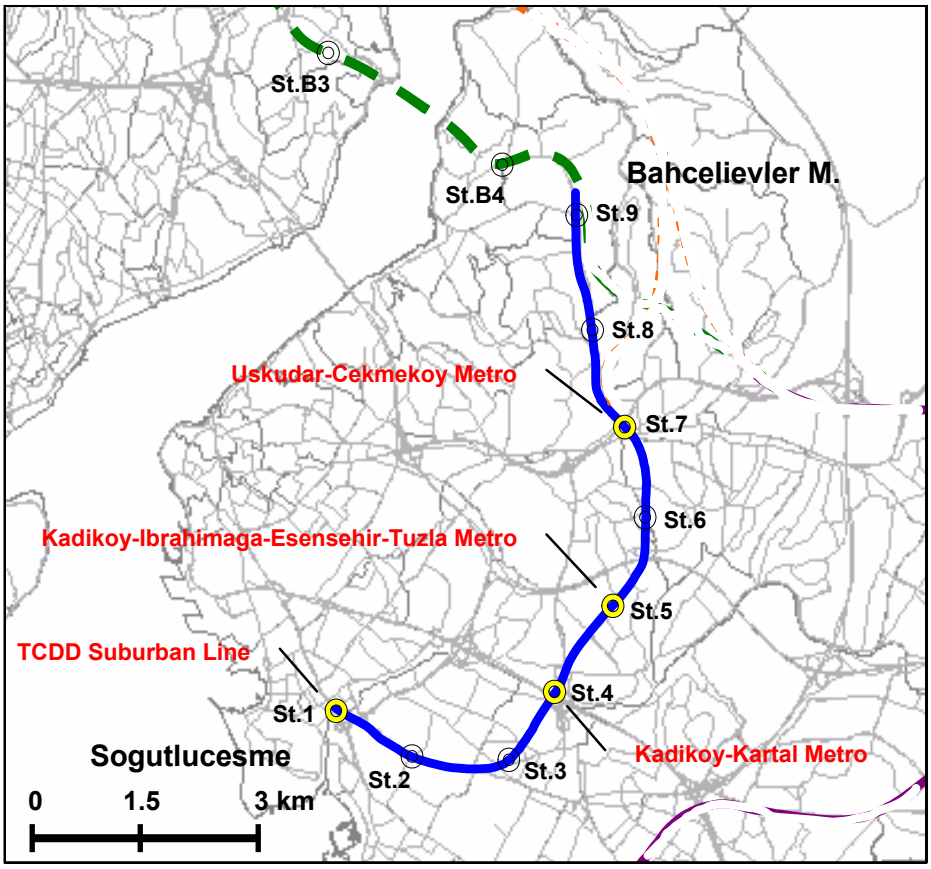
(1) General

This line is connects between Sogutlucesme station and Bahcelievler Mahallesi in Uskudar District passing through Marmaray University and Goztepe SSK Hospital in Kadikoy District, and Namik Kemal residential area and Umraniye District Office in Umraniye District. Total length of this route is 10.9 km with 9 underground stations. There are four transfer stations connecting with TCDD Suburban Line, Kadikoy-Kartal Metro (C-3), Ibrahimaga-Sabiha Gokcen Airport Metro (PP-3) and Uskudar-Cekmekoy Metro (T-1).

This route is part of the PP-2: Topkapi - 2nd Bosporus Bridge –Goztepe AGT project which is proposed by the Study Team for new railway project in master plan network. During discussion with IMM for selection of Pre-feasibility route, they have strongly requested the Study Team to conduct this route as an alternative option of P1-3 from following reason.

- Alternative route area has been developed quickly and large amount of passenger demands are expected.
- P1-3 route study has been started by Ulasim A.S. requested by IMM, and this route will not be extending to European side by Bosporus Crossing in future.

In case of under-sea route will be selected for Bosporus crossing, last station at northern part is ended at St. No.7.



Source: *ibid.*

Figure 19.2.7 Route and Station Location of Sogutlucesme – Bahcelievler Mahallesi Metro

(2) Stations

Station No.1 (Sogutlucesme): Located in front of Kadikoy District Office with connection of existing TCDD Sogutlucesme station. Underground station with two line and one island type of platform is proposed.

Station No.2: Located on Fahrettin Kerim Gokay Street at Marmaray University and Goztepe SSK Hospital. Underground station with two line and one island type of platform is proposed.

Station No.3: Located on Ressam Salih Ermez Street in front of Goztepe Clinic. Underground station with two line and one island type of platform is proposed.

Station No.4: Located at D100 Goztepe Junction with connection of Kadikoy – Kartal Metro (C-3) Station. Underground station with two line and one island type of platform is proposed.

Station No.5: Located on Fevzi Cakmak Street in Esatpasa residential area with connection of Ibrahimaga-Sabiha Gokcen Airport Metro (PP-3) station. Underground station with two line and one island type of platform is proposed.

Station No.6: Located on Divit Street in Namik Kemal residential area. Underground station with two line and one island type of platform is proposed.

Station No.7: Located on the cross point of Bosna B Street and Alemdag Street in front of

Umraniye District Office with connection of Uskudar – Cekmekoy Metro (T-1) station. Underground station with two line and one island type of platform is proposed.

Station No.8: Located on the cross point of Bosna B Street and Mehmet Akif Ersoy Street. Underground station with two line and one island type of platform is proposed.

Station No.9: Located on the cross point of Bosna B Street and Nato Yulu Street near the Maxi City shopping center. Underground station with two line and one island type of platform is proposed.

Table 19.2.4 Sogutlucesme – Bahcelievler Mahallesi Metro Station

Station No.	Type	Distance (km)	Position (km)	GL (m)	RL (m)	Connection
St. 1	UG	0.000	0.000	10	-10	TCDD Sogutlucesme Station
St. 2	UG	1.120	1.120	33	13	
St. 3	UG	1.300	2.420	49	19	
St. 4	UG	1.340	3.770	17	-10	Kadikoy - Kartal Metro Station (C-3)
St. 5	UG	1.320	5.090	60	27	Ibrahimaga – Sabiha Gokcen Airport Metro Station (PP-3)
St. 6	UG	1.510	6.600	97	69	
St. 7	UG	1.380	7.980	148	108	Uskudar – Cekmekoy Metro Station (T-1)
St. 8	UG	1.300	9.280	138	118	
St. 9	UG	1.570	10.850	106	86	
Total		10.850				

Source: *ibid.*

2) Structure and Construction Methods

This route is all underground. Underground stations as well as tunnel structure and construction methods are described in Section 19.2.1, 2), (ii).

3) Depot Location

This route is mainly running middle of the residential area and it is hardly to find suitable depot location close to this line. Possible location can be at Hekimbasi area along the Highway O-2, which is around 3 km further north-east from the St.9 or St.7. It is possible to construct additional station on the connection line to the depot, but when the Bosporus crossing route is connected, this depot line can not utilize as main line, it is placed as a spur line. Another option can be use the part of No.9 station as temporally depot until Bosporus crossing route is connected, which is same as existing Taksim – 4.Levent Metro (E-1). When the route is connected, main depot will be at Alibeykoy Triyaj Alani Depot proposed for Line P2-1. During the study and discussion with Ulasim A.S. and IMM, it is possible to connect Uskudar – Cekmekoy Metro by spur track just for utilizes their depot. However, more detail analysis is required to select the suitable location for PP-2 line.

19.2.4 PP-1: Bosporus Crossing Route

1) Route and Station Location

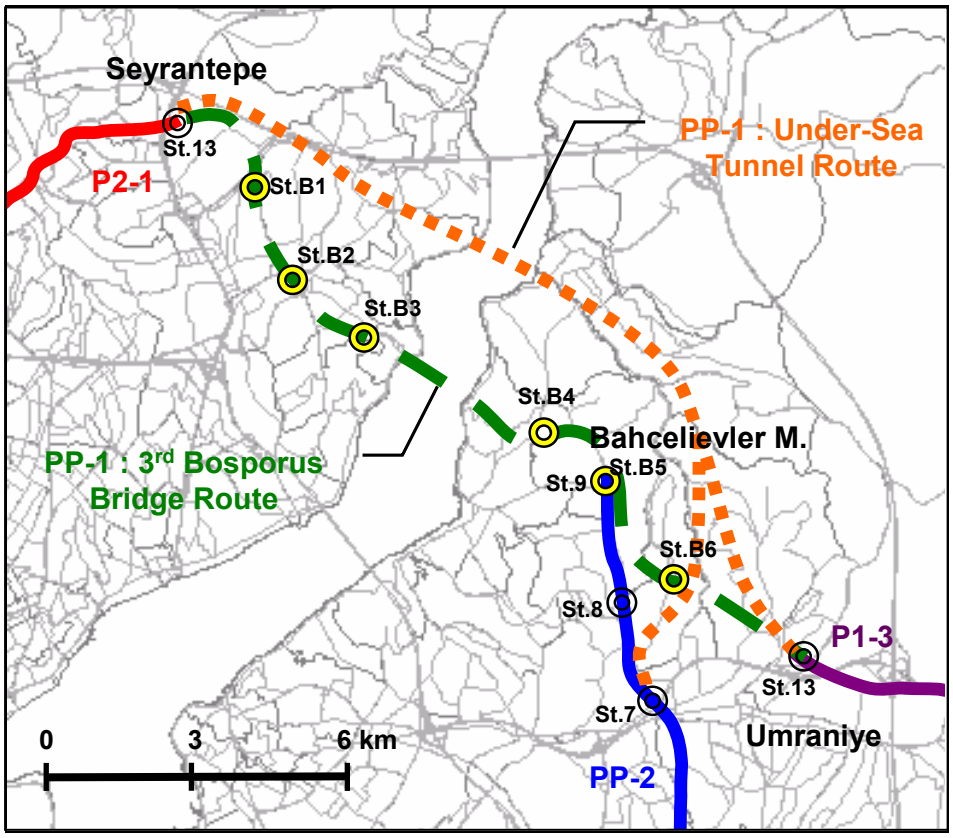
(1) General

This line is connects P2-1 line and P1-3 or PP-2 line by Bosporus crossing either under-sea tunnel or bridge. In case of bridge crossing is selected, bridge will be located

same as 3rd Bosporus Bridge proposed by road network in this master plan. It is preferable to construct 3rd bridge as road and railway combined bridge. Three stations can be placed on this line in European side. Asian side has two options depending on the connection to P1-3 or PP-2 line. Three stations can be placed for P1-3 and one station for PP-2 connection. In case of sea-tunnel crossing is selected, route will be further north to have enough length to clear the bottom of the Bosporus Strait, which depth is approximately 110 meter below the sea level. No additional station can be constructed. On the contrary, under-sea crossing route needs to start from St.12 in European side, and connect at St.13 for P1-3 and St. No.7 instead St. No.9 for PP-2 line in Asian side.

Total length and station numbers of this route by each PP-1 alternative are as follows;

- Alternative 1 (P2-1 + PP-1(B) + P1-3) : 12.6 km with 6 additional stations
- Alternative 2 (P2-1 + PP-1(B) + PP-2) : 8.9 km with 4 additional stations
- Alternative 3 (P2-1 + PP-1(T) + P1-3) : 13.0 km without additional stations
- Alternative 4 (P2-1 + PP-1(T) + PP-2) : 13.0 km without additional stations



Source: *ibid.*

Figure 19.2.8 Route and Station Location of PP-1 Bosporus Crossing

(2) Stations

Station No.B1: Located on Lojmanlar Street in Konaklar area next to the Highway O-2. Underground station with two line and one island type of platform is proposed.

Station No.B2: Located on the junction point of Aytar Street, Nispetiye Street and Ahmet Adnan Saygun Street in Besiktas District. Underground station with two line and one island type of platform is proposed.

Station No.B3: Located between Sekbanlar Street and Korkadi Street in Kultur residential area just before the Bosporus Bridge. Underground station with two line and one island type of platform is proposed.

Station No.B4: Located near the cross point of Kaldirim Street and Selvi Yolu Street in Asian side after the crossing Bosporus Bridge. Underground station with two line and one island type of platform is proposed.

Station No.B5: Located on the cross point of Bosna B Street and Nato Yulu Street near the Maxi City shopping center. This station is same as St.No.9 of PP-2 route. Underground station with two line and one island type of platform is proposed.

Station No.B6: Located on the junction point of Mandira Street, Sehit Serdar Eyuboglu Street and Ayazaga Street on the border of Uskudar and Umraniye District. Underground station with two line and one island type of platform is proposed.

There is no station for under-sea tunnel route.

Table 19.2.5 Seyrantepe – Bosporus - Umraniye Metro Station Crossing by Bridge (Alternative 1)

Station No.	Type	Distance (km)	Position (km)	GL (m)	RL (m)	Connection
St. 13	UG	0.000	0.000	125	80	Last station of P2-1 route
St. B1	UG	1.950	1.950	88	60	
St. B2	UG	1.360	3.310	137	92	
St. B3	UG	1.120	4.430	68	75	
St. B4	UG	3.000	7.430	113	75	
St. B5	UG	1.510	8.940	106	86	Same station of PP-2 St. No.9
St. B6	UG	1.910	10.850	109	79	
St. 13	UG	1.720	12.570	123	99	Last station of P1-3 route
Total		12.570				

Source: *ibid.*

Table 19.2.6 Seyrantepe – Bosporus - Bahcelievler Mahallesi Metro Station Crossing by Bridge (Alternative 2)

Station No.	Type	Distance (km)	Position (km)	GL (m)	RL (m)	Connection
St. 13	UG	0.000	0.000	125	80	Last station of P2-1 route
St. B1	UG	1.950	1.950	88	60	
St. B2	UG	1.360	3.310	137	92	
St. B3	UG	1.120	4.430	68	75	
St. B4	UG	3.000	7.430	113	75	
St. 9	UG	1.510	8.940	106	86	Last station of PP-2 route
Total		8.940				

Source: *ibid.*

2) Structure and Construction Methods

(1) Underground Structure

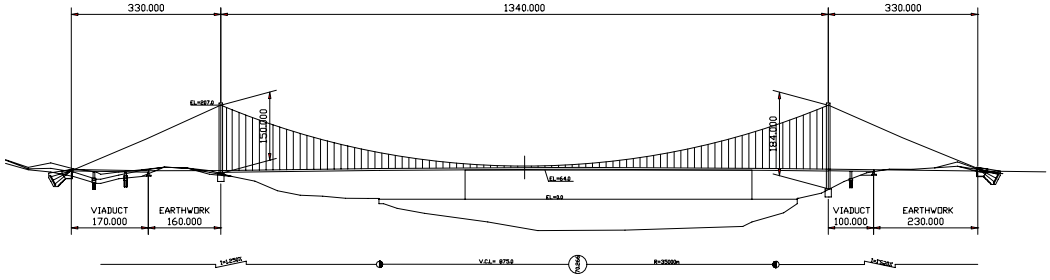
Underground stations as well as tunnel structure and construction methods are described in Section 19.2.1, 2), (ii). For crossing Bosporus Strait, construction by Shield Machine tunneling method as TBM is preferable because of the geological condition under the

Bosporus Strait.

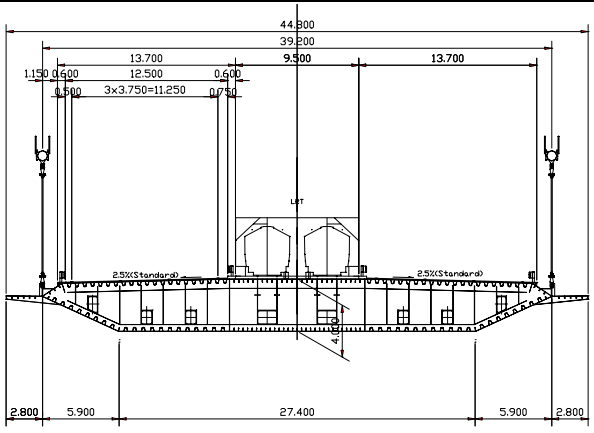
(2) Bosporus 3rd Bridge

The 3rd Bosporus Bridge study "The Study Report for Construction of the New Bosporus Crossing in the Republic of Turkey" has been conducted by JIBC SAPROF on March 2005. General overview of the structure for road and railway combined bridge as follows;

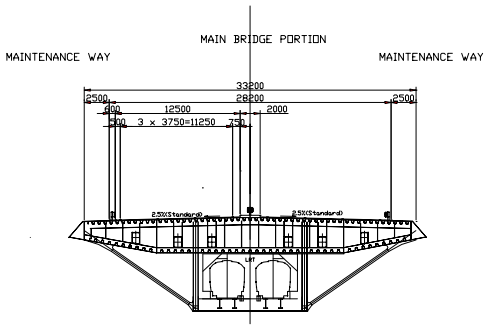
Bridge over the Bosporus crossing is decided to be a suspension bridge. Since the side spans will be on the land, the bridge is designed as a single span. In order to avoid slip of cables at the top of the tower, the side span length of the cable is decided to be 330 m, which is equivalent to a side span ratio of 0.25. An orthotropic steel box girder is used for the stiffening girder. The height of the girder is selected to be 4 m in consideration of aerodynamic stability. The cable intervals and hanger intervals are 39.2m and 15m, respectively. The towers are steel rigid structure having two horizontal crossbeams. The columns of the towers will have a mono-cell structure. The foundation will be direct foundation. General sections are shown in the following drawings from JBIC SAPROF Report.



Elevation of Suspension Bridge (Reference Only)



Girder Cross Section
(Reference Only)



Double-Deck Girder Cross Section
(Reference Only)

Source: The Study Report for Construction of the New Bosporus Crossing by JBIC Report

Figure 19.2.9 General Drawings of Bosporus Crossing Bridge

3) Comparison of Bridge and Tunnel for Bosporus Crossing

From the view point of railway operation analysis, connecting by bridge is preferable than the tunnel crossing. General information for Bosporus rail crossing is described in Chapter 14.2.3. Following table shows the comparison of bridge and under-sea tunnel route.

In addition to that, based on the passenger demand, level of investment, construction schedule and analysis of EIRR & FIRR for entire route described in next section, Alternative 2 which is crossing by bridge is selected as optimum route for Bosporus Crossing.

Table 19.2.7 Comparison of Bridge and Under-Sea Tunnel

	Bridge	Tunnel
Structure (at Bosporus Crossing)	Suspension Bridge (Road & Rail Combined Bridge)	TBM / NATM Tunnel
Construction Cost Ratio (for PP-1 Route)	1.00 (8.8 km : approx. 750 mil. US$)	1.17 (13.0 km : approx. 880 mil.US$)
Number of Station	4	0 (13.0 km without station)
Land Acquisition	Both side of bridge and stations	-
Others	• Impact on Environment Aspect • Coordination with road and railway project is required	• Needs special attention for passenger evacuation • Steep gradient (35‰)

Source: Study Team

19.3 Demand Characteristics

19.3.1 Concept of Alternative Route Selection and Demand Forecast

P2-1 & P1-3/PP-2 routes are located north-south direction in European and Asian side respectively in order to mitigate traffic congestion in both areas. PP-1 route is connecting European and Asian side by bridge or tunnel in order to satisfy the growth of public transport demand for Bosporus crossing. In view of the level of investment and construction schedule, it is proposed that the entire route would be operational by 2022. PP-2 and PP-1 for alternative 2 routes can be partially operational by 2021.

In this section, the Study Team will select the optimum route from the four alternatives based on the passenger demand together with project cost and implementation schedule at the target year of 2023. Latter of this section, future traffic demand such as number of passenger, daily traffic volume between stations will be calculated for selected route.

19.3.2 Selection of Optimum Route

Following table shows comparison of four alternatives. Alternative 2 shows the highest EIRR and FIRR among the four alternatives. As a result of evaluation, the Study Team selected Alternative 2 as the optimum route for further study.

Plan & Profile drawing for Alternative 2 route will show in Appendix to Chapter 19 attached to this report.

Table 19.3.1 Comparison Table of Alternatives

	Project Code	Length (km)		No. of Station		Operation Year	Project Cost (Billion Us$)			EIRR (%)	FIRR (%)	Evaluation
			Total		Total		Civil, E&M	Rolling Stock	Total			
Alternative 1	P2-1	16.3	42.9	13	32	2022	3.00	0.45	3.44	16.3	11.9	B
	PP-1(B)	12.6		6								
	P1-3	14.0		13								
Alternative 2	P2-1	16.3	33.8	13	26	2022	2.40	0.38	2.78	24.7	12.7	A
	PP-1(B)	8.9		4		2021						
	PP-2	8.6		9								
Alternative 3	P2-1	16.3	43.3	13	26	2022	2.90	0.40	2.30	12.0	11.3	C
	PP-1(T)	13.0		0								
	P1-3	14.0		13								
Alternative 4	P2-1	16.3	37.9	13	20	2022	2.36	0.33	2.69	19.7	11.6	B
	PP-1(T)	13.0		0								
	PP-2	8.6		9		2021						

Source: *ibid.*

19.3.3 Future Traffic Demand

1) Number of Passenger

Based on the concept and method of demand forecast descried in the previous section, number of passengers per day is calculated for Alternative 2 by phasing manner as shown in the following table.

Table 19.3.2 Number of Passenger

passengers/day

	2021	2021	2022
Alternative 2	PP-2 (10.9 km, 9 stations)	PP-2 + PP-1(Bridge) (19.8 km, 13 stations)	P2-1 (18.1 km, 13 stations)
	612,566	958,051	962,090
	-	-	PP-2 + PP-1(Bridge) + P2-1 (37.9 km, 26 stations)
	-	-	1,834,534

Source: *ibid.*

2) Daily Traffic Volume between Stations

Daily cross-sectional traffic volume for each alternative and years are shown in the following table.

Table 19.3.3 Cross-Sectional Traffic Volume (Alternative 2)

passengers/day

		2021			2021			2022		
	Station No.	up	down	total	up	down	total	up	down	total
PP-2	St. 1 - 2	196,658	180,445	377,103	188,936	170,372	359,308	236,462	221,373	457,835
	St. 2 - 3	192,199	180,637	372,836	185,187	170,544	355,731	234,243	220,775	455,018
	St. 3 - 4	204,653	199,414	404,067	205,707	191,906	397,613	249,736	241,032	490,768
	St. 4 - 5	232,925	230,392	463,317	262,008	277,228	539,236	279,599	275,941	555,540
	St. 5 - 6	212,547	221,150	433,697	249,392	270,692	520,084	267,389	269,618	537,007
	St. 6 - 7	197,813	208,889	406,702	230,503	267,125	497,628	249,291	263,751	513,042
	St. 7 - 8	62,543	48,782	111,325	256,374	258,674	515,048	275,982	258,380	534,362
	St. 8 - 9	27,664	33,734	61,398	240,850	252,979	493,829	258,096	250,446	508,542
PP-1	St. 9 - B4				241,022	228,923	469,945	257,792	225,366	483,158
	St. B4 - B3				220,603	245,653	466,256	236,401	247,527	483,928
	St. B3 - B2				108,306	112,389	220,695	189,494	198,168	387,662
	St. B2 - B1				65,614	107,850	173,464	199,313	209,852	409,165
	St. B1 -13				68,958	111,386	180,344	227,828	213,236	441,064
P2-1	St. 13 - 12							272,922	244,731	517,653
	St. 12 - 11							293,107	274,391	567,498
	St. 11 - 10							232,854	226,521	459,375
	St. 10 - 9							247,801	236,138	483,939
	St. 9 - 8							249,483	247,274	496,757
	St. 8 - 7							238,874	233,969	472,843
	St. 7 - 6							269,709	241,974	511,683
	St. 6 - 5							160,806	141,847	302,653
	St. 5 - 4							144,330	153,480	297,810
	St. 4 - 3							150,480	160,117	310,597
	St. 3 - 2							126,485	137,135	263,620
	St. 2 - 1							76,071	80,773	156,844

Source: *ibid.*

3) Traffic Volume between Stations at Peak Hours

In order to calculate the peak hour traffic volume per direction, following design peak hour and factor have been assumed.

Peak hour: between 7 to 8 o'clock AM

Peak hour ratio: 12.15 %

Based on the cross sectional traffic volume and above factor, cross sectional traffic volume at peak hour has been calculated as shown in the following table.

Table 19.3.4 Cross-Sectional Traffic Volume at Peak Hour (Alternative 2)

passengers/day

		2021		2021		2022	
	Station No.	up	down	up	down	up	down
PP-2	St. 1 - 2	16,599	15,190	16,964	15,575	17,106	15,727
	St. 2 - 3	16,042	15,211	16,346	15,697	16,741	15,545
	St. 3 - 4	17,562	16,194	17,967	16,781	18,190	16,589
	St. 4 - 5	15,971	16,710	17,399	18,139	17,541	18,220
	St. 5 - 6	14,451	15,545	15,535	17,085	16,133	17,146
	St. 6 - 7	13,691	14,359	15,170	16,001	15,211	15,930
	St. 7 - 8	4,419	3,659	6,851	6,293	7,682	7,104
	St. 8 - 9	2,351	2,514	5,067	5,371	5,949	6,222
PP-1	St. 9 - B4			4,996	3,284	5,868	4,206
	St. B4 - B3			2,797	4,844	4,115	6,192
	St. B3 - B2			912	1,399	3,304	5,138
	St. B2 - B1			943	1,419	3,699	5,483
	St. B1 -13			1,156	1,642	5,543	5,766
P2-1	St. 13 - 12					11,127	8,837
	St. 12 - 11					13,062	11,867
	St. 11 - 10					5,554	5,554
	St. 10 - 9					7,094	7,074
	St. 9 - 8					7,367	8,938
	St. 8 - 7					9,799	9,506
	St. 7 - 6					19,963	14,785
	St. 6 - 5					13,235	11,188
	St. 5 - 4					12,627	13,387
	St. 4 - 3					14,430	15,170
	St. 3 - 2					14,299	15,616
	St. 2 - 1					8,523	9,161

Source: *ibid.*

19.4 Railway System and Rolling Stock

19.4.1 Selection of System

The passenger traffic volume between stations at peak hour in the year of 2023 is estimated as 21,017 passengers at the section of station No.6 and No.7 of P2-1 line as maximum volume. Based on the necessity of safely and comfortable system as a public transportation system with economical operation, Metro type as MRT system will be recommended. However, for the next stage, detailed route alignment study including location of station is required with considering other planning routes which are crossing this studied line. In case of the gradient exceeds 3.5%, LIM system is also can be adopted for this route.

19.4.2 Basic Specification of Rolling Stock

Rolling Stock for selected route shall have the following characteristics;

- A safe, reliable, user-friendly and attractive vehicle, with capacity to meet the specified demands and good riding qualities.
- Easy access for physically-disable people.
- Performance shall be designed to meet the limiting gradients and curves in both normal and emergency operation, while optimizing the balance between journey time, total number of vehicles, energy consumption, power supply, and traction equipment.

- High capacity.

Following table shows basic dimensions and specification of proposed system.

Table 19.4.1 Rolling Stock Dimensions and Specifications

Items	Metro System
Track Gauge	1,435 mm
Car Width	2.95 m
Car Length	20 m
Car Height	3.655 m (excluding pantograph and AC)
Axle Load	15 t
Weight of Car	M:31 ton T: 26 ton
Rail	UIC 60 kg/m
Platform Height	1,100 m
Traction Power	1,500V DC
Power Supply	Overhead/Rigid Catenary
Maximum Gradient	3.5 % (Level at station)
Minimum Curve Radius	300 m (600 m at station)
Minimum Vertical Curve Radius	3,000 m
Maximum Train Operation Speed	80 km/h
Acceleration Rate	0.92 m/s2 (3.3 km/h/s)
Deceleration Rate	0.97 m/s2 (3.5 km/h/s)
Emergency braking	1.25 m/s2 (4.5 km/h/s)

Source: *ibid.*

19.5 Train Operation Planning

Preparation of train operation plans, it is essential to make the railway as a means of passenger transport which can provide safe, stable, speedy, and high-frequency transport as a main transport mode in the Istanbul to meet the transport demand and to introduce a modern operational safety system suitable for proposed routes.

Train operation plan will be conducted in order to satisfy the following phases.

PP-2 and PP-1 lines are scheduled to be open in 2021 as a first phase. Second phase will be connection of P2-1 line which is planned to be operational by 2022.

19.5.1 Train Capacity / Headway

The passenger traffic volume in the year of 2023 is estimated to be 21,017 passengers per hour per direction (pphpd) at peak hour. In the year of 2021, when the PP-2 and PP-1 lines are start operation, passenger traffic volume is estimated to be 18,139 pphpd.

Following table indicate the capacity of four (4) car formation and six (6) car formation trains at different headways. The assumption for each car has 240 passengers. This represents 6 passengers per square meter floor density. Capacity of four car and six car train is 960 and 1440 passengers respectively.

Table 19.5.1 Capacity of Train

Headway	Capacity (pphpd)	
	4-cars train	6-cars train
2 min	28,800	43,200
2 min 15 sec	25,600	38,400
2 min 30 sec	23,000	34,500
2 min 45 sec	20,900	31,400
3 min	19,200	28,800
3 min 15 sec	17,700	26,500
3 min 30 sec	16,400	24,600
3 min 45 sec	15,300	23,000
4 min	14,400	21,600
4 min 15 sec	13,500	20,300
4 min 30 sec	12,800	19,200
4 min 45 sec	12,100	18,100
5 min	11,500	17,200

Source: *ibid.*

Based on the above train capacity, it will required 15 trains with 6-cars or 24 trains with 4-cars running at a headways of 4 minutes or 2.5 minutes in the year of 2023. Consideration of passenger volume after the year of 2023, it is necessary to have an allowance to minimize the headway to cope with the passenger growth. In case of selecting 4-cars train, maximum capacity of train at 2 minutes headway is only 28,800 instead of 6-cars train of 43,200. Moreover, it is hardly to extend underground station length to shift from 4-cars to 6-cars train. In this context, the Study Team will recommend 6-car train operation from the initial stage.

As for the first phase 1, operational by 2021, PP-2 or PP-2 + PP-1 route required 13 trains with 6-cars at headways of 4.5 minutes at peak hour.

19.5.2 Standard Operation Time

Based on the following basic conditions, the standard operation time has been calculated and the results of the calculation are as shown in the tables 19.5.2 to 19.5.4.

- PP-2 and PP-1 lines are scheduled to be open in 2021 as a first phase. Second phase will be connection of these two lines with P2-1 which is planned to be in 2022. Therefore, year of 2021 and 2022 will be considered for operation planning.
- Metro type of MRT system is introduced and basic dimensions and specification are described in Section 19.4.2.
- The assumption for each car has 240 passengers. This represents 6 passengers per square meter floor density. Passenger weight is assumed as 70 kg/person.
- Dwell time is set as 30 seconds at ordinary stations and 45 seconds at transfer stations.
- The operation time is rounded up by 15 seconds units.

Table 19.5.2 Standard Operation Time Phase 1, PP2 Section

St. No.	Distance	Standard Operation Time				
	(km)	Between Station		Dwell Time	Total	
		Down	Up	(sec.)	Down	Up
St. 1					0	18:30
	1.120	1:30	1:30			
St. 2				30	2:00	17:00
	1.300	1:45	1:45			
St. 3				30	4:15	14:45
	1.350	1:45	2:00			
St. 4				45	6:45	12:15
	1.320	1:45	1:45			
St. 5				45	9:15	9:45
	1.510	2:00	1:45			
St. 6				30	11:45	7:15
	1.380	1:45	1:45			
St. 7				45	14:15	5:00
	1.300	1:45	1:45			
St. 8				30	16:30	2:30
	1.570	2:00	2:00			
St. 9					18:30	0
Total	10.850					
Standard Operation Time					18:30	18:30
Commercial Speed					35.2 km/h	35.2 km/h

Source: *ibid.*

Table 19.5.3 Standard Operation Time Phase 1, PP2+PP1 Section

St. No.	Distance	Standard Operation Time				
	(km)	Between Station		Dwell Time	Total	
		Down	Up	(sec.)	Down	Up
St. 1					0	31:30
	1.120	1:30	1:30			
St. 2				30	2:00	30:00
	1.300	1:45	1:45			
St. 3				30	4:15	27:45
	1.350	1:45	2:00			
St. 4				45	6:45	25:15
	1.320	1:45	1:45			
St. 5				45	9:15	22:45
	1.510	2:00	1:45			
St. 6				30	11:45	20:15
	1.380	1:45	1:45			
St. 7				45	14:15	18:00
	1.300	1:45	1:45			
St. 8				30	16:30	15:30
	1.570	2:00	2:00			
St. 9				30	19:00	13:00
	1.510	2:00	1:45			
St. B4				30	21:30	10:45
	3.000	3:00	3:00			
St. B3				30	25:00	7:15
	1.120	1:30	1:30			
St. B2				30	27:00	5:15
	1.360	1:45	2:00			
St. B1				30	29:15	2:45
	1.950	2:15	2:15			
St. 13					31:30	0
Total	19.790					
Standard Operation Time					31:30	31:30
Commercial Speed					37.7 km/h	37.7 km/h

Source: *ibid.*

Table 19.5.4 Standard Operation Time Phase 2

St. No.	Distance	Standard Operation Time				
	(km)	Between Station		Dwell Time	Total	
		Down	Up		Down	Up
PP-2 St. 1					0	1:02:00
	1.120	1:30	1:30			
PP-2 St. 2				30	2:00	1:00:30
	1.300	1:45	1:45			
PP-2 St. 3				30	4:15	58:15
	1.350	1:45	2:00			
PP-2 St. 4				45	6:45	55:45
	1.320	1:45	1:45			
PP-2 St. 5				45	9:15	53:15
	1.510	2:00	1:45			
PP-2 St. 6				30	11:45	50:45
	1.380	1:45	1:45			
PP-2 St. 7				45	14:15	48:30
	1.300	1:45	1:45			
PP-2 St. 8				30	16:30	46:00
	1.570	2:00	2:00			
PP-2 St. 9				30	19:00	43:30
	1.510	2:00	1:45			
St. B4				30	21:30	41:15
	3.000	3:00	3:00			
St. B3				30	25:00	37:45
	1.120	1:30	1:30			
St. B2				30	27:00	35:45
	1.360	1:45	2:00			
St. B1				30	29:15	33:15
	1.950	2:15	2:15			
P2-1 St. 13				45	32:15	30:30
	2.110	2:15	2:30			
P2-1 St. 12				30	35:00	27:15
	1.270	1:45	1:45			
P2-1 St. 11				45	37:30	25:00
	1.330	1:45	1:45			
P2-1 St. 10				30	39:45	22:30
	2.080	2:15	2:15			
P2-1 St. 9				45	42:45	19:45
	1.630	2:00	2:00			
P2-1 St. 8				30	45:15	17:00
	1.350	1:45	1:45			
P2-1 St. 7				45	47:45	14:45
	1.660	2:00	2:00			
P2-1 St. 6				45	50:30	12:00
	0.900	1:30	1:30			
P2-1 St. 5				30	52:30	9:45
	1.090	1:30	1:30			
P2-1 St. 4				30	54:30	7:45
	1.540	2:00	1:45			
P2-1 St. 3				45	57:15	5:30
	1.920	2:15	2:15			
P2-1 St. 2				45	1:00:15	2:30
	1.220	1:45	1:45			
P2-1 St. 1					1:02:00	0
TOTAL	37.890					
Standard Operation Time					1:02:00	1:02:00
Commercial Speed					36.7 km/h	36.7 km/h

Source: *ibid.*

19.5.3 Number of Trains

The total number of trains operated per day is calculated from the cross-sectional traffic volume of the largest transport cross-section by considering distribution ratio. This ratio was assumed from the typical service of the system and total network hourly ratio calculated by the Study Team. Based on the analysis of cross-sectional traffic volume at peak hour, there is no special necessity of conducting turn-around operation at an intermediate station. Therefore, the number of trains is scheduled to be the same throughout the entire sections. Operating hour is scheduled to be from 5:00 (departure of the 1st train) to 24:00 (arrival of the last train). Following tables are the result of distribution ratio of trains by time period and number of trains per direction for each phase.

Table 19.5.5 Distribution Ratio of Trains by Time Period and Number of Trains (One-Way)

Time		5–6	6–7	7–8	8–9	9–10	10–11	11–12	12–13	13–14	14–15
Distribution Ratio		0.2	0.6	1	0.9	0.5	0.5	0.5	0.5	0.5	0.5
No. of Train	2021 (Ph.1) PP–2	3	8	12	11	6	6	6	6	6	6
	2021(Ph.1) PP–2 + PP–1	3	8	13	12	7	7	7	7	7	7
	2023 (Ph.2)	3	9	15	14	8	8	8	8	8	8
Time		15–16	16–17	17–18	18–19	19–20	20–21	21–22	22–23	23–24	**Total**
Distribution Ratio		0.5	0.7	0.8	0.8	0.7	0.6	0.5	0.5	0.2	
No. of Train	2021 (Ph.1) PP–2	6	9	10	10	9	8	6	6	3	**137**
	2021(Ph.1) PP–2 + PP–1	7	10	11	11	10	8	7	7	3	**152**
	2023 (Ph.2)	8	11	12	12	11	9	8	8	3	**171**

Source: *ibid.*

Following table shows the summary of train operation result.

Table 19.5.6 Summary of Train Operation Plan

Item	Unit	Year 2021	Year 2021	Year 2023
		PP-2	PP-2 + PP-1	PP-2 + PP-1 + P2-1
Section	(km)	8.6	17.5	33.8
No. of Station		9 station	13 station	26 station
Max Speed		80 km/h	80 km/h	80 km/h
Running Time		18:30	31:30	1:02:00
Schedule Speed		35.2 km/h	37.7 km/h	36.7 km/h
Headway (Peak hour)		5 minutes	4.5 minutes	4 minutes
Train Formation	Unit	6	6	6
No. of Train (Peak hour)	Trains /hour	12	13	15
Ditto (All day)	Trains /day	274	304	342
Train km	km/day	3,000	6,000	13,000
Car km	km/day	18,000	36,000	78,000
Transport Vo. (No. of Parson)	Pers./day	612,566	958,051	1,843,712
Transport Vo. (Parson – km)	Pers. km/day	2,456,517	5,404,802	10,175,480
Average – km	km/pers.	4.0	5.6	5.5

Source: *ibid.*

19.5.4 Number of Rolling Stock

The numbers of train sets and rolling stock necessary for ensuring the required transport capacity are decided on the basis of the number of trains in the peak time zones described in the above sections. The total number of the necessary train sets is obtained by adding 2 sets (1 set for operational stand-by, 1 set for maintenance) to the number of train sets used for operation. At the partial opening, the number of stand-by train set is planned to be one set.

Table 19.5.7 Number of Rolling Stock

Item	Year 2021 PP-2	Year 2021 PP-1 + PP-2	Year 2023 PP-2 + PP-1 + P2-1
No. of Train Set	10	17	35
Stand-by Train Set	1	1	2
Total Train Set	11	18	37
Train Formation	6 cars	6 cars	6 cars
Total No. of Car	72 cars	108 cars	222 cars

Source: *ibid.*

19.5.5 Operation Organization and Personnel

The size and functions of the operation organization is based on the amount of the operation service expected in the year 2021 for PP-1 and PP-1+PP-2, and year of 2022 for all lines are connected. The number of station staff can be estimated from the number of station and the size of each station, while the number of other staff such as drivers and engineers depends on the transport volume. Transport volume is usually expressed as the number of passengers, passenger- kilometers, train-kilometers, and car-kilometers. The number of drivers is related to train-kilometers while the number of rolling stock engineers is related to car- kilometers. In this stage, detail break down is not possible then the number of drivers and maintenance staff is calculated by car-kilometers.

Based on the analysis, the unit numbers of staff are shown in Table 19.5.8 and numbers of staff for each phase are shown in Table 19.5.9.

Table 19.5.8 Unit of Number of Staff

	Unit of No. of Staff
General Administration Staff (Per route-km)	3.0
Station Staff (Per station)	10.0
Other Staff (Per 1000 car-km/day)	6.7

Source: *ibid.*

Table 19.5.9 Number of Staff for Each Phase

	Year 2021 PP-2	Year 2021 PP-1 + PP-2	Year 2023
General Administration Staff	27	60	114
Station Staff	40	130	270
Other Staff	149	331	634
TOTAL	216	521	1018

Source: *ibid.*

19.5.6 Depot

Based on the analysis from the predicated passenger demand figure for car requirements, following table indicates the depot capacity required for each phase. The depot to be built under phase 1, for the initial system, has been sized to cater for all workshop requirements for phase 1 & 2.

The Phase 1 depot should be designed to, at least accommodate the initial system train requirements. As for the PP-2 route depot, further expansions are not required, once Bosporus crossing route is connected, additional train requirement will be utilize the Alibeykoy Triyaj Alani Depot which was proposed for P2-1 route depot. PP-2 route is mainly running middle of the residential area and it is hardly to find suitable depot location close to this line. Possible location can be at Hekimbasi area along the Highway O-2, which is around 3 km further north-east from the St.9 or St.7. During the study and discussion with Ulasim A.S. and IMM, it is possible to connect Uskudar – Cekmekoy Metro by spur track just for utilizes their depot. However, more detail analysis is required to select the suitable depot location for PP-2 line and its layout.

The workshop facilities should be accommodated in the depot to cater for maintenance and overhaul functions for future requirement. In addition, the depot site should also accommodate the operation control center and administration buildings.

Table 19.5.10 Required Size of Depot

Location of Depot	2021		2023	
	Required No. Car	Required Size	Required No.Car	Required Size
Depot for PP-2 (Phase 1)	72	2.5 ha	-	-
Alibeykoy Triyal Alani Depot (P2-1)	-	-	222	7.0 ha

Source: *ibid.*

To optimize the performance of the trains and infrastructure, and maintain quality and reliability of services, maintenance is of prime importance. The depot shall provide the requirements for carrying out the following aspects of railway maintenance.

- Preventive maintenance
- Light maintenance
- Heavy maintenance (overhaul)
- Corrective maintenance

The size, scope and number of facilities within the depot shall be designed to satisfy the rolling stock fleet initially and in long term.

19.6 Cost Estimates

19.6.1 Condition of Cost Estimate

The cost estimate for the alternative 2 route is based on the average unit cost of construction works, consists of civil and E&M work, per kilometer of similar projects in Istanbul. The cost for land acquisition was estimated by applying the land price information corrected from IMM. Unit cost for land acquisition was using the average of market price per square meter of 29 districts in Istanbul. However, the compensation for resettlement is not taken into consideration. The unit cost of a vehicle is taken from the recent procurement contracts in Istanbul and abroad. The unit cost of civil works, rolling stock and land price assumed for this project is shown in the following table.

Table 19.6.1 Estimated Unit Cost

Item	Unit	Cost
Civil Work Under Ground	per km	60 million US$
Civil Work Elevated	per km	30 million US$
Rolling Stock Procurement	per car	1.7 million US$
Land Price for Resettlement	per m2	444 US$

Source: *ibid.*

As for the Bosporus Crossing, the Study Team proposed combined road and railway suspension bridge. Construction cost of bridge was estimated as 682 million US$ with length of 2.0 km. In this study, 50% of total construction cost for suspension bridge was assumed as project cost for railway.

Methodology and calculation of project cost are presented in Chapter 14.5.2.

19.6.2 Summary of Cost Estimate

Summary of cost estimate is presented in the following table.

Table 19.6.2 Summary of Cost Estimate

Stage	Project	Length (km)	No. of Station	No. of Train	Const. Work Civil+E&M (mil. US$)	Rolling Stock (mil. US$)	Land Acquisition (mil. US$)
Phase 1 (2021)	PP-2	8.6	9	72	654.0	122.4	12.0
Phase 1 (2021)	PP-1	8.9	4	36	755.0	61.2	5.3
Phase 2 (2023)	P2-1	16.3	13	114	993.0	193.8	31.4
TOTAL		33.8	26	222	2402.0	377.4	48.3
Grand Total						2827.7 million US$	

Source: *ibid.*

19.6.3 Operation and Maintenance Cost

The operation and maintenance (O&M) costs are “variable costs” which depend on the quantity of the railway services, and the costs per the service volume such as train-km, passenger-km, or the number of passengers or trains are usually used to estimate the O&M costs on the assumption that the costs increase in proportion to the service volumes. This assumption can be applied when the volume is large; if it is small, the portion of “fix

cost" in the O&M costs effects the unit cost.

The O&M costs were estimated from two methods: 1) usage of the unit costs calculated from the financial data of Ulasim A.S., and 2) usage of the unit costs calculated from Japanese experience. Since detail statistics for the analysis of operation and maintenance is available for all rail operators in Japan, usage of Japanese data is useful especially for underground railway.

The O&M costs consist of 1) personnel cost, 2) general administrative cost, 3) station operation cost, 4) train operation cost, 5) transport management cost, and 6) maintenance costs.

Methodology and calculation of O&M cost are presented in Chapter 14.5.4. Following table shows the result of O&M cost estimate for selected project.

Table 19.6.3 Summary of O&M Cost Estimate

Stage	Project	Length (km)	No. of Station	No. of Staff	Personnel Expense (mil. US$)	Other Expense (mil. US$)	Total (mil. US$)
Phase 1 (2021)	PP-2	8.6	9	305	8	27	35
Phase 1 (2021)	PP-1	8.9	4	216	6	22	28
Phase 2 (2023)	P2-1	8.6	13	497	13	45	58
TOTAL		33.8	26	1018	27	94	121

Source: *ibid.*

19.7 Implementation Schedule

The implementation of the Alternative 2 Route shall be divided into two phases and phase 1 has two projects as follows;

(1) Phase 1: PP-2 Sogutlucesme – Bahcelievler Mahallesi Metro (8.6 km, 9 stations)

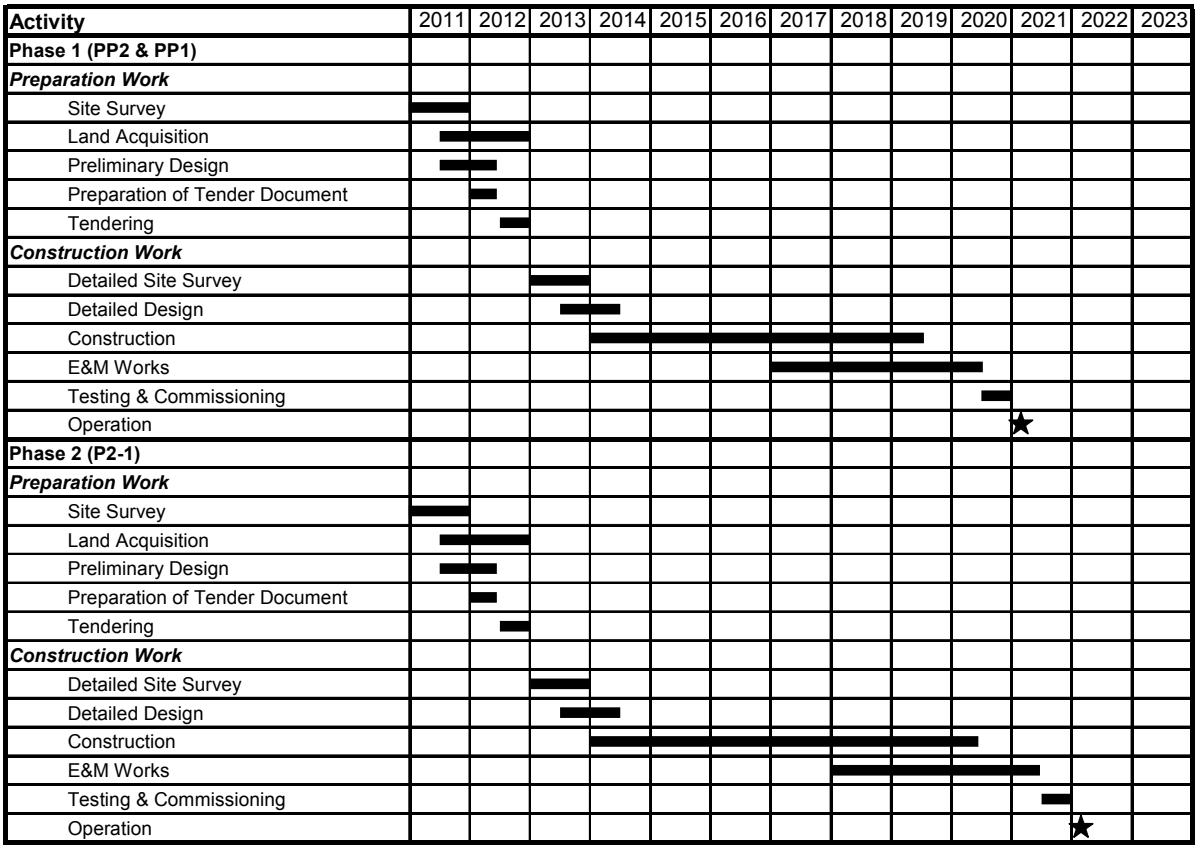
(2) Phase 1: PP-1 Bosporus Crossing by Bridge (8.9 km, 4 stations)

(3) Phase 2: P2-1 Seyrantepe – Zeytinburnu Metro (16.3 km, 13 stations)

The Study Team will propose Design and Build procurement method for shortening the project period. The following explains the time savings of adopting Design and Build base contract.

- There is no selection period for the detailed design consultants, but General Consultants are still required to prepare a preliminary design or design basis. Typically the General Consultant is awarded prior to the detailed design consultant.
- The basic design will be done during the period of preparation for construction tender documents.
- There is no period of detailed designing prior to award of the construction contract as the detailed design is by the contractor. This allows up to 12 months time saving.

Following figure shows the implementation schedule of the projects assuming the Design and Build base contract.



Source: *ibid.*

Figure 19.7.1 Project Implementation Schedule

Chapter 20 Road and Sea Based Public Transport Plan

20.1 Expansion of Metrobus Service

20.1.1 Present IETT Plan

Metrobus started its first operation in 2007 on the Avcilar Merkez University – Cevizlibag section of D100 Expressway. This is considered to be a remarkable success in the IETT bus operation. As of February, 2008 that about 240 thousand people use Metrobus everyday and this corresponds to about 50% of all passenger traffic between Avcilar and Topkapi.

Metrobus also provides a good business opportunity for IETT. While demand is large, construction cost of Metrobus that IETT has to shoulder is very small because IETT borrows the road space of expressway from the central government without explicitly shouldering the construction cost of infrastructure.

IETT intends to extend Metrobus routes and expand its services as much as possible. Table 20.1.1 and Figure 20.1.1 show the Metrobus routes proposed by IETT and approved by UKOME as of February 2008.

Table 20.1.1 IETT Metrobus Route Extension Plan as of February 2008

Route	Length (m)	Current Status
Beylikduzu - Avcilar	9,145	Approved (Expressway)
Avcilar - Cevizlibag	18,430	Existing (Expressway)
Cevizlibag - Mecidiyekoy	9,200	Under construction (Expressway)
Mecidiyekoy - Kozyatagi	15,000	Approved (Expressway)
Besiktas – 4.Levent	4,940	Approved (Arterial road)
Aksaray – Milliyet	11,000	Approved (Expressway and arterial road)
Vezneciler – Edirnekapi	3,325	Approved (Arterial road)
Bostanci - Sogutlucesme	6,940	Approved (Arterial road)

Source: Metrobus Dept., IETT

Source: *ibid.*

Figure 20.1.1 IETT Metrobus Route Extension Plan, February 2008

These routes are planned to be implemented in the short term in a few years. Although most of them are planned on existing expressways, some routes are assumed on regular arterial roads.

20.1.2 Further Extension of Metrobus Routes

Metrobus is a BRT (Bus Rapid transit). A BRT system was developed as a continuous system of separated road space, operated by a fleet of high-capacity buses. Initially, modern articulated buses were proposed, but if justified by demand increases, double-articulated buses can be introduced of the type that operate in South America. Such a system can be closed (only for specially assigned buses) or open (buses can enter and leave the BRT section). Since the closed system is similar to a rail system, it is a feasible option during a transition period and is therefore assumed here (this is also the system proposed by IETT).

Metrobus service should be expanded to cover all the expressways as long as the demand is there. It is inexpensive and quick to repay the investment. Construction period is short and, therefore, Metrobus can be introduced even to a route where railway construction is scheduled as mentioned above. Until railway project becomes ready for implementation, Metrobus can verify the magnitude of public transport demand, and above all Metrobus will ensure a linear space to accommodate a railway to be introduced there.

At this stage of the study, a concrete proposal for the expansion of Metrobus service cannot be submitted. After future road and rail network is evaluated in more detail, new Metrobus routes will be proposed in this study.

20.1.3 Preliminary Cost Estimate

Based on the feasibility study of the Avcilar – Topkapi Metrobus that is now existing, the unit cost of construction was calculated at YTL 5.3 million (EUR 3.0 million) per km. Using this unit cost, construction cost of the IETT plan was estimated as shown in Table 20.1.2.

Table 20.1.2 Estimated Construction Cost of IETT Planned Metrobus Routes

Route	Length (m)	Cost (YTL million)	Current Status
Beylikduzu - Avcilar	9,145	48	Approved
Avcilar - Cevizlibag	18,430	-	Existing
Cevizlibag - Mecidiyekoy	9,200	49	Under construction
Mecidiyekoy - Kozyatagi	15,000	80	Approved
Besiktas – 4.Levent	4,940	26	Approved
Aksaray – Milliyet	11,000	58	Approved
Vezneciler – Edirnekapi	3,325	18	Approved
Bostanci - Sogutlucesme	6,940	37	Approved

Source: Study Team

In addition, cost of bus fleet was estimated at YTL 529 thousand (EUR 300 thousand).

20.2 Reorganization of Bus Service

20.2.1 Strategy of Bus System Development

In the rail-oriented scenario, Istanbul will develop a mass transit system consisting mainly of a number of railway lines within the City. However, because the completion of a rail-

based system requires at least 6-8 years (and possibly more), bus will continue, for many years to come, to be the main provider of public transport. Even when a rail transport system is eventually fully developed, a large percentage of urban public transport trips will still be by bus operating on the surface of the road and street network of Istanbul. Development and maintenance of the bus system is therefore essential and cannot be avoided while waiting for the completion of the railway network.

Aside from the Metrobus, the regular bus system should be reorganized according to the following strategies:

1) Shift of operational focus from long-distance line-haul to rail station based

As railway lines develop, bus ridership is inevitably affected. Congestion on road will aggravate the performance of bus operators. Thus, the bus operators are forced to shift its operational focus to the place where a large passenger demand is foreseen, such as railway stations or intermodal transfer points. Good news for bus operators is that the performance of bus usage tends to improve due to short turn-around time inherent to feeder transport services.

2) Diversification of premium bus service

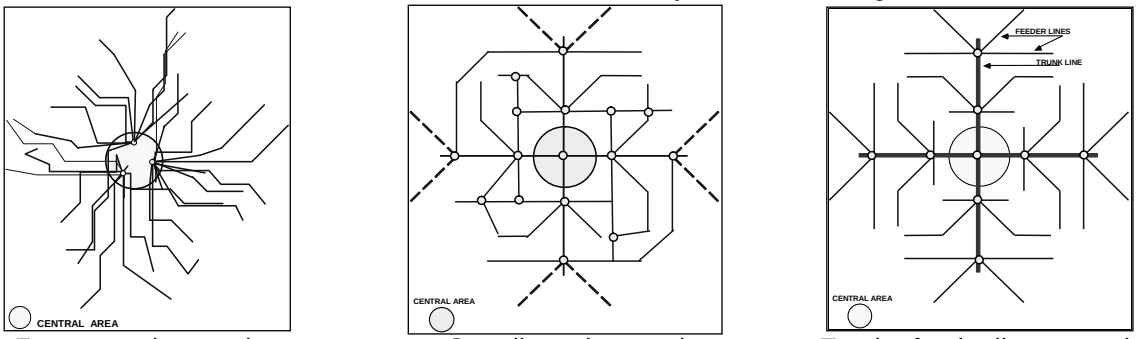
There are already some premium bus services available in Istanbul such as express and double-decker (no standee). However, many other premium services may be conceived depending on different local needs, such as midnight service for specific routes. Additional revenue from the premium service will improve the financial performance of bus operators.

20.2.2 Future Bus Route Network

Generic options for the network and service structure have been reviewed. An evolution is recommended from the present “coordinated” network (bus routes of the same hierarchy distributed in the system) into a trunk - feeder line network (see Figure 20.2.1).

Different organizational options will be taken into consideration. A development towards controlled competition with participation from the private and the public sector will be recommended.

The combination of options will be done with careful consideration of their compatibility with each other. For example, public investment in a high-capacity metro, light rail or Metrobus line can be justified in a coordinated trunk line-feeder line system since the service will then be available for all inhabitants, not only those few living close to the line.



Fragmented network | Coordinated network | Trunk - feeder line network

Source: *ibid.*

Figure 20.2.1 Different Types of Bus Network

Under the network system described above, bus transportation will be supplied in three forms:

(i) Metrobus network with special high-capacity buses,
(ii) Primary bus network with high-capacity/standard buses, and
(iii) Secondary feeder bus network with standard/small buses.

Primary bus network, part of which will be replaced by railway in the future, provides relatively high-speed line-haul service while secondary bus network gives accessibility for local people with a dense service network.

20.2.3 Bus Priority Infrastructure Network

An important feature in bus transportation is to secure mobility for the buses. A good commercial speed improves performance and attracts passengers.

A possible strategy to ensure mobility can be to reduce traffic generally but this usually requires restrictions of the ownership and use of private vehicles. A more realistic strategy is to provide priority for public transport in certain streets. This is done in European cities even though they have underground railway systems.

In Istanbul, a bus priority infrastructure network will be proposed. The purpose is to create a coherent system where mobility is secured. The ways of achieving bus priority will differ. The optimal solution is to provide a two-way busway in the center of the road, physically separated from other traffic. This is the same concept as Metrobus. This may be possible in some sections while elsewhere tailor-made solutions will have to be found, for example one-way mid road lanes or side lanes. In addition to physical separation, time separation can be applied with buses given priority in traffic lights.

Another possible approach to secure mobility for buses could be to link the primary bus network to a congestion charging scheme on the street level. Motorcycles and cars would pay a monthly fee for the privilege to use the designated part of the street network during peak hours.

A priority bus network can vary from a closed system with designated buses and preticketing facilities (true BRT) to an open or semi-open system possible to use for all buses (which does not mean that all buses must always be allowed). A closed system is most effective if full standard is available in the whole network. An open system, on the other hand, requires monitoring to prevent bus congestion. Generally speaking; the more uncertainties and/or missing links there are, the more there is a case for the less complex approach.

20.3 New Role of Sea Transport

20.3.1 Strategy of Sea Transport Development

The role of cross-Bosporus ferry has been historically important. Since the 1st and the 2nd Bosporus Bridge were constructed, however, most of the responsibility shouldered by the ferry seemed to have shifted to these bridges. Sea transport industry had a difficult time.

However, in the late 1990’s, the capacity of the cross-Bosporus bridges was reached by

ever increasing traffic demand, and the patronage of ferry started to increase to fill this demand/supply gap. Currently sea transport functions as an indispensable alternative for road transport.

The importance of ferry will not change in Istanbul in the future unless numerous bridges or tunnels are constructed across the Bosporus Strait. Since this “numerous bridges or tunnels” option is unrealistic, the sea transport system should be maintained and developed further.

IDO, the sea transport giant of Istanbul, is actively strengthening its fleet at present. This investment will certainly continue for at least a few years. IDO, however, has already identified the next market for its operation; ferry services around the Marmara Sea using modern Ro-Ro ships on inter-regional routes such as Ambarli – Mudanya. Anticipating the future implementation of cross-Bosporus bridges or tunnels, IDO intends to shift its focus to inter-regional ferry to a certain extent while maintaining and upgrading its fleet for the conventional sea transport services.

Under these circumstances, the strategies for sea transport development for the master plan are:

1) To increase transport capacity of the fleet

The implementation of the proposed cross-Bosporus infrastructure of bridges and tunnels will take at least 6-8 years. Thus the increasing cross-Bosporus traffic demand must be filled by ferry for the time being.

2) To modernize and upgrade the fleet

Although IDO is vigorously investing on new vessels, there still remain obsolete vessels. These should be gradually replaced by new vessels. Modern Ro-Ro ships may be introduced also for the short-distance operation particularly of cross-Bosporus routes.

3) To upgrade port/pier facility

Improvement of port/pier facility is required in terms of efficiency and convenience. If Ro-Ro ships are used, piers and connection roads should be upgraded to maximize the efficiency. Since ports are important transfer points, inter-modal connection must be well planned and equipped with necessary facilities including connection road, bus/dolmus/railway terminal, pedestrian path, waiting shed and service facilities.

20.4 Improvement of Inter-Modal Transfer Points

20.4.1 Strategy for Development of Inter-Modal Transfer Points

Inter-modal transfer is one of the key issues of urban transport because it is actually the factor that determines the levels of service of entire public transport system. At present, there are many terminals or inter-modal transfer points in Istanbul including bus terminals of IETT as shown in Figure 20.4.1. However, most of them are merely a space where passengers and public transport vehicles congregate without paying much attention to convenience and safety of passengers.

Source: IETT

Figure 20.4.1 Location of IETT Bus Terminals, 2007

Development of advanced inter-modal transfer points should consider:

- Structured space for various transport modes intersecting at or gathering to the point, paying attention not only to public transport but to private vehicles
- Space sufficient to accommodate waiting passengers
- Walking path to ensure shortest, comfortable and rectified passenger movement for transfer and boarding/alighting
- Service facilities for passengers' convenience and comfort

Extent of the levels of service depends on the magnitude of demand and area characteristics. In the CBD, large-scale commercial development could be coupled with inter-modal transfer points taking advantage of the passenger flow. In contrast, simple inter-modal facility may be suitable in suburban areas. Figure 20.4.2 is an example of well-planned small-scale facility.

Source: Study Team

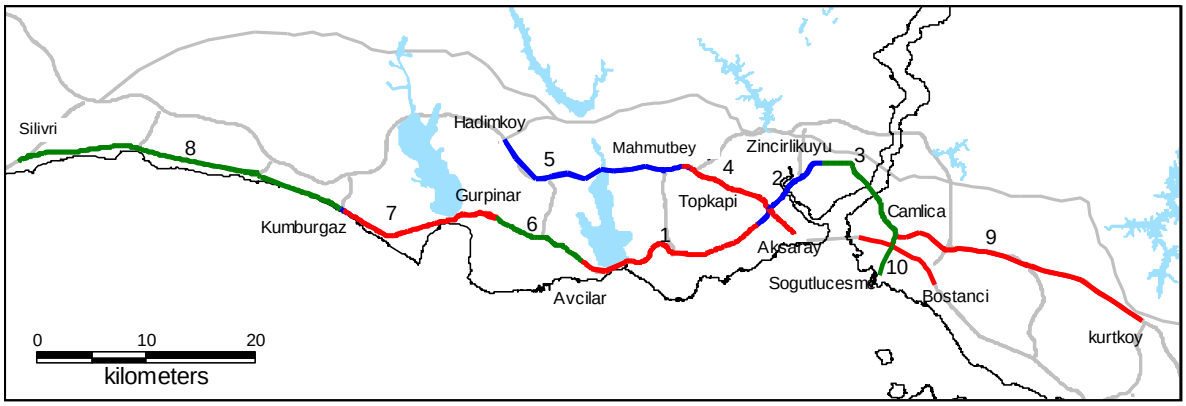
Figure 20.4.2 Example of Simple Inter-Modal Transfer Facility (Hannover, Germany)

20.5 Pre-Feasibility Study of Metrobus Project

20.5.1 Route

Extension of Metrobus system which is operated on the motorway of Trans European Motorway (TEM) and D100 (National Road), is subjective for pre-feasibility project. The Avcilar – Topkapi section (19.5 km) on D100 has been operated since September 2007 and the second section of Topkapi – Zincirlikuyu (10.5 km) was opened on September 2008 and the Zincirlikuyu – Sogutlucesme (9.5 km) section on D100 stretching to Asian side crossing the Bosporus Bridge has been under construction of the exclusive lanes and Metrobus Stops.

Proposed pre-feasibility projects consist of additional six sections of 117.8 km in total, are to be extended from the sections existing and under construction.



Source: IETT/Study Team

Figure 20.5.1 Existing and Planned Metrobus Routes

20.5.2 Demand

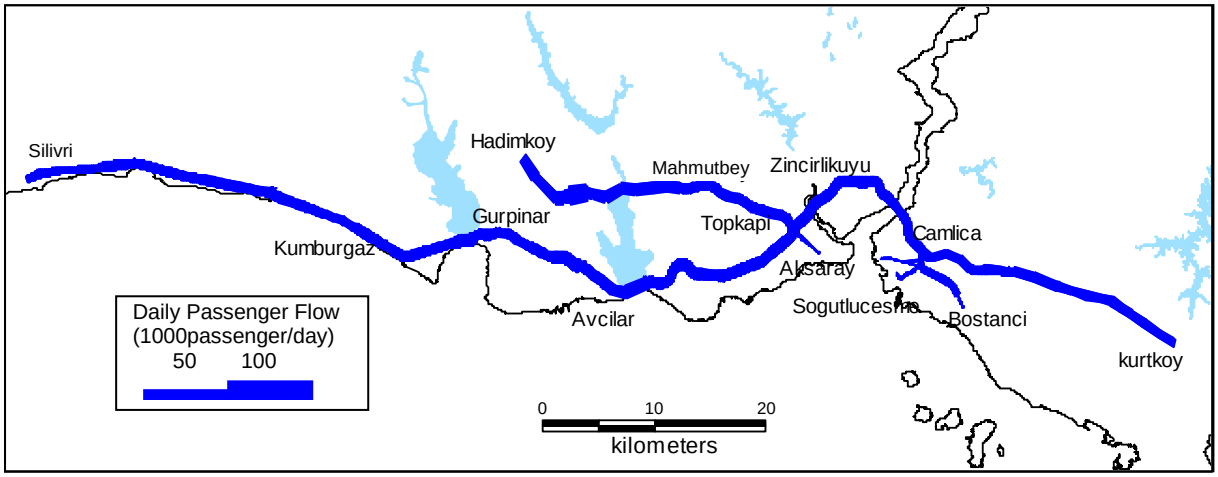
Population is assumed to grow following the past trend and consequently, it reached the planned population of 16 million in 2016. By this reason, demands for Metrobus are similar in 2013, 2018 and 2023.

Table 20.5.1 Cross-Sectional Daily Passenger Flow of Metrobus

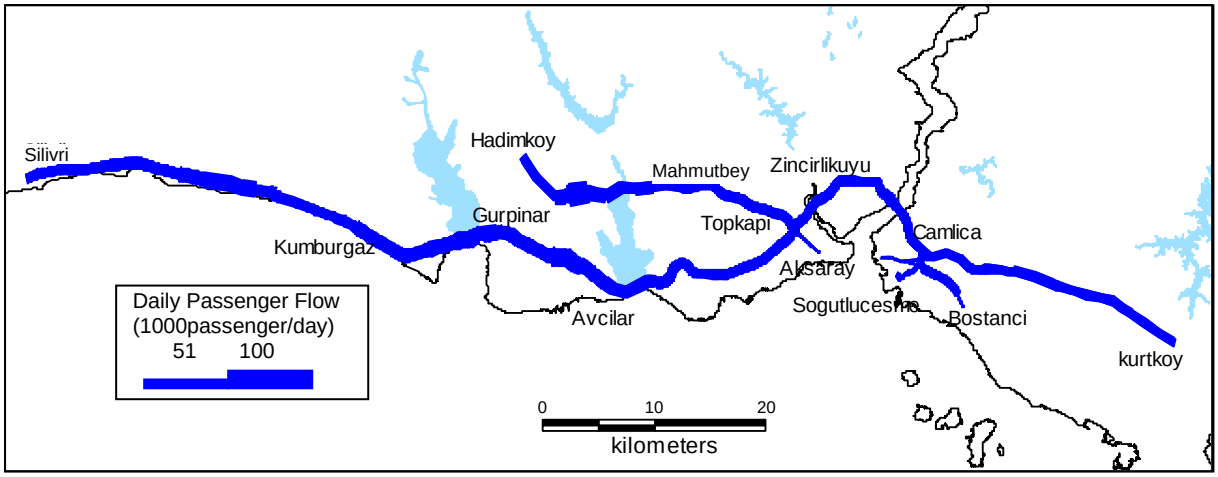
No.	Route	Average Passenger/day			Maximum Passenger/day		
		2013	2018	2023	2013	2018	2023
1	Avcilar - Topkapi	80,998	76,035	78,726	89,092	115,723	127,153
2	Topkapi - Zincirlikuyu	80,236	68,732	83,260	82,029	72,737	90,835
3	Zincirlikuyu - Sogutlucesme	64,984	67,085	71,549	77,307	88,413	90,572
4	Aksaray - Mahmutbey	51,982	51,254	56,606	74,521	71,896	87,907
5	Mahmutbey - Hadimkoy	75,159	85,229	101,763	131,146	159,509	190,912
6	Avcilar - Gurpinar	80,906	98,677	103,834	88,971	130,294	170,949
7	Gurpinar - Kumburgaz	84,378	96,302	86,972	115,631	128,916	121,478
8	Kumburgaz - Silivri	60,184	73,788	76,152	85,738	106,957	118,449
9	Camlica - Kurtkoy	66,310	68,491	67,016	70,528	73,051	72,443
10	Harem - Bostanci	54,778	56,579	55,361	73,616	76,250	75,615

Note: The data corresponds to Figure 20.5.2
Source: Study Team

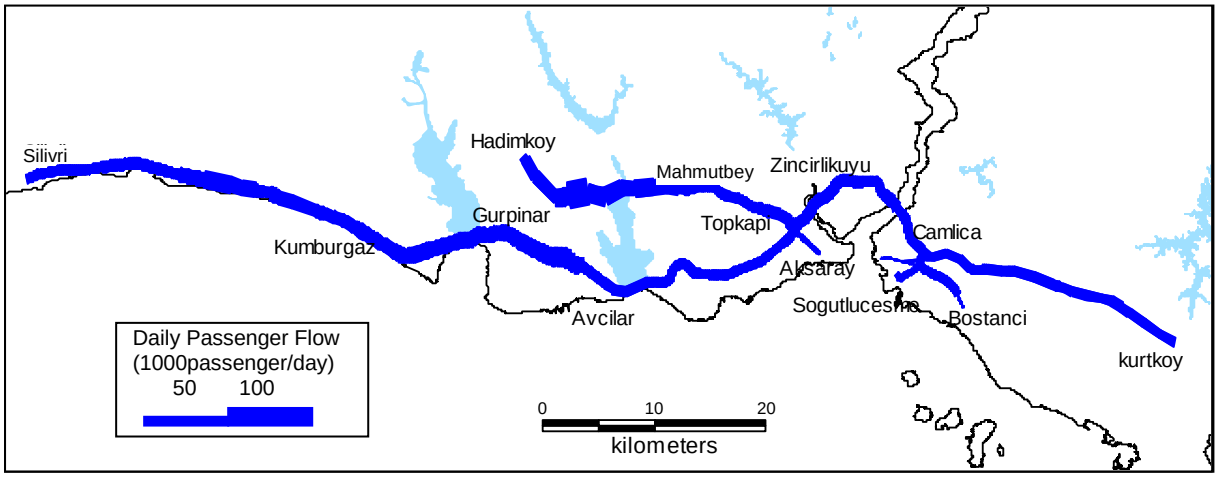
(1) 2013



(2) 2018



(3) 2023



Source: *ibid.*

Figure 20.5.2 Daily Passenger Flow by Metrobus Route

Table 20.5.2 Passenger-km by Metrobus Route

No.	Route			Passenger-km/day (1000)		
				2013	2018	2023
1	Avcilar	-	Topkapi	3,053	2,866	2,967
2	Topkapi	-	Zincirlikuyu	1,318	1,129	1,367
3	Zincirlikuyu	-	Sogutlucesme	2,107	2,175	2,320
4	Aksaray	-	Mahmutbey	1,384	1,365	1,508
5	Mahmutbey	-	Hadimkoy	2,789	3,163	3,776
6	Avcilar	-	Gurpinar	1,446	1,764	1,856
7	Gurpinar	-	Kumburgaz	2,620	2,990	2,700
8	Kumburgaz	-	Silivri	3,727	4,570	4,716
9	Camlica	-	Kurtkoy	3,329	3,439	3,365
10	Harem	-	Bostanci	3,392	3,503	3,428

Source: *ibid.*

Revenue will be calculated based on passengers using Metro bus Service shown in Table 20.5.3. Total passenger of the Table includes passengers going to and coming from the connected Metrobus Routes and they are double counted in both routes. Therefore, if a flat rate of fare system is assumed, those passengers should be excluded when calculating fare revenue.

Table 20.5.3 Daily Passengers (Patronage) by Route

(Passenger/day)

No.	2013			2018			2023		
	Total Passenger	From/to Connected Route	Net Passenger of Route	Total Passenger	From/to Connected Route	Net Passenger of Route	Total Passenger	From/to Connected Route	Net Passenger of Route
1	293,122	158,633	134,489	328,903	139,916	188,987	309,224	161,252	147,972
2	271,680	221,576	50,104	238,159	191,101	47,058	291,227	218,978	72,249
3	324,769	105,772	218,997	451,521	96,672	354,849	476,414	104,440	371,974
4	232,946	144,633	88,313	238,808	140,094	98,714	245,171	148,896	96,275
5	348,268	67,655	280,613	454,749	67,356	387,393	530,779	64,033	466,746
6	250,258	127,989	122,269	322,195	165,365	156,830	322,909	170,235	152,674
7	301,867	85,637	216,230	323,213	128,663	194,550	295,271	124,001	171,270
8	285,598	41,066	244,532	364,248	46,097	318,151	370,470	48,726	321,744
9	245,475	36,389	209,086	253,157	35,426	217,731	247,071	36,617	210,454
10	209,452	36,157	209,444	216,007	35,201	218,103	210,814	36,384	210,814
Total	2,553,983	989,350	1,564,633	2,974,953	1,010,690	1,964,263	3,088,536	1,077,178	2,011,358

Source: *ibid.*

20.5.3 Project Cost

The first phase of Avcilar – Topcapi section of 19.5km is estimated to cost approximately US$150 million. The second phase of Topkapi – Zincirlikuyu of 10.5km section opened in early September 2008. Reportedly, it costed about US$ 100 million. The third section of Zincirlikuyu – Sogfllucesme of 11km is estimated at US$ 80 million. In average, the infrastructure for Metrobus costs about US$ 8.0 million per km. Thus, infrastructure costs of new lines are estimated as shown in Table 20.5.4.

Table 20.5.4 Construction Cost of Metrobus Way

(US$ million)

	Route			Distance (km)	Infrastructure Cost	Fleet	
						Fleet Size	Cost
1	Avcilar	-	Topkapi	19.5	150.0	97	41.1
2	Topkapi	-	Zincirlikuyu	10.5	100.0	52	22.0
3	Zincirlikuyu	-	Sogutlucesme	9.5	80.0	47	19.9
4	Aksaray	-	Mahmutbey	21.9	175.2	109	46.2
5	Mahmutbey	-	Hadimkoy	17.1	136.8	85	36.0
6	Avcilar	-	Gurpinar	10.7	85.6	53	22.5
7	Gurpinar	-	Kumburgaz	17.6	140.8	88	37.3
8	Kumburgaz	-	Silivri	27.8	222.4	139	58.9
9	Camlica	-	Kurtkoy	22.7	181.6	113	47.9
10	Harem	-	Bostanci	8.6	68.8	783	331.8
	Total			165.9	1341.2	1566	663.6

Source: *ibid.*

It is an articulated bus for fleet of Metrobus, the model is Mercedes-Benz Capacity, with 193 passenger capacity, low floor and no step at the entrance and exit, and its engine compliances with Euro 4 and Euro 5 Emission Standard as well as current European Standard. Fleet cost is assumed at EUR 300,000 (US$ 424,000) per unit, of which fuel consumption rate is about 2.0 km per liter of diesel oil.

20.5.4 Financial Evaluation

1) Fare Revenue

Although the current normal fare of Metrobus is YTL 1.4 per ride, average revenue is about YTL1.0 per passenger due to discounted fares for children, students, transfer passengers and others. Therefore, if a flat fare at YTL 1.4 is taken for the entire Metrobus network, total daily income will be the same figures as total net passengers in Table 20.5.5. Distributing the revenue among project sections in proportion to passenger-km transported in each section, annual revenue will be as follows.

Table 20.5.5 Annual Revenue of Metrobus

No.	Route			Annual Revenue (US$ Million)		
				2013	2018	2023
1	Avcilar	-	Topkapi	78.6	84.7	85.9
2	Topkapi	-	Zincirlikuyu	33.9	33.3	39.6
3	Zincirlikuyu	-	Sogutlucesme	54.2	64.3	67.2
4	Aksaray	-	Mahmutbey	35.6	40.3	43.7
5	Mahmutbey	-	Hadimkoy	71.8	93.4	109.4
6	Avcilar	-	Gurpinar	37.2	52.1	53.7
7	Gurpinar	-	Kumburgaz	67.4	88.3	78.2
8	Kumburgaz	-	Silivri	95.9	135.0	136.6
9	Camlica	-	Kurtkoy	85.7	101.6	97.5
10	Harem	-	Bostangi	87.3	103.5	99.3
11	Total			647.5	796.6	811.1

Source: *ibid.*

2) Evaluation Result

All the projects except No. 4 (Aksaray – Mahmutbey) are judged financially feasible with financial internal rate of return (F-IRR) higher than 12%. Entire projects from No.5 to No.9 are also feasible with Financial IRR at 13.0%.

Table 20.5.6 Financial Evaluation of Metrobus Project

No.	Route	Evaluation Indicator	
		F-IRR (%)	NPV(US$ Million)
1	Avcilar - Topkapi	-	-
2	Topkapi - Zincirlikuyu	-	-
3	Zincirlikuyu - Sogutlucesme	-	-
4	Aksaray - Mahmutbey	1.2	-98.8
5	Mahmutbey - Hadimkoy	17.4	52.1
6	Avcilar - Gurpinar	14.2	12.9
7	Gurpinar - Kumburgaz	14.4	21.5
8	Kumburgaz - Silivri	14.0	30.2
9	Camlica - Kurtkoy	13.3	14.7
10	Harem - Bostanci	37.3	137.6
11	Total	12.5	32.6

Source: *ibid.*

20.5.5 Economic Evaluation

1) Methodology

Economic cost was assumed to be 85% of the financial cost if all kinds of taxes included in the financial cost were deducted. Savings in operating cost of vehicles, wail cars and vessels and in travel time cost attributable to a project were estimated, regarding them as economic cost of the project. See Chapter 16 in detail.

2) Results

Economic IRRs of all the projects are extremely high because initial project costs are rather low comparing to a railway project, while the numbers of passengers are as large as a railway project.

Table 20.5.7 Economic Evaluation of Metrobus Project

Project	Savings in VOC and TTC		Savings in VOC only	
	E-IRR (%)	NPV (US$ million)	E-IRR (%)	NPV (US$ million)
4 and 5	101.2	5,898.1	85.5	4,009.3
6, 7and 8	172.3	8,601.1	140.5	6,043.2
9	46.0	3,339.1	40.3	1,987.2
10	44.6	234.5	31.0	116.0
Total 4-10	125.0	11,990.5	100.8	8,412.2

Source: *ibid.*

20.5.6 Environmental Evaluation

1) Legal Requirement

In accordance with EIA Regulation No.25318, 2003, the project is not subjective to any EIA procedure so that a social and environmental consideration in line with JICA Guideline for Environmental and Social Consideration was made for the pre-feasibility project.

2) Sensitive Aspects

(1) Project Site

Project sites are located on existing motorways such as Trans European Motorway (TEM) and D100 (National Road). These median spaces will be utilized for lane of Metrobus System as well as existing Metrobus systems. It is therefore the project spaces are within current Rights of Way and there is neither land expropriation nor resettlement for this project.

Table 20.5.8 Project Site of Pre-Feasibility Project

No.	Route	L (km)	Site
1	Avcilar - Topkapi	19.5	D100 (E5)
2	Topkapi - Zincirlikuyu	10.5	D100 (E5)
3	Zincirlikuyu - Sogutlucesme	9.5	D100 (E5)
4	Aksaray - Mahmutbey	21.9	D100
5	Mahmutbey - Hadimkoy	17.1	TEM
6	Avcilar - Gurpinar	10.7	D100 (E5)
7	Gurpinar - Kumburgaz	17.6	D100 (E5)
8	Kumburgaz - Silivri	27.8	D100 (E5)
9	Camlica - Kurtkoy	22.7	TEM
	Total	157.3	
	Route4-9	117.8	

Source: *ibid.*

(2) Traffic Flow at Entrance of the Bosporus Bridge

Route No.3 which is on-going project passes through the Bosporus Bridge from Zincirlikuyu to Sogutlucesme intends to use normal traffic lane with other traffic for Metrobus system on the bridge section, while other routes run through guided lane exclusively for MetoBus.

(3) Bus Stop Areas

It is limited area in each bus stop due to the location that Metrobus runs through median of the road.

3) Recommendations for Further Activities

As the results, introducing extension of Metrobus system has no serious negative impact for both natural and social environment in pre-construction, construction and operation stages respectively, while some minor considerations such as safety measure at bus stops, accessibility to bus stop and traffic measures at the Bosporus Bridge were identified. It should be paid attention for more examination on project implementation stage.

(1) Safety Measures for Passenger at Bus Stops

Safety measures for other traffic flow during construction stage and another safety

measures for bus stop areas during operation stage shall be considered. Especially for bus stop areas, it is limited space with many passengers getting on and off Metrobus in short time.

(2) Accessibility to Metrobus Stops

It is expected 130,000 demands daily at busiest route. Not only bus stop but also transfer and access facilitates with enough capacity are required for safe and convenient accessibility to Metrobus. In addition, paying system by Akbil or equivalent is recommended for smooth operation. Currently bus driver has to take care of payment in cash and it will be loss for efficient operation.

(3) Traffic Flow at the Bosporus Bridge

Exclusive bus lane will be ceased at the Bosporus Bridge (Route No.3) and normal lane will be used for Metrobus system with other traffic, so it shall be paid attention to traffic safety measures at both of merging and branching points. For example, the following measures are worthwhile to plan.

a) To designate one lane for metrobuses, even not for exclusive use and metrobuses should keep the lane.

b) To prohibit cars, trucks and ordinary buses to enter the designated lane for metrobuses during off-peak time.

c) To allow cars, trucks and ordinary buses to merge to or branch from the designated lane for metrobuses only at specified section during peak time.