FOLLOW-UP STUDY ON ROAD SAFETY AND ACCESSIBILITY OF İSTANBUL METROBÜS

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Working Paper

EMBARQ Türkiye

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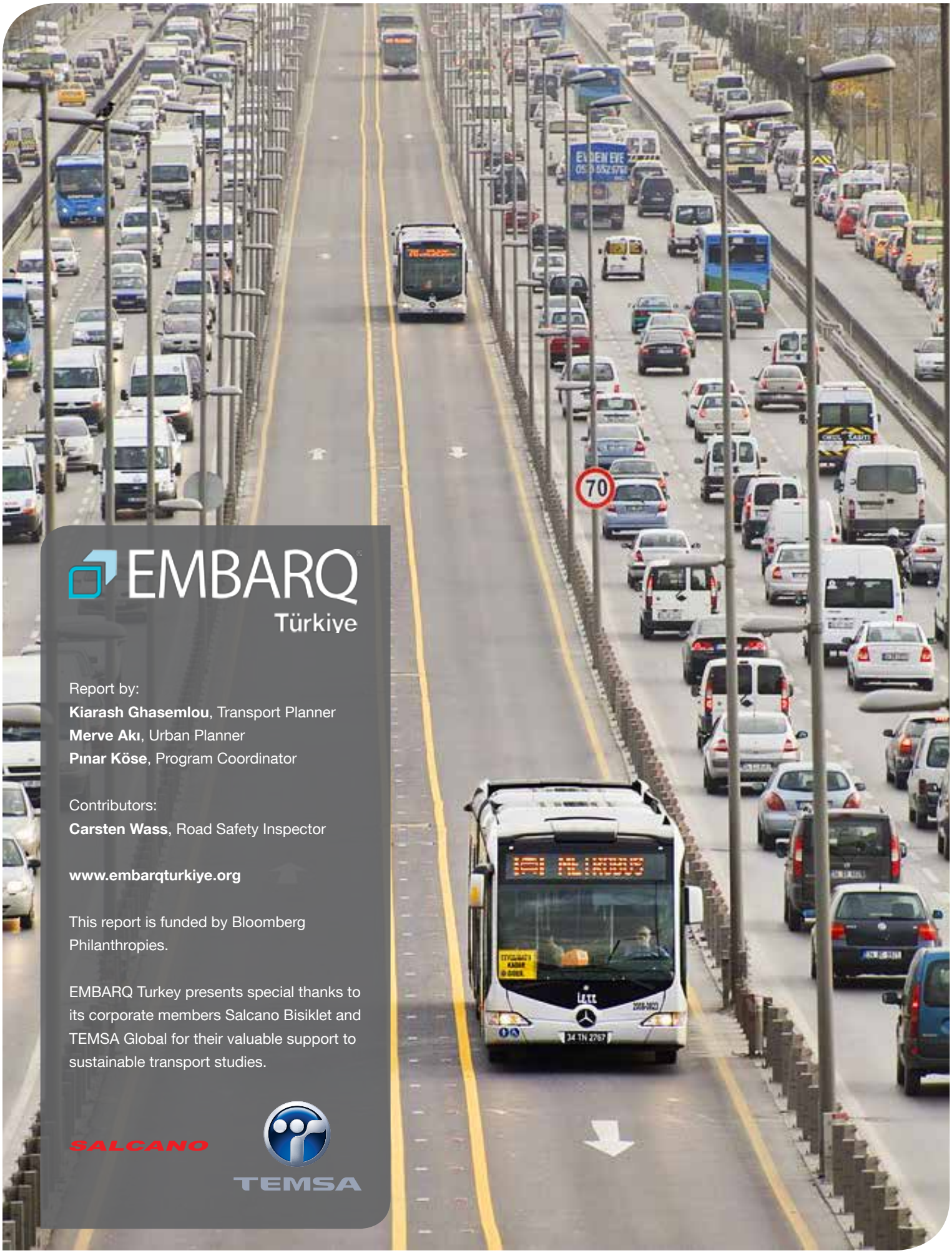

EMBARQ Türkiye

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1. INTRODUCTION

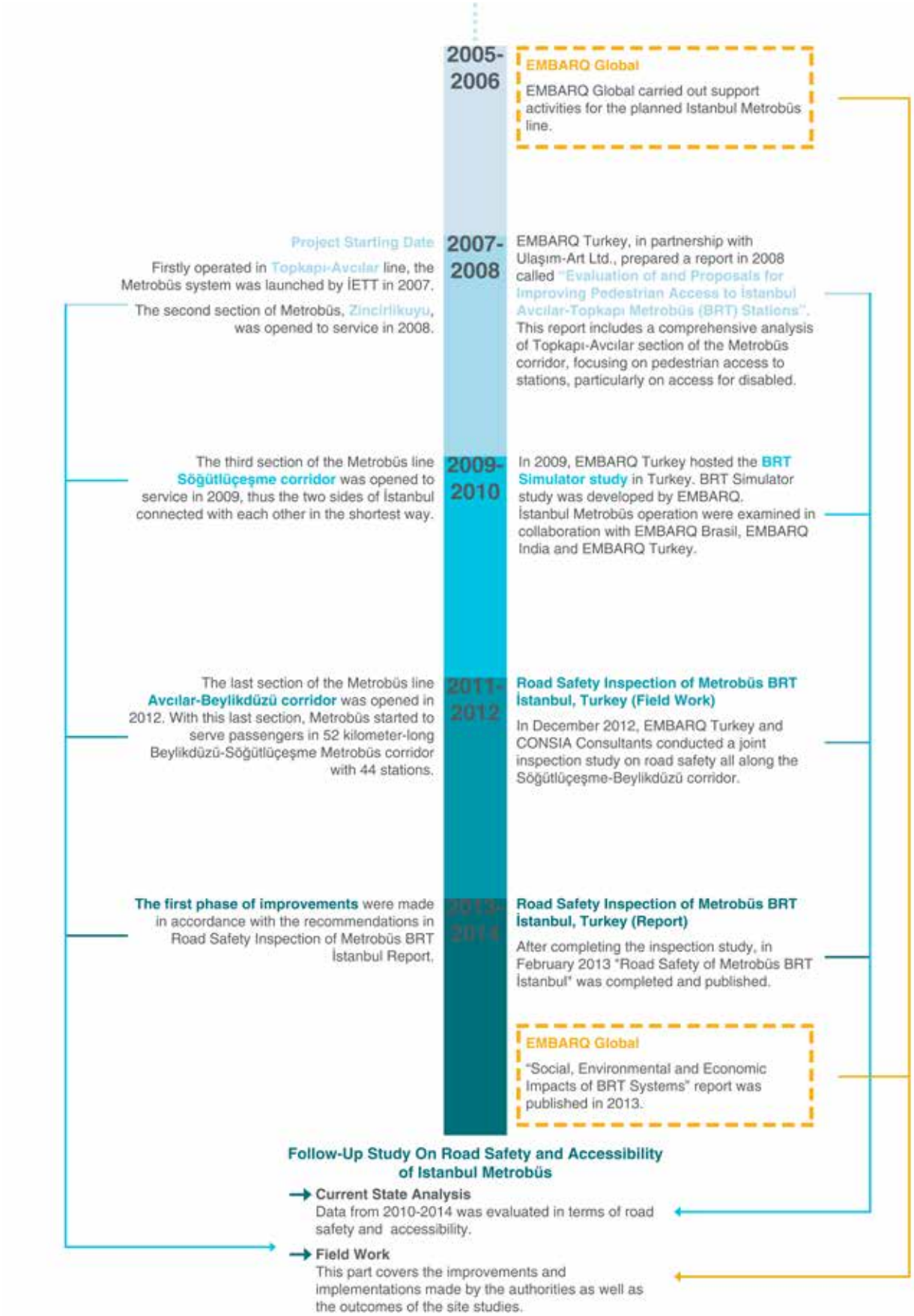
"Metrobüs" (the BRT[1] system of İstanbul), the first phase of which was commissioned in 2007 by IETT (İstanbul Electricity, Tramway and Tunnel) with an aim to reduce the traffic volume on the main arterial roads and offer passengers a rapid and comfortable journey, has evolved to a 52-km corridor with 44 stations[2]. It makes approximately 800,000 trips per day. Considering this high ridership of Metrobüs, road safety approaches and practices become very important. İstanbul Metrobüs corridor was initiated in 2007 when the first section opened (Topkapı-Avcılar corridor – 18,3 km). The second (Zincirlikuyu corridor) and the third sections (Söğütlüçeşme corridor) were commissioned in 2008 and 2009, respectively. The last section (Avcılar-Beylikdüzü corridor) was opened in 2012. Figure 1 shows the Timeline and Figure 2 and 3 show Metrobüs corridor and the lines.

EMBARQ Turkey, in partnership with Ulaşım-Art Ltd., prepared a report in 2008 called "Evaluation of and Proposals for Improving Pedestrian Access to İstanbul Avcılar-Topkapı Metrobüs (BRT) Stations". This report includes a comprehensive analysis of Topkapı-Avcılar section of the Metrobüs corridor (almost 18 km), focusing on pedestrian access to stations, particularly on access for disabled.

In December 2012, EMBARQ Turkey and CONSIA conducted a joint inspection study on road safety all along the Söğütlüçeşme-Beylikdüzü corridor (52-km). The road safety inspection revealed critical points (e.g. safety, capacity and operation) along the Metrobüs corridor and presented proposals to address them. Moreover, it focused on the design and accessibility of the stations on the Metrobüs corridor.

[1] BRT-Bus Rapid System.
[2] IETT has announced that Vatan Caddesi station is no longer available for service.

Figure 1 Timeline - History of studies on İstanbul Metrobüs



On the other hand, walking is the most elementary form of transportation for every community in the world. Almost all trips start and end with a walk. Some are walk-only trips while some are walk-linked trips[4]. Unfortunately, pedestrians have high risk of death and injury when they are involved in a collision. Pedestrians are susceptible to road collisions, not only due to the growing number and frequency of use of motor vehicles, but also due to poor road designs and urban plans that ignore the needs of pedestrians. Where traffic laws are insufficient, pedestrians safety problems are gradually increasing[5]. Safe system approach is solution for this issue and aiming to reduce deaths and serious injuries. The strategy becomes the responsibility of everyone, not just roads users. Safer infrastructure, speeds, vehicles and behaviors all play a vital part. This approach allows us to focus our efforts where the greatest gains can be made, creating a safe

Figure 2 İstanbul Metrobüs Corridor and Stations[3]

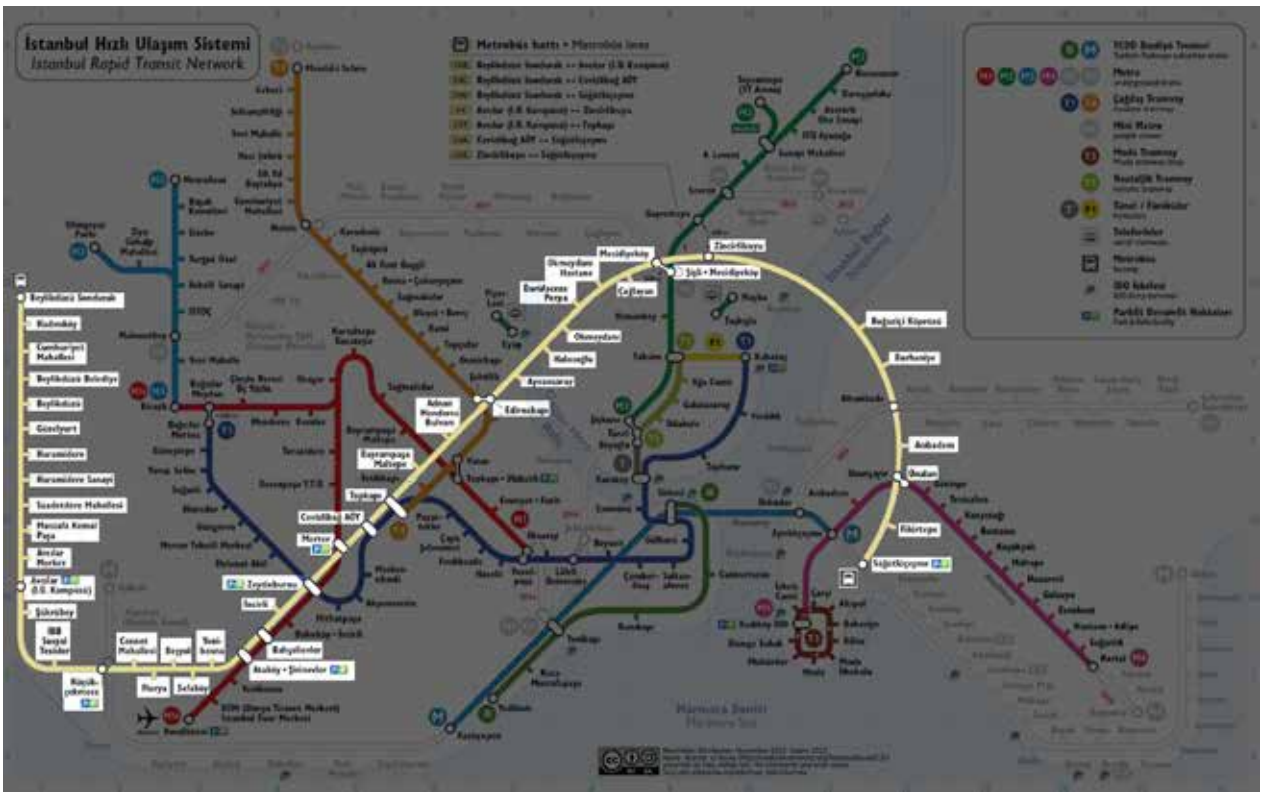


Figure 3 İstanbul Metrobüs Corridor and the Lines

[3] EMBARQ Türkiye (2013) "Road Safety Inspection of Metrobüs BRT", İstanbul
[4] Basset Jr DR, et al. Walking, cycling, and obesity rates in Europe, North America, and Australia. Journal of Physical Activity and Health, 2008, 5: 795–814.
[5] Rabl A, de Nazelle A. Benefits of shift from car to active transport. Transport Policy, 2012, 19: 121–131.

Follow-Up Study on Road Safety and Accessibility of İstanbul Metrobüs - Main Purpose:

The Follow-up Study Report on the Road Safety and Accessibility of Metrobüs BRT/İstanbul includes a post-2014 investigation and assessment of the improvements made by İstanbul Metropolitan Municipality (IMM) and IETT after the "Road Safety Inspection of Metrobüs BRT" that was conducted in December 2012. Within this scope, a checklist was created based on the items that were defined and reported as a result of this road safety inspection. This checklist was then used to assess the changes made both throughout the existing Metrobüs corridor and on its stations. Moreover, interviews were conducted with the officials to get the latest information on updates that have been made on the Metrobüs corridor since the Road Safety Inspection. As part of the "Road Safety Inspection of Metrobüs BRT" report, the 2010-2011 accident history of İstanbul Metrobüs corridor was assessed. The assessment revealed three main causes for these accidents. In this context, the main safety issues include:

"busses colliding with pedestrians when they are crossing a street",
"collisions involving vehicles plowing into Metrobüs platforms and corridor", and
"buses colliding with people waiting on the Metrobüs platform".

The detailed investigation of the findings has revealed that it is essential to ensure pedestrian safety in Metrobüs operations.

road system increasingly free of death and serious injury[6]. The ethics that lies behind the safe system approach is that transport-related traumas are not acceptable. People can be guided to behave safely in the traffic environment. Despite that, mistakes still occur in the system, leading to accidents. Although these mistakes cause traffic accidents, they should not necessarily end up with deaths or severe injuries[7]. Therefore, both the "Road Safety Inspection of Metrobüs BRT" report and this report, which is a follow-up to the former, focus on pedestrian safety and highlight the importance of making the Metrobüs corridor safer for pedestrians. This report includes a current situation analysis and provides assessment and proposals. The current situation analysis examines road accidents and passenger demand from 2010 to 2014 at macro level with focus on road safety and accessibility. The report also presents some recent specific investments in the improvement of Metrobüs corridor from the perspective of two key performance indicators: "saving life" and "accessibility". This section also covers the improvements and implementations made by the authorities as well as the outcomes of the site studies. The Evaluation and Proposals section presents new proposals that came out from the follow-up study to the 2013 road safety inspection report.

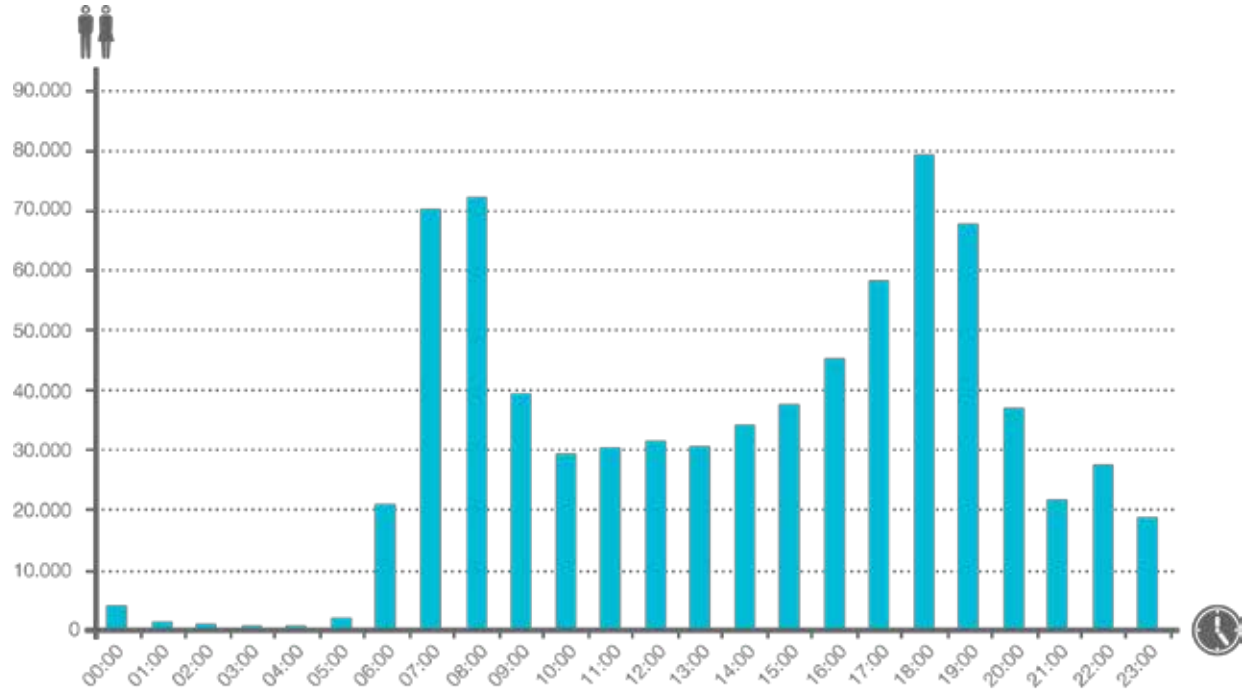
[6] World Health Organization. (2006) "Helmets: a road safety manual for decision-makers and practitioners."
[7] http://www.saferjourneys.govt.nz/assets/Uploads/Well-save-more-lives-if...-leaflet.pdf

2.CURRENT SITUATION ANALYSIS

In this section of the Report, available data and the site study findings were analyzed from such perspectives as: Operations, Infrastructure Construction and Maintenance, Access to Stations, Pedestrian Flow to Stations, and Education/Awareness-Raising.

Figure 5 and Figure 4 represent the monthly ridership of Metrobüs and the daily ridership by hour, respectively.

Figure 4 Metrobüs daily ridership by hour [8]



[8] M. Kahveci (2012), "İstanbul Ulaşımında Metrobüs Uygulaması", Transist 2012, İstanbul.

Figure 5 shows that the passenger demand of Metrobüs is growing over time. Ridership increases for two main reasons: growing population in İstanbul and the expansion of the Metrobüs corridor with an additional 10-km section (Avcılar-Beylikdüzü) that was commissioned on 20th of July 2012. It must be noted, however, that the ridership, which previously originated from Avcılar station (the former terminal station of Metrobüs), is now shared by the new stations that were added to the Metrobüs corridor in July 2012.

In parallel to the growing ridership, the number of busses and the distance travelled along the corridor also increased. Mobility escalated because of the increased ridership, number of buses, and the length of the corridor. This leads to an increase in the possibility of traffic accidents. Figure 6 represents the number of monthly traffic accidents involving fatalities and injuries that occurred between 2010 and 2014.

Figure 5 Metrobüs Ridership by Month (2011-2014)

Figure 7 shows the cumulative number of these accidents station based in corridor. The red and blue lines represent the cumulative number of fatal and personal injury accidents that occurred before 2012 and after 2012, respectively. The longer the Metrobüs corridor is, the more likely that a traffic accident will occur. There are two main reasons for this: (i) increased ridership and (ii) increased number of kilometer travelled by Metrobüs buses. Compared to the red line, the blue line has higher inclination. The ellipse represent the accidents, which occurred after the improvements made by IETT on the basis of the road safety inspection report.

As part of this project, the investments that IMM and IETT have undertaken are examined in line with the 2013 Metrobüs road safety inspection report. Also, key performance indicators (KPIs) are evaluated. Evaluating the KPIs in Metrobüs road safety will not only help the manager to measure the success of its investments but also serve as a reference for future improvement projects.

Figure 6 Number of Accidents by Month (Fatal and Personal Injury Accidents)

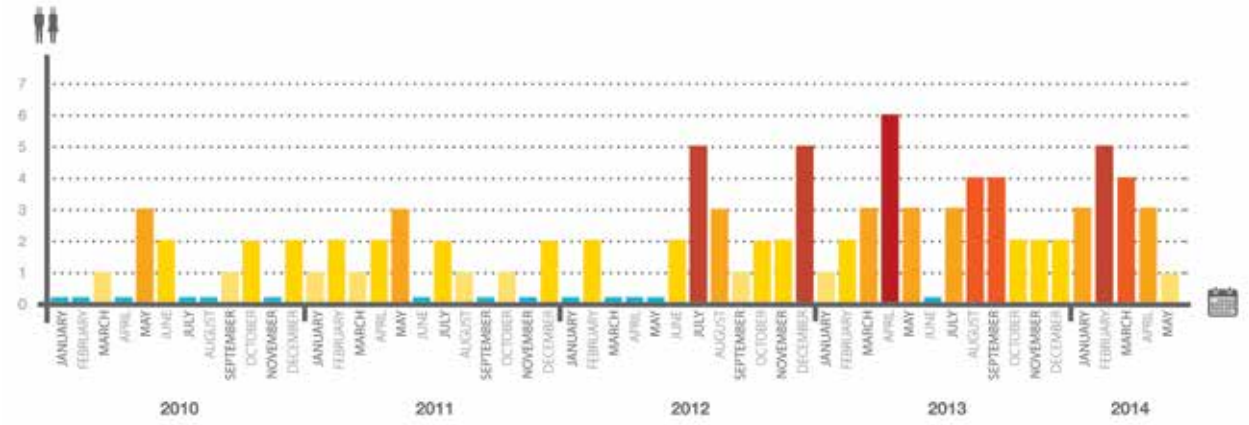
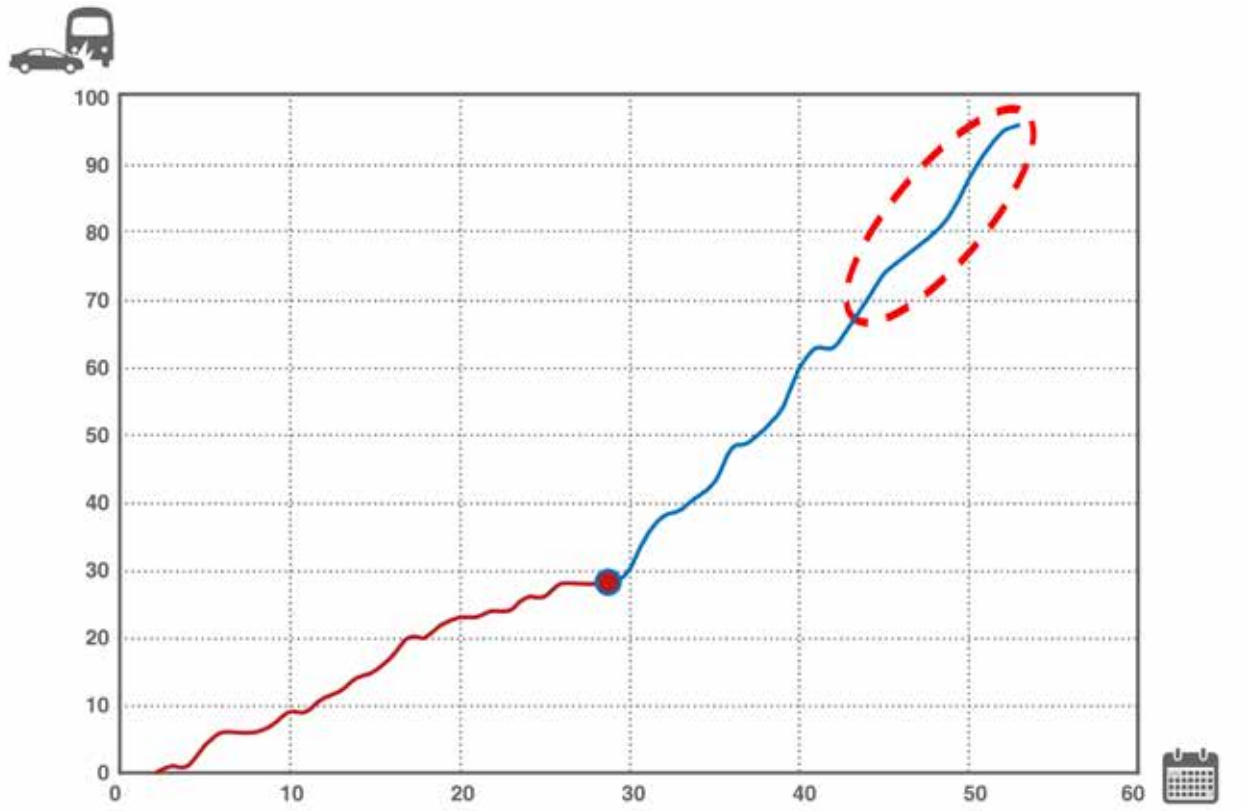


Figure 7 Cumulative number of accidents (2010-2014)



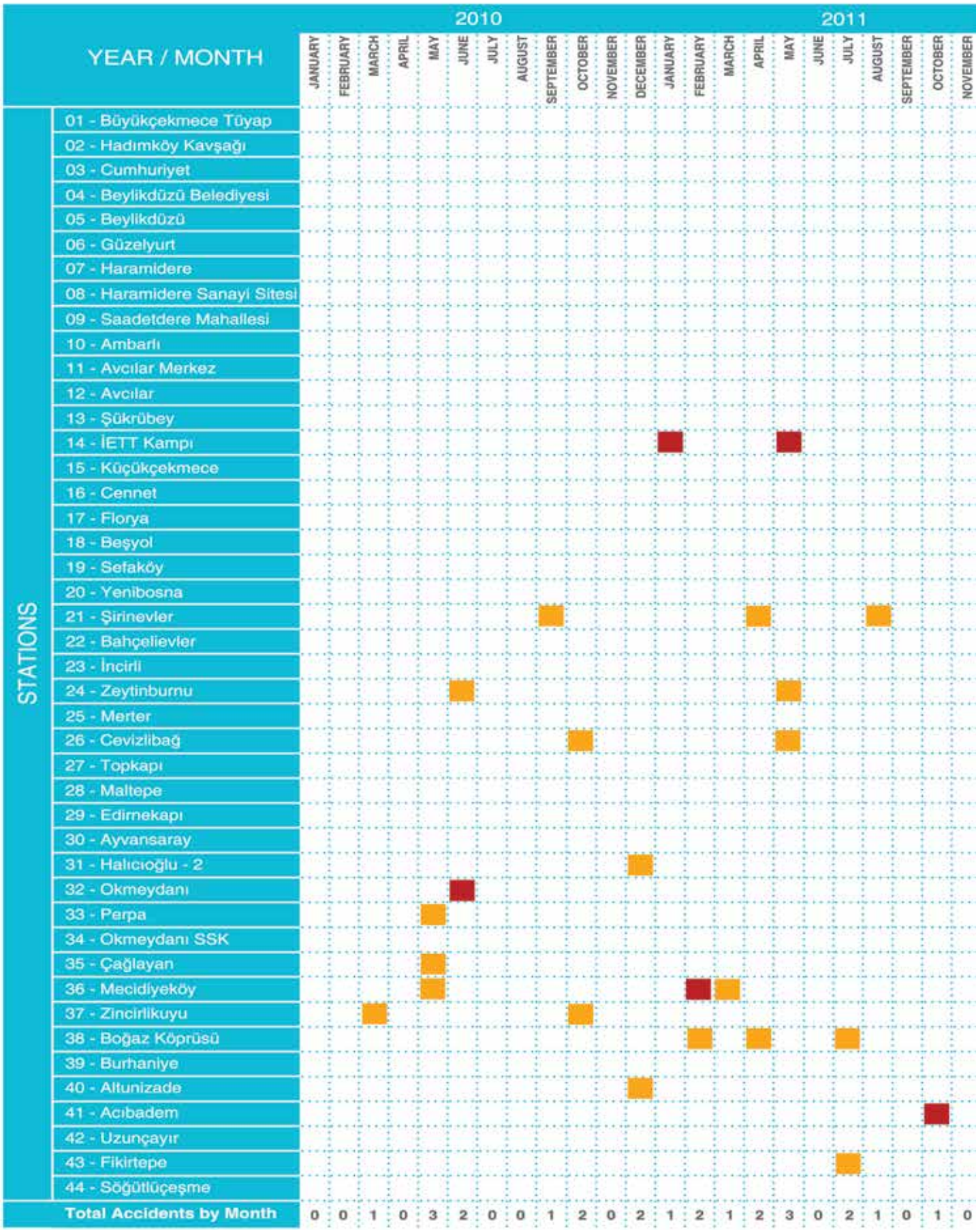
There are two approaches to evaluate the KPIs. The first approach is called "Before and After". The second approach involves "business as usual" and "Scenario" scenarios. Analysis of the relationship of the number of accidents involving death and personal injury (Table 1) to the increase in the number of station-based passenger trips and buses shows the inevitable importance of the investments in Metrobüs systems. Comparing the number of station-based personal injury accidents before and after improvement, increased from 29 to 32 in the two one-year periods. On the other hand, the number of fatal accidents decreased from 6 to 1 in the same periods.

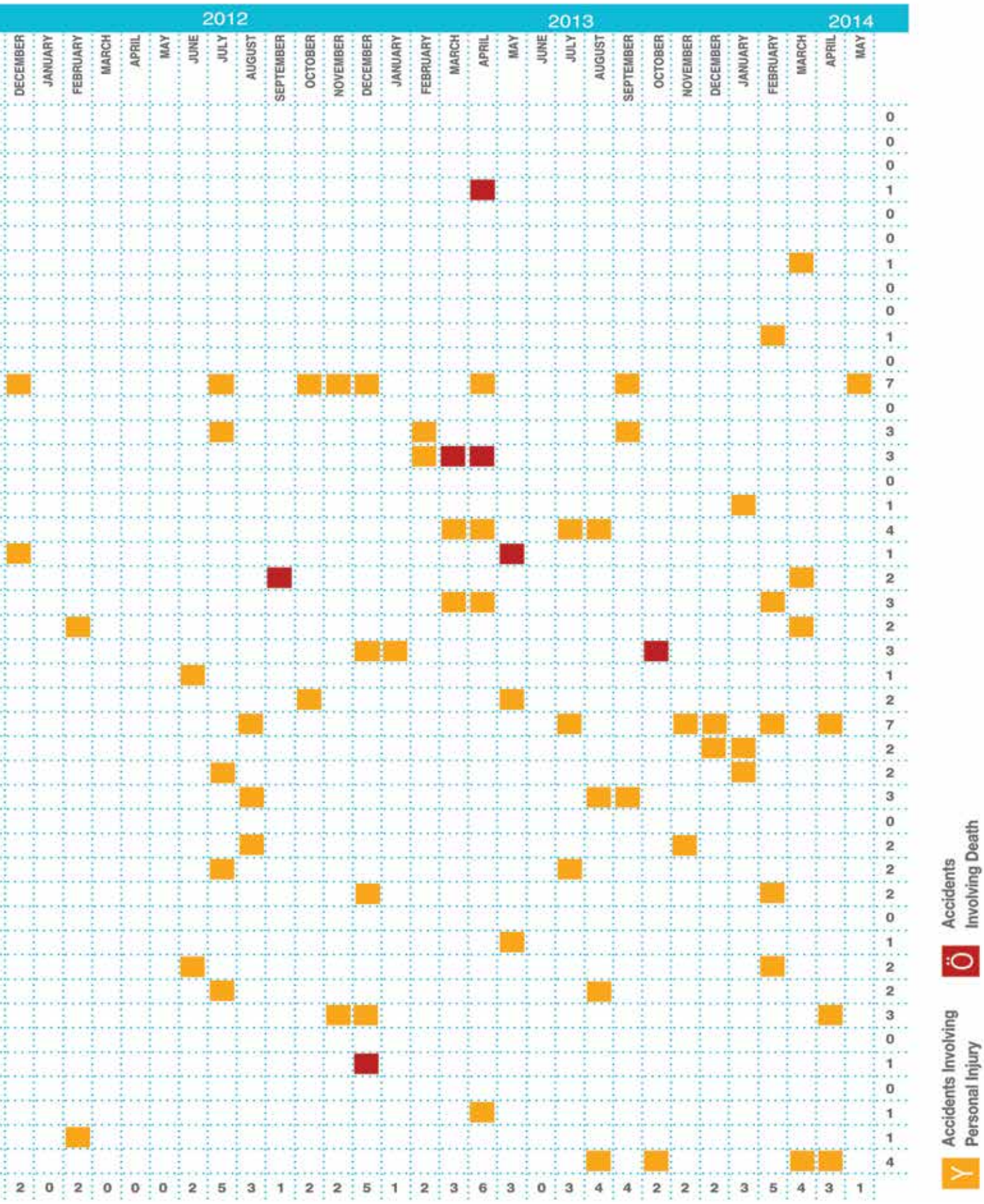
From the perspective of "business as usual" and "Scenario", pre-improvement accident trend and the regression analysis were used to estimate the number of accidents that might occur in the post-improvement environment. Real facts and figures were used for comparison. Accident data was analyzed by station and by month. Table 2 shows the number of accidents by station and by month. The change in the number of accidents involving death and personal injury is used in Table 2 to compare the periods before and after improvement. Based on this, we estimated the number of accidents involving death and personal injury that might occur in the post-improvement period. According to our estimation, 5 fatal accidents would have been avoided. In other words, at least 5 deaths would have been prevented before they occurred.

Table 1 Number of Fatal and Personal Injury Accidents between June 2012-2013 and June 2013-2014

	June 2012 - May 2013 (Before)	June 2013 - May 2014 (After)	Difference in number of accidents
Accidents involving personal injury	29	32	+3
Accidents involving death	6	1	−5

Table 2 Accidents Involving Death and Personal Injury by Station and by Month (2010-2014)




2012
2013
2014
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
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MAY
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MARCH
APRIL
MAY
2 0 2 0 0 0 2 5 3 1 2 2 5 1 2 3 6 3 0 3 4 4 2 2 2 3 5 4 3 1
Accidents Involving Death
Accidents Involving Personal Injury

Table 3 lists the annual number of accidents by station before and after improvement.

According to Table 3, the number of accidents involving personal injury increased significantly on Cevizlibağ and Söğütlüçeşme stations when compared to the pre-improvement period. On the other hand, the number of fatal accidents decreased in the majority of the stations.

Table 3 Comparison of Accidents by Station Involving Death and Personal Injury Before and After Improvement

Date	Type of Accident	01 - Büyükçekmece Tüyap	02 - Hadımköy Kavşağı	03 - Cumhuriyet	04 - Beylikdüzü Belediyesi	05 - Beylikdüzü	06 - Güzelyurt	07 - Haramidere	08 - Haramidere Sanayi Sitesi	09 - Saadetdere Mahallesi	10 - Ambarlı	11 - Avcılar Merkez	12 - Avcılar	13 - Şükrübey	14 - İETT Kampı	15 - Küçükçekmece	16 - Cennet	17 - Florya	18 - Beşyol	19 - Sefaköy	20 - Yenibosna	21 - Şirinevler	22 - Bahçelievler
2012/06 - 2013/06	Y	0	0	0	0	0	0	0	0	0	0	0	5	0	2	1	0	0	2	0	0	2	0
	Ö	0	0	0	1	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	1	0	0
2013/06 - 2014/06	Y	0	0	0	0	0	0	1	0	0	1	0	2	0	1	0	0	1	2	0	1	1	1
	Ö	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
INJURY		0	0	0	0	0	0	-1	0	0	-1	0	3	0	1	1	0	-1	0	0	-1	1	-1
DEATH		0	0	0	1	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	1	0	0

Date	Type of Accident	23 - İncirli	24 - Zeytinburnu	25 - Merter	26 - Cevizlibağ	27 - Topkapı	28 - Maltepe	29 - Edirnekapı	30 - Ayvansaray	31 - Halıcıoğlu - 2	32 - Okmeydanı	33 - Perpa	34 - Okmeydanı SSK	35 - Çağlayan	36 - Mecidiyeköy	37 - Zincirlikuyu	38 - Boğaz Köprüsü	39 - Burhaniye	40 - Altunizade	41 - Acıbadem	42 - Uzunçayır	43 - Fikirtepe	44 - Söğütlüçeşme	Total Accidents
2012/06 - 2013/06	Y	2	1	2	1	0	1	1	0	1	1	1	0	1	1	1	2	0	0	0	1	0	0	29
	Ö	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	6
2013/06 - 2014/06	Y	0	0	0	6	2	1	2	0	1	1	1	0	0	1	1	1	0	0	0	0	0	4	32
	Ö	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
INJURY		2	1	2	-5	-2	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-4	-3
DEATH		-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	5

Y INJURY ACCIDENTS

Ö FATALITY ACCIDENTS

We made a similar analysis also on the change in ridership as a result of the improvements on accessibility, safe transfer zones, and inter-modal integration. In Figure 8, the blue line shows the ridership before the improvement when no safe transfer zones were available. The red line shows the monthly ridership after the improvements. The black line represents the trend of average ridership per month that is estimated based on monthly ridership before the improvements. We used this trend to estimate the increase in ridership after the improvements. We then compared it with the real ridership of the current period to estimate the additional travel demand on Metrobüs. An additional inclination has been observed in the uptrend curve based on the improvements made

Figure 8 Number of Ridership by Month between January 2011 and July 2014

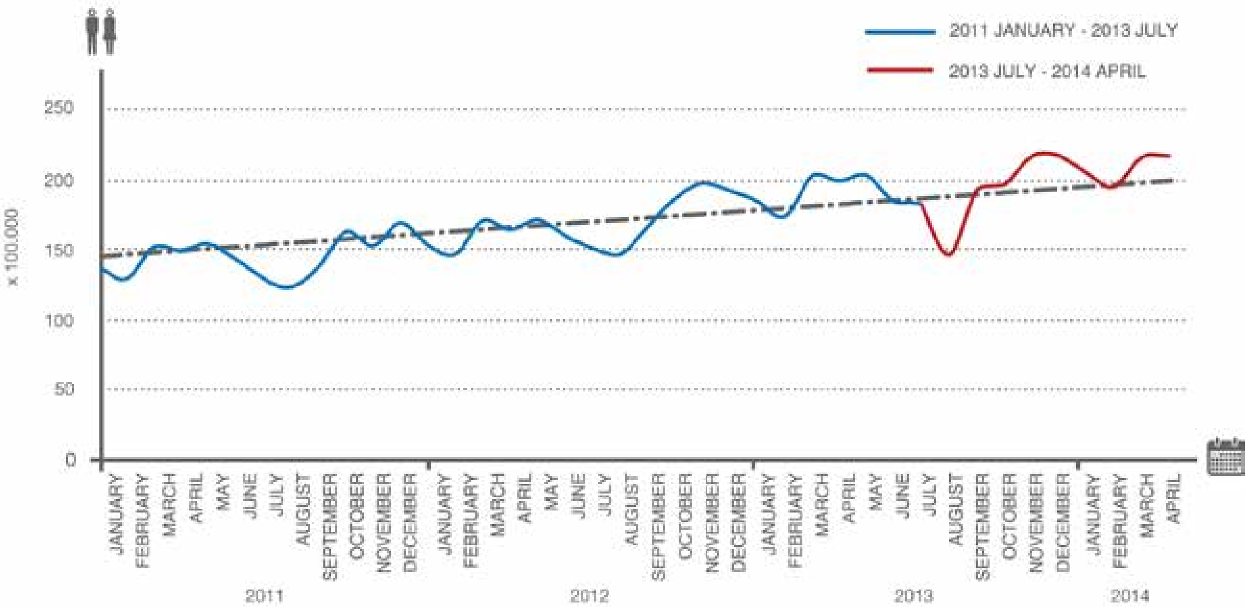
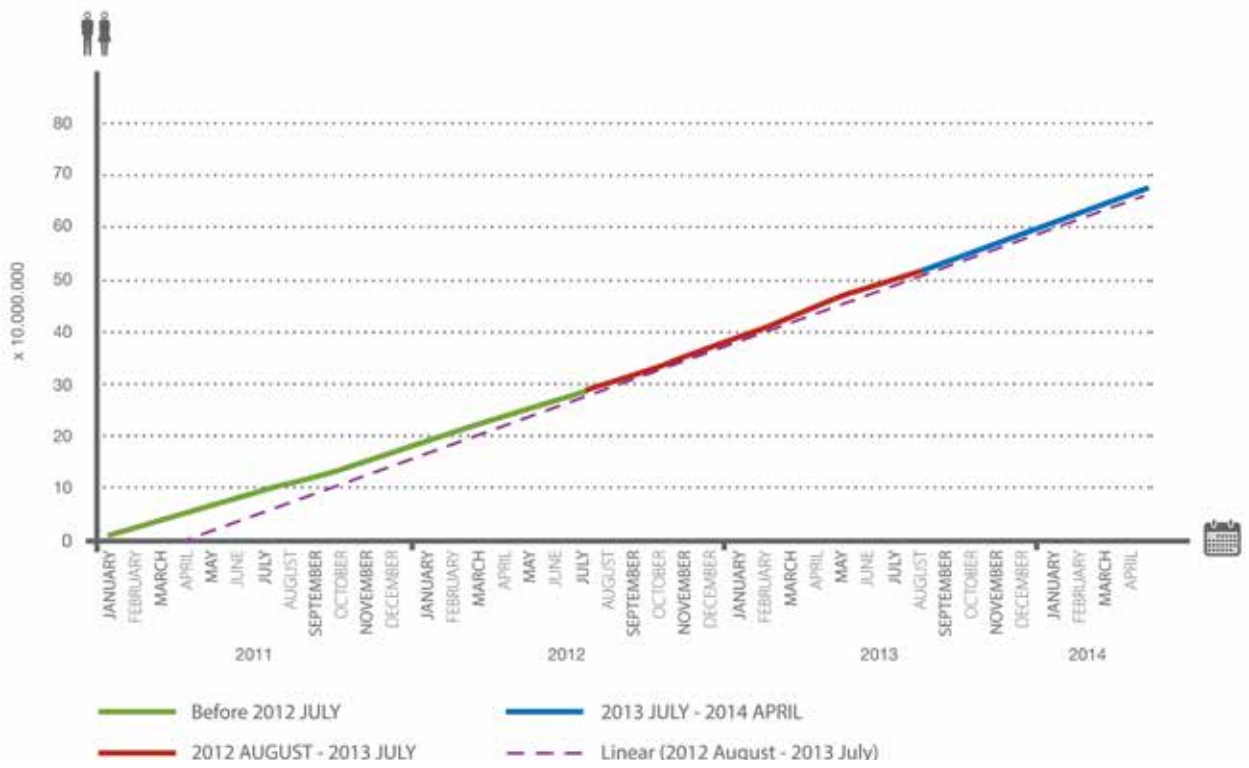


Figure 9 Cumulative Number of Ridership by Month between January 2011 and July 2014



after the analysis[9]. Figure 8 and Figure 9 show monthly average ridership and cumulative monthly average ridership between January 2011 and July 2014[10].

Operation

Identifying the passenger demand and its distribution correctly is essential to improve road safety. For example, if during peak hours, the platform wait time (PWT) on busy stations gets longer, then platforms will be crowded with passengers waiting in long queues, and demand might be higher than capacity on such platforms. A similar situation occurs when a part of the Metrobüs corridor is shut down for any reason (e.g. mechanical breakdown, accidents). This creates an oversaturated flow, as a consequence of which some of the passengers wait and/or walk on the Metrobüs lanes rather than on the platform. Therefore, improving the system will not only reduce passenger wait time but also increase passenger safety.

Figure 10 Oversaturated flow results in some passengers wait or walk on the Metrobüs corridor rather than on the passenger platform[11]

[9] Metrobüs ridership estimation includes the Metrobüs system only. This estimation neither includes parameters that influence the selection of the mode of transport nor the inter-modal changes due to any change in the transportation system.
[10] Exact increase in passenger demand is not given since it changes by season and month and improvement period covers one whole year.
[11] http://fotogaleri.hurriyet.com.tr/galeridetay/83286/2/7/metrobuse-ulasamayan-yolcular-e-5-i-yuruyerek-gecti

Although Metrobüs system is well operated, having a demand over its capacity reduces the comfort and operation speed especially in peak hours. Depending on the travel demand IETT uses express busses in peak hours particularly on routes where demand is highest (e.g. between Avcılar-Zincirlikuyu and Cevizlibağ). Again depending on the travel demand, 34U line that is engaged between Zincirlikuyu and Uzunçayır has recently been put into service too.

As part of a recent research project targeting Metrobüs passengers, an origin and destination (OD) matrix was estimated based on data provided by IETT officials. We have been informed that the officials currently assess different proposals to increase the operational capacity of Metrobüs. Moreover, two U-turn ramps (one in Yenibosna and one in Darülaceze) are under construction, which will enable the Metrobüs operation to be reorganized.

IETT separated the boarding and alighting platforms in Sefaköy, Yenibosna, Şirinevler, Zeytinburnu, Cevizlibağ, Bayrampaşa-Maltepe stations to reduce queuing and dwell time in peak hours. Moreover, there is staff in the alighting area responsible for dispatching the buses from the stations to prevent queuing. This causes BRT buses to have two “stop-and-go”s in the stations, resulting in delay due to acceleration and deceleration of the busses. Moreover, BRT busses have to open and close their doors twice since passengers use separate platforms for boarding and alighting, which results in longer dwell time. On the other hand, having separate zones for boarding and alighting reduces on-board congestion and shortens the time for boarding / alighting. In such stations where boarding and alighting are separated, there is an additional lane for each direction. This enables BRT buses to overtake, thereby reducing the dwell time. The effect of this implementation on the total dwell time of BRT busses has yet to be examined fully due to lack of the necessary information for this.

Figure 11 A station designed for separated boarding/alighting

In 2014, stop and go signals have been placed in both directions. Before that, platform staff was available to manage it. Our on-site inspection has revealed that this is still done by the platform staff at some stations.

Figure 12 A station where stop and go signals are erected in both directions

BRT buses should stop close to the station platform so that passengers can board / alight from the bus safely and comfortably. Therefore, bollards have been placed in some stations to ensure that BRT busses stops closer to the passenger platform (Figure 13).

Figure 13 Bollards are placed in some stations so that BRT busses can draw in the passenger platform

It has been observed that Metrobüs drivers fail to stop close to the passenger platform in stations where no bollards are in place. The gap between the station platform and Metrobüs busses is a challenge for physically disadvantaged people during their boarding and alighting. To solve this problem, station-specific configurations have been introduced. For example Bollards were placed to narrow lanes so that drivers were guided to stop close to station. It is proposed that this solution be adopted in other stations, and that Metrobüs and other IETT drivers be trained in how to pull in alongside the station platforms.

Figure 14 The gap between the bus and the passenger platform

The risk of death or severe injury in traffic accidents increases considerably for pedestrians when vehicle speeds are higher. For example, when a vehicle hits a pedestrian at 40 km/h speed, the risk of fatality is 40%. This rate is 80% and near 100% when the speed of the vehicle is 50 km/h and 80 km/h, respectively[12]. In other words, buses are highly dangerous when they drive through stations with high speed. Therefore, the road surface is marked with the speed limit just before the stations. We have observed that these horizontal markings are not fully visible in some station because of repair and maintenance works on the road surface. It is important that the markings be renewed as soon as possible for the sake of traffic safety.

Figure 15 Horizontal Markings Showing the Speed Limit

It has been observed during the site inspection that some bus drivers disobey the speed limit and drive through the stations with high speed. A Metrobüs driver who loses control due to excessive speed might pose a great risk to the passengers waiting on the station platform. The Metrobüs system is supervised with a speed radar system, which is thought to be effective for

[12] EMBARQ Türkiye (2013) "Road Safety Inspection of Metrobüs BRT", İstanbul

reducing the speed. Three of the total six radars are designed to be unnoticeable. The other three are located in Uzunçayır, Sefaköy and Beylikdüzü. However, it is additionally essential to train drivers on speed rules.

Infrastructure Construction and Maintenance

Taking the issue of road safety into account when maintaining, repairing and constructing the infrastructure facilities is particularly important to reduce the risk of accident. Within this scope, we inspected to what extend the proposals given in the "Road Safety Inspection of Metrobüs BRT" report have been implemented so far. Almost 60% of the accidents on the Metrobüs corridor involve vehicles hitting passengers[13]. The majority of these accidents happen because pedestrians ignore traffic rules and signs and try to reach the station platform by crossing the highway. Therefore, it is very important to install guardrails with fences along the stations to prevent such crossings. IETT officials have reported that they made some improvements on this issue. We strongly recommend that these guardrails be stretched over to the end of the central ghost islands at both sides of the station.

We have observed that the road surface was repaired and maintained along the Metrobüs corridor, while in some areas the repair-maintenance works are still ongoing. In some sections of the route, ghost islands on the road surface have faded due to asphalting. Metrobüs officials have reported that they will remark the ghost islands step by step all along the route. They also reported that they would mark ghost islands on the road surface in Cennet Mahallesi station.

Figure 16 Wire fences for predestrians

Despite the maintenance we still observe surface deterioration (e.g. rutting and etc.) in some stations due to such reasons as the heavy weight of the busses, their stop-and-go movements, and weather conditions.

Figure 17 Metrobüs road surface repair-maintenance works

[13] EMBARQ Türkiye (2013) "Road Safety Inspection of Metrobüs BRT", İstanbul

Figure 18 Examples of rutting and similar surface deterioration

We have observed surface deteriorations, which are related to tensions and deformations on the road pavement particularly along the stations and when approaching and leaving the stations. Rutting is the most common surface deterioration that we observed. Rutting is the longitudinal surface depression that develops in the wheel paths of asphalt concrete. This depression may develop at any layer of the road from subgrade to pavement. It generally develops due to high and heavy traffic and climatic conditions. The water puddles that occur on the asphalt surface due to rutting jeopardize the road safety directly, leading to shocks, loss-of-control, skidding, and shorter stopping distance. Especially in winter when water in the ruts is frozen, drivers may lose control and cause major accidents. To minimize the rutting on the road surface, the workmanship during laying of asphalt as well as the weather conditions during road works should be taken into account especially within the road repair and maintenance program.

To prevent such deterioration, we recommend that polymer derivatives be added to the asphalt mixture in specific stations depending on the weather conditions of İstanbul. Another recommended solution is to replace these sections of the road with concrete pavement.

We have observed in the on-site inspection that station platforms were extended and enlarged depending on travel demand.

In the majority of the stations, floors of the platforms were replaced and marked with yellow lines at the edge when enlarging the station. Moreover, platform surface was smoothened during the enlargement work. It is essential to lay tactile tiles on station platforms for visually impaired people. IETT currently plans to turn the yellow lines on the station platforms into tactile tiles.

Figure 19 Example of an enlarged station platform

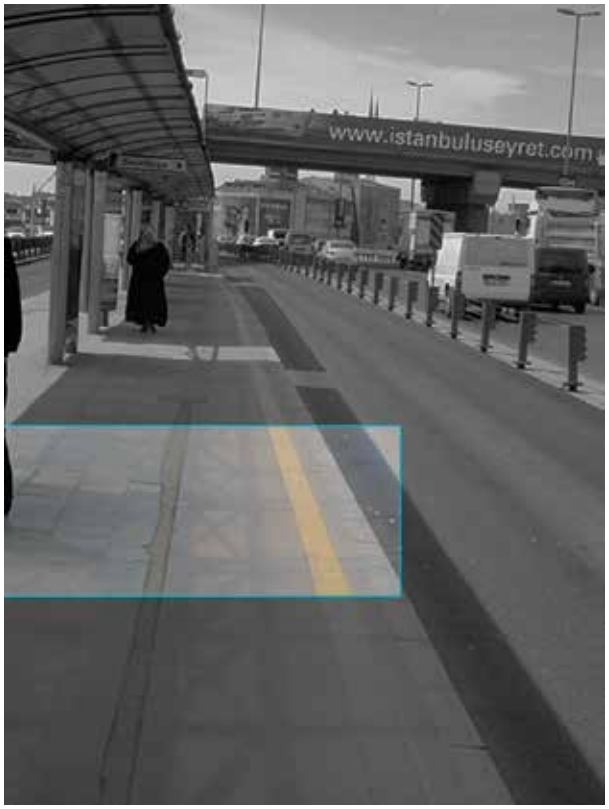


Figure 20 Example of a yellow line marking and surface smoothening

It is proposed in the traffic safety report that the end borders of the station platforms are blocked and fences be stretched over to the end of the ghost islands to stop passengers from entering to station platforms by violating traffic rules and signs and prevent them from walking on the Metrobüs way. Officials placed billboards and concrete planters on the platform ends to at least show people that it is not a waiting area. However, it did not work well. Therefore platform ends must be closed to passenger entry. If the platform ends have to be used for alighting in special cases (e.g. bus breakdown), access to the ghost islands both from the highway and the station platform should be blocked. In this case, we propose that an entry gate be built for the access of staff members and passengers under special circumstances.

Figure 21 An example of a station where platform ends are not blocked for access and fences are not stretched long enough to the end of the ghost islands

Another risk is that there is no median refuge available between the two opposite lanes. This increases the risk of head-on collision. “Road Safety Inspection of Metrobüs BRT” report recommended that the opposite lanes be separated not only with yellow line but also with cat’s eyes to capture the attention of the drivers. Therefore cat’s eyes were laid down along the median refuge.

Figure 22 Example of cat’s eyes lay down along the median refuge

Only one section of the Metrobüs corridor does not have any median refuge. Having no median refuge increases the risk of head-on collisions. Therefore, this section of the corridor has been equipped with cat eyes and markings. Since this is not adequate by itself a median refuge is recommended to reduce the risk of accident.

Figure 23 Example of a Metrobüs section where there is no median refuge (the section between Florya and Cennet Mahallesi)

Another deficiency, for which an improvement is proposed in the “Road Safety Inspection of Metrobüs BRT” Report, is that the poles lack configuration and protection against accidents. For this, officials marked the poles with yellow (for guiding) to make them more noticeable. It is also very essential to protect the poles against collision.

“Road Safety Inspection of Metrobüs BRT” report recommends that vehicle and bus guardrails be improved and maintained. Therefore, it is recommended to use vehicle and bus guardrails, which are already available in Phase IV of Metrobüs, in other parts of the corridor as well. However, we did not see any guardrail in the site inspection.

Considering the importance of Metrobüs operation, it is very clear that the shutdown of the Metrobüs corridor even for a very short time due to an accident has an impact on the overall transport system. Designing the car and bus guardrails according to standards has a major role in that. Site inspection has revealed that the solutions, which are proposed in the road safety inspection study on guardrails, have yet to be realized. We strongly recommend that the officials place BRT guardrails along the Metrobüs corridor and replace the car guardrails as per the standards.

Figure 24 Example of a pole not protected against collision

Access to Stations

Access to Metrobüs stations in İstanbul is one of the main challenges of the system. IMM and IETT officials have had a set of attempts to solve this problem. "Road Safety Inspection of Metrobüs BRT" report also examines the issue of access to Metrobüs stations comprehensively. The issue is also a major problem from the road safety aspect: "buses hitting pedestrians when they are crossing the road" is the most common of the three main causes of accidents that occur on İstanbul Metrobüs corridor.

Figure 25 Buses hitting passengers when they are crossing the road (lack of safe access)

One major issue with regards to the access to stations is that pedestrians do not tend to use overpasses/underpasses when crossing the road. IETT officials used wire fences to prevent this and 28 stations were equipped with wire fences. Wire fences are mainly used at stations located on the European side of the city. Only the stations Uzunçayır, Acıbadem and Altunizade on the Asian side are equipped with fences. Bigger wire fences were installed at stations on the Avcılar-Beylikdüzü section (Phase IV of İstanbul Metrobüs corridor) since people tend to jump over the highway guardrails there to reach the stations, leading to major accidents. Beylikdüzü Belediye and Haramidere stations were provided with wire fences immediately after they were commissioned because of the accidents that used to occur there. "Road Safety Inspection of Metrobüs BRT" report emphasized that wire fences should be taller at certain sections of the Metrobüs corridor as well as at stations. However, attempts for that remained limited. Similarly, the report also emphasized that wire fencing should be extended until the end of the station platforms including the ghost islands, but this has not been done for the entire corridor but for some parts of it only.

Another problem is that the ends of Metrobüs stations are open, not blocked with physical barriers. That is why passengers access the

Figure 26 Example of a station where wire fencing stretches to the end of the ghost islands

stations over the ghost islands. To prevent this, the officials have put billboards and concrete planters to the side ends of some stations. We have observed during the inspection that 10 of the Metrobüs stations have been improved in that respect. 2013 inspection report also recommended closing the area where over/underpasses are interfaced with the station

Figure 27 Example of a station where guardrails are placed at the point of interface between over/underpassages and the station platforms to keep people away from the Metrobüs lanes

platform. The majority of them were closed using guardrails. In almost all stations along the Metrobüs corridor, guardrails have been placed at the entrance points and after the stairs.

In one station only, the guardrail is in the Metrobüs lane, which poses a risk to passengers. Therefore, the passenger platform of this station should be expanded adequately to accommodate the guardrail rather than keeping it in the Metrobüs lane.

Integration of Metrobüs with other modes of transport is also important from a road safety perspective. “Road Safety Inspection of Metrobüs BRT” report identified a set of deficiencies and problems with regards to integration, and highlighted the need for improvement at some stations particularly. The report has also put forth recommendations to make the access to stations easier and safer. Other problems include the lack of illumination at overpasses connecting to stations and lack of security in the Metrobüs system at late hours of the night. Solving the issue of integration requires an upper scale approach in the long run since it is in the jurisdiction of different authorities. Although the issue of access to Metrobüs stations is not addressed at large scale,

Figure 28 Example of a station where guardrail for passengers is on the road

IETT made some station-specific improvements and created new facilities for connection and access.

“Road Safety Inspection of Metrobüs BRT” report recommends the improvement of regular bus and minibus connection that is in close proximity to Metrobüs stations. Improvement of the connection

Figure 29 Example of the recently introduced facilities in Zincirlikuyu for safe inter-modal exchange and access.

Figure 30 Example of a safe inter-modal exchange and access in Mecidiyeköy

with the feeder bus can be done at three stages: Firstly the station platforms should be designed for easy and direct access of the passengers. Moreover, designing the exits of BRT stations close to feeder bus stations also matters a lot to facilitate passenger access and prevent them from jumping over the highway guardrails in locations where no wire fence is available. Either a large-scale approach was adopted (e.g. Mecidiyeköy and Zincirlikuyu stations) or an alternative overpass was constructed (e.g. Şirinevler and Perpa stations) in majority of the stations, which have been re-designed recently.

The second proposal to improve the connections is to update the location of the bus stations around Metrobüs stations. The third proposal is to expand pedestrian pavements in bus/minibus stations to facilitate pedestrian mobility. No action has been taken to directly addressing these two

Figure 31 Example of a new pedestrian overpass in Şirinevler

proposals since they are in the jurisdiction of different authorities.

Another challenge for integration is the lack of pavements around Metrobüs stations or pavements in poor condition. Similarly, curbside parking and fixed objects blocking the pavements are among the major problems of accessibility from an overall perspective. Considering the daily ridership of Metrobüs, it is essential to give adequate space for pedestrians at and around the stations. Offering adequate space to pedestrians to ensure efficient mobility is determinant on how they access to stations, which is quite essential for road safety.

Figure 32 Example of a station with poor accessibility for disabled people, elderly people, and people with pushchair

Figure 33 Example of a station where accessibility is improved with ramps for disabled people, elderly people and people with pushchair

Moreover, ramps and elevators should be in place for people with special conditions (e.g. disabled people, elderly people, people with pushchairs, etc.) to improve their access to stations, especially in locations where people access to stations using underpasses and overpasses. This is what the officials primarily addres when improving access to Metrobüs stations.

Ramps and elevators are available now in Zincirlikuyu, Mecidiyeköy, Çağlayan, Okmeydanı, Edirnekapı, Cevizlibağ, Beşyol, Florya, Şükrübey and Avcılar stations. Moreover, all the stations of Avcılar-Beylikdüzü line (Phase IV) have been designed for disabled access. IETT intends to adopt a holistic approach in designing the stations. Similarly, repair works are on-going in stations where elevators are broken down.

Figure 34 Example of Infrastructure Repair and Maintenance to Improve Access to Stations

Passenger Flow to Stations

High pedestrian volume during peak hours is the main challenge with regards to passenger flow to Metrobüs stations. This causes congestion when entering and leaving the stations, decreasing the passenger access capacity. IMM and IETT have made improvements to increase station capacity and reduce queuing at the entry and exit of the stations. The main action that was taken for this was to enlarge the station platforms. When constructing the stations of Avcılar-Beylikdüzü line (Phase IV) platforms were designed wide enough while Mecidiyeköy and Avcılar station platforms were enlarged. Similarly, the passenger platform at Uzunçayır station was widened. Moreover, the buffet in Zincirlikuyu station was removed to give more space to passengers.

Figure 35 The buffet in Zincirlikuyu station was removed to give more space to passengers

Water dispensers that have been placed recently on station platforms also affect the passenger flow adversely in peak hours. In platforms, which are not wide enough for passenger movement, the water dispensers decrease the cross-section capacity and the volume of passenger circulation. As a result passengers walk off the station platform and encroach on the Metrobüs lanes during peak hours at busy stations. The proposal is to move the water dispensers to the platform ends.

"Road Safety Inspection of Metrobüs BRT" report also addresses to the issue of congestion at

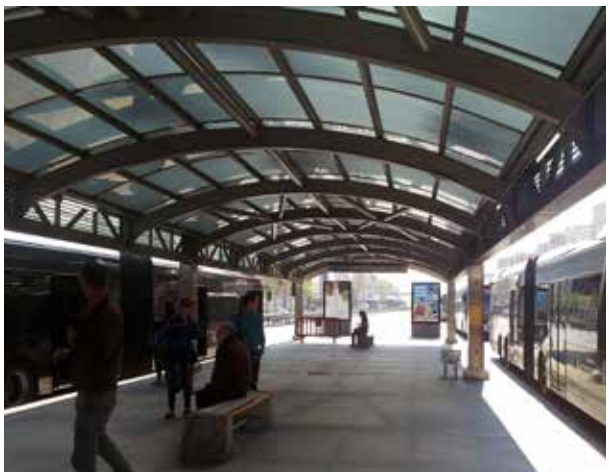
Figure 36 Example of a station where water dispensers decrease cross-section capacity and affect the volume of passenger circulation

the entrance and exit of the stations. To solve this problem in some stations, turnstiles were removed from the station platform and relocated on the underpasses/overpasses. Turnstiles are located on the overpasses at the majority of stations of the Avcılar-Beylikdüzü line (Phase IV of Metrobüs). The report reveals that it is more challenging to solve the congestion problem in stations such as Cevizlibağ and Okmeydanı where platforms are relatively narrower. The proposal is to separate the passenger flow using two escalators and to increase the turnstile capacity[13]. The entrance and exit of the passengers are separated in some Metrobüs stations to reduce congestion. These include Hadımköy, Cumhuriyet Mahallesi, Beylikdüzü Belediye, Beylikdüzü, Güzelyurt, Haramidere Sanayi, Haramidere, Saadetdere Mahallesi, M. Kemal Paşa, Cihangir Üniv. Mahallesi, Avcılar, Beşyol, Şirinevler, Cevizlibağ, Mecidiyeköy, Uzunçayır, Fikirtepe, and Söğütlüçeşme stations.

Billboards were relocated to the middle of the passenger platform in all the stations of Metrobüs corridor. This improvement, which is in line with the proposals given in the road safety inspection report, facilitates the boarding and alighting of the passengers. In addition to that, benches were also placed on the passenger platforms.

Figure 37 Example of a station where entry and exit gates are separated

Figure 38 Example of a station where billboards were removed from the platform ends



[13] EMBARQ Turkey (2013) "Road Safety Inspection of Metrobüs BRT", İstanbul

Education – Awareness Raising

Passenger information systems and applications are essential in selecting the route and mode of the travel. Such applications shorten the travel time, improve the comfort of the passengers and increase system performance. This application is available in the Metrobüs system providing passengers with information about the stations. On-board monitors are used on buses to display station information and information panels are available in many stations.

On-site inspection has revealed that passengers tend to get on the bus, which arrives first to the station, not waiting for the following bus. This results in uneven distribution of passengers on buses and prolongs the travel time in peak hours. Displaying the time of arrival of the buses at stations is helpful for passengers because they may wait for the next bus as long as they know when it arrives. Moreover, displaying the occupancy of buses can improve the service level considerably. It is proposed to place signs to warn people not to step down on the Metrobüs lane (e.g. Do not cross the yellow line or Do not step down on the road).

Lack of disabled access in some stations causes trouble for physically disabled people. It is essential to inform such people on and off board.

From the education perspective, IETT provides trainings for Metrobüs drivers. Metrobüs officials have reported that they increased the number of staff, all of whom were trained on emergency response, actions and structural problems. They also created a responsibility structure that resembles a chain of command. However, it has been observed that drivers still violate some basic safety rules. These include the violation of speed limits and not pulling alongside the passenger platform. It is essential to inform drivers about road safety and encourage them to obey the road safety rules as soon as possible. Road safety should be communicated to the passengers as well through ads, applications and information panels. An incentive programe for drivers could also be considered.

Figure 39 Example of an information panel at a station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3. EVALUATION AND PROPOSALS

In general, considering the improvements that have been done so far, İstanbul Metrobüs corridor is in good condition in terms of road safety. The main reason for that it is totally separated from the urban traffic. Metrobüs buses do not cross any at-grade junction or intersection along the corridor. Since it is physically separated from the urban traffic, İstanbul Metrobüs has a higher operation speed than other BRT systems. On the other hand, operating at a higher speed increases the risk of fatality and severe injury in case of an accident. Pedestrians are the group that has the highest risk of fatality and severe injury in case of an accident.

An assessment of key performance indicators was carried out. Using the raw data provided by the authority a quantitative assessment was conducted. Moreover, implementations were inspected along the corridor. The deficiencies and the proposed actions for improvement include the following:

- Wire fences were installed in 17 stations. However, they failed to be adequate in Fikirtepe, Darülaceze and Cevizlibağ stations. Wire fences should be placed on both sides of the road, and extended till the end of the ghost islands.

- Horizontal road markings of speed limit and ghost islands are available in almost all stations. Such markings should be refreshed as soon as possible during the repair and maintenance of the asphalt pavement.

- The platform ends were connected to newly construct under/overpasses in 3 stations. It is proposed that the end borders of other stations be closed as well.

- Station platforms were enlarged in 7 stations to reduce crowding.

- Entrances and exits are separated in 19 stations. Moreover, boarding and alighting platforms are separated in 6 stations.

- Turnstiles were relocated to the overpasses at 9 stations.

- Inter-modal exchange stations and overpasses were constructed in 5 stations to ensure safer integration of the BRT system with other mode of transports. The rest of the stations should also be redesigned to ensure passenger safety and new areas for inter-modal exchange that are accessible to everybody should be created.

- The road surface on Söğütlüçeşme-Avcılar corridor has been repaired, resurfaced and rehabilitated. Poor surfaces, which have been worn out recently, should be rehabilitated immediately.

- Bus drivers should be trained to obey the traffic rules. In addition, it is recommended that signs be placed for passengers warning them to wait behind the yellow line on the station.

- Guardrails should be constructed on station platforms between Söğütlüçeşme and Avcılar. Moreover, the loose guardrails should be replaced. It is proposed to place these guardrails in the entire Metrobüs corridor as soon as possible. The height and specifications of the guardrails should be in line with the standards.

- Footpaths should be renewed in line with the standards to increase safety of access to Metrobüs stations.

- Ramps and elevators should be in place in every station so that disabled and elderly people can also access all stations.

- According to accident data, there is not any change in the general accident trend, but it is noticeable that fatal accidents were reduced from 6 to 1. Accidents have increased noticeably in Cevizlibağ and Söğütlüçeşme stations. Accident data set has not suggested the exact cause of such an increase. On the other hand, it is very important that stations be safe for pedestrians. Especially in Cevizlibağ station, more space should be given to pedestrians so that they can move comfortably.

Below is recommended a list of actions that should be taken primarily and immediately.

- Platform wait time (PWT) should be reduced by improving the system

- Road surface should be rehabilitated
- Horizontal markings should be available in every station
- Poles should be protected against accidents
- Metrobüs safety guardrails should be placed

- Pedestrian wire fences should be stretched until the end of the ghost islands in all stations
- The end of station platforms should be closed with wire fences
- Ramps and elevators should be in place in stations for disabled access, and existing elevators should be maintaned

- Warning signs shoud be in place in all stations
- Station platforms should be enlarged

4. FUTURE STEPS

It has been very clear for a while that cities need high quality public transportation for a better urban environment. Policy makers should provide people with high quality transport systems by assessing the urban transport system continuously in terms of safety and accessibility.

This report focuses on safety and accessibility components of İstanbul Metrobüs, which is an important mode of public transport for İstanbul. BRT has now become a solution for emerging cities of the world that seek rapid and cost-effective ways to solve the issue of transportation. Undoubtedly, these components are also applicable to non-BRT systems such as rail transport and cycling.

In the light of the given inspection and assessments, we propose that a comprehensive survey be conducted in partnership with IETT to analyze passenger expectations and accessibility problems. Similar to other BRT systems in the world, this survey should be conducted regularly every 6-12 months. Moreover, the survey results are also helpful for examining the short- and long-term influence of the system performance and of the improvement/changes from the passengers' perspective. The next step is to identify the effect of the newly constructed or rearranged stations on travel demand using ID (personal information) based data.

Considering that the recent improvements were introduced only less than one year ago, we plan to conduct another follow-up study on road safety and accessibility of İstanbul Metrobüs in the future depending on the forthcoming improvements and changes.

APPENDIX

APPENDIX-1 CHECKLISH FROM THE STUDY IN 2012

TOPICS	SUBTOPICS
Pedestrian Fences	Insufficient guardrails
Vehicle Crash Barriers	Damaged cable crash barriers
	Weak cable crash barriers
Bus Crash Barrier	Only on the newest section there is a crash barrier for buses
Pedestrian guardrails at stations	There are no signs and markings indicating the maximum speed limit allowed
	In the end of the platforms, there are ghost islands marked in the pavement for a safe approach of the bus into the station
	At certain sections there is a gap between the vehicle lanes and the BRT lanes. It is not clear why these areas were created
	The borders of the stations are open and do not have any physical barrier to prevent people from accessing or leaving the station by unregulated access.
Pedestrians in bus lane	At crowded stations passengers walk on the bus lane
	Overcrowding (Giriş-çıkışlarda yogunluk, turnikeler)
Transfers to other public transport modes	Unsafe transfer paths between Metrobus and Metro
	Connections to regular buses and minibuses
Conventional bus drivers not stopping inside bays	Bus drivers picking up passengers on vehicular lanes
Pedestrian guardrails and crash barriers	Missing pedestrian guardrails and inadequate crash barriers
Bus docking assistance	Missing pedestrian guardrails and inadequate crash barriers
Platform pavement and markings	Pavement cracks and other irregularities are common at station platforms, especially in the older sections
Pillars in bus lane	Often pillars are placed in the bus lane.
Pavement maintenance	It was often observed that in the bus lanes rutting and other degradation of the pavement was widespread
	It was observed that after heavy rain water accumulated on the surface at some places. This will be unexpected and can lead to accidents.
	Uneven manhole covers
Guardrail on the bus lane	At a few stations guardrails are placed on the bus lane.
Central reserve	On one section there is no central reserve and on others there is only a double line
Edge marking on platforms	The yellow edge marking on platform is worn out on several stations.

APPENDIX

Parking and stop areas	Some areas where buses or service vehicles can stop are not marked or are marked as ghost islands
Access for disabled	Not all stations have elevators or long ramps
	In many places there are no ramps for disabled
Maintenance of accessibility aids	Elevators and escalators were often found to be out of order.
Sidewalks missing or too narrow	Sidewalks are often missing or in bad condition.
Sidewalks blocked	Sidewalks are often blocked by parked cars.
	Sidewalks are often blocked by fixed objects
Access to local buses	Buses stop near station exits not in bus bays
Stopping of local buses	Major risk: possible rear-end crashes with vehicles coming from behind
	Access to local bus stations not well designed – or used
Pedestrian crossings near stations	Pedestrian crossings are not always provided near bus stations
Side road crossings	Crossing of side roads not safe for pedestrians
Illegal parking at accesses to stations	Illegally parked vehicles block access to stations
Ghost island utilization	Vehicle parked at ghost island
Pedestrian guardrails at stations	Missing guardrails at the end of the stairs
Central barrier in the BRT corridor	BRT corridors are only separated by markings in the pavement
Advertising signs at stations	Advertisement boards block access to the bus
Signalling traffic cones	The use of Traffic cones
TUYAP Tunnel	Buses use the opposite lane when exiting the tunnel. The curves are sharp here and visibility poor
Pedestrian Facilities	Narrow sidewalks and inexistent pedestrian crossings
Parking	Along the BRT corridor, there are several businesses which use the sidewalks for parking
Accessibility	The existing infrastructure along the corridor is not adequate for all types of users
Pavement	The lanes of the BRT are already suffering some damage and deformation due to the constant movement of buses and the "stop and go" friction
Overcrowding	Clogged access path to the some stations during the evening rush hour

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EMBARQ catalyzes and helps implement environmentally, socially and financially sustainable urban mobility and urban planning solutions to improve people's quality of life in cities. Founded in 2002 as a program of the World Resources Institute (WRI), EMBARQ operates through a global network based in Brazil, China, India, Mexico, and Turkey.

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