ITDP

GENERAL ORGANIZATION FOR PHYSICAL PLANNING

محافظة الجيزة

UN HABITAT
FOR A BETTER URBAN FUTURE

Bus rapid transit for Greater Cairo: Prefeasibility assessment

Institute for Transportation and Development Policy

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Contents

1. Executive summary

Greater Cairo is a dense, sprawling metropolis known for its daunting traffic jams. A lack of sufficient rapid transit options leads to traffic snarls on the many wide roads that criss-cross the metropolitan area. To solve this problem, authorities in Cairo and Giza have begun to look to bus rapid transit (BRT) as a cost-effective means of expanding the rapid transit network in a short time frame.

During the week of May 3, 2015, the Institute for Transportation and Development Policy (ITDP) made its first mission to Greater Cairo to perform a pre-feasibility study for bus rapid transit (BRT) in Cairo, New Cairo, and Giza. The ten-day mission, supported by UN-HABITAT Cairo, included meetings with relevant planning bodies and preliminary data collection on road segments with significant public transport demand. These surveys revealed that sufficient existing demand to justify the construction of a multiple corridor network. There is also considerable interest in implementing BRT on the part of relevant government agencies.

To provide an initial estimate of the potential demand for improve public transport services, ITDP conducted a frequency and visual occupancy (FVO) survey in Giza and New Cairo. An FVO survey indicates how frequently each bus route runs and the approximate occupancy of each vehicle. The FVO survey found sufficient demand for a BRT corridor on several roadways in Giza, Nasr City, and New Cairo.

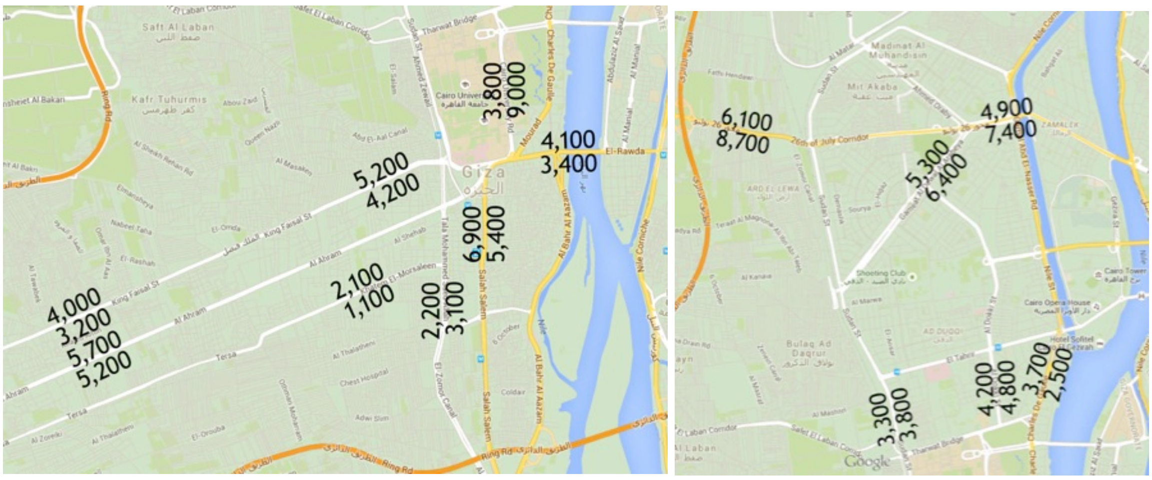
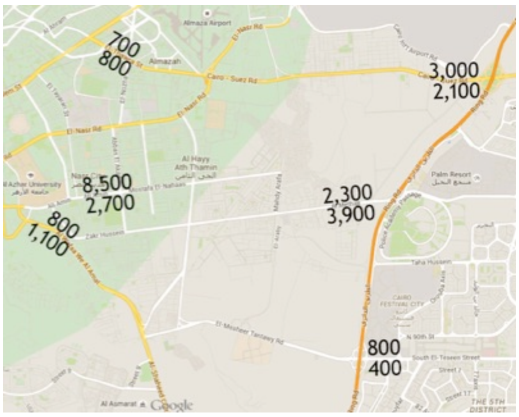


Figure 1: Observed public transport and paratransit demand (passengers per hour per direction) in Giza (above), Cairo, and New Cairo (below).



Opening the first phases of BRT in Greater Cairo in areas in which there is high demand will help demonstrate the viability of BRT. Specific BRT corridors for Cairo and Giza were determined after carefully evaluating a number of parameters including passenger demand and available right-of-way (ROW).

In Giza, ITDP worked with the Giza Governorate to identify a potential BRT corridor running from Remaya Square on King Faisal Street, Cairo University Road, Al Dokki Street, and Gameat Al Dewal Al Arabeya before terminating at Ahmed Oraby. This corridor alignment has a total length of 16.1 km, will provide service to many of the segments at which high passenger volumes were observed during the FVO survey, and has ample ROW.

In New Cairo, a 34.1 km was identified to provide a connection from New Cairo City in the east, through Nasr City before terminating in Cairo. It will travel on South El Teseen Street, Mohammed Nagib Axis, Al Methak, Mostafa El Nahass, Youssef Abbas, Salah Salem St, and Al Azhar.

These corridors will require a fleet of 240 high-capacity articulated buses and will see frequencies of 50-60 buses per hour. The implementation cost of the phase 1 network is expected to be at least USD 250 million.

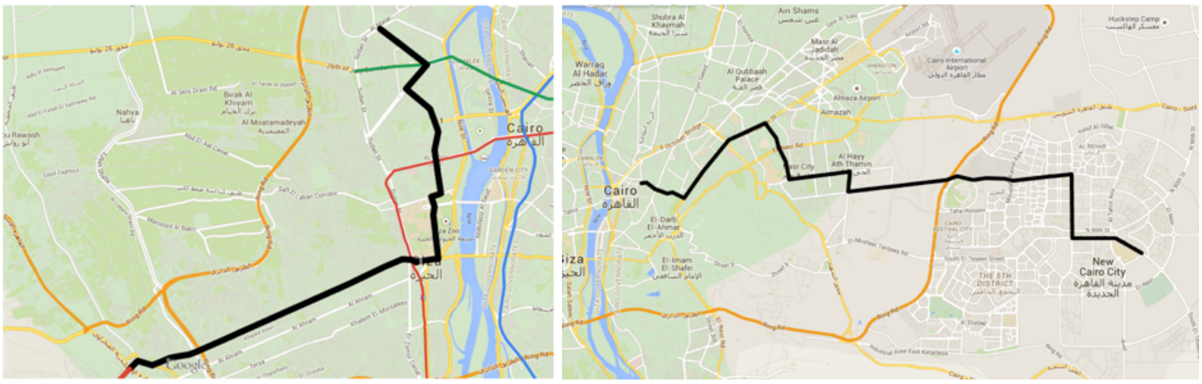


Figure 2: Proposed phase 1 corridors in Giza (left) and New Cairo (right).

To ensure high quality service for passengers, the Greater Cairo BRT should incorporate internationally accepted best practice elements:

- A dedicated right-of-way for BRT buses
- Bus lanes aligned in the middle of the road
- Off-board fare collection with smart card ticketing
- Intersection treatments prohibiting turns across the busway
- Platform level boarding

These elements, known as the BRT Basics, form the core of the BRT Standard, an evaluation tool created by an international group of BRT experts.

Dedicated Right-of-Way
Bus-only lanes fully segregated from mixed traffic

Busway Alignment
Bus-only lanes aligned to the middle, not the curb, of a road

Off-Board Fare Collection
Turnstile-controlled or proof-of-payment fare collection system

Intersection Treatments
Mixed-traffic is prohibited from making turns across the busway

Platform-Level Boarding
Station platforms level with bus floors when boarding and alighting

Figure 3: The BRT basics

While the BRT Basics will create dramatic service improvements for bus riders in Giza and Cairo, the Phase 1 corridor should push to achieve Gold Standard, the highest classification in the BRT Standard. Gold Standard BRT systems are consistent in almost all aspects with international best practice. These systems provide a high quality of service while operating at the highest level of efficiency. Gold Standard BRT systems can be found in Guangzhou, China as well as Bogota and Medellin, Colombia. These systems have inspired cities across the globe to implement BRT and have served as a catalyst for further improvements of urban spaces in their home cities.

New Gold Standard BRTs in Giza and New Cairo will not only benefit the significant volumes of travellers on the two corridors; it will also become a model of world-class mass transit for Greater Cairo, Egypt, the Middle East and the world.

Figure 4: Gold Standard BRT systems, such as Bogotá's Transmilenio, provide fast performance and excellent customer service.

BRT often costs up to ten times less than a LRT system, and ten to one hundred times less than an elevated or underground rail system. This is benefit is crucially important to cities in need of rapid expansion of their transit network such as Cairo and Giza. BRT will allow the two cities to quickly add kilometres of rapid transit to their network as they seek to meet the needs of today's population while planning for future growth.

Several agencies are currently developing separate plans for public transport improvements in Greater Cairo. In order to construct an integrated transport network and improve the daily lives of Cairenes, a framework for cooperative efforts will need to be created. Toward this end, a BRT steering committee should be formed to bring together all of the agencies that are involved in BRT planning. This committee should meet on a regular basis (i.e., at least once per month).

To operate the BRT system, a special purpose vehicle (SPV) is proposed. The special purpose vehicle will function as a separate government entity that oversees the planning and execution of the BRT system. The primary mission of this entity will be to promote and implement a high quality BRT system. The SPV will contract activities such as bus operations, fare collection, and fund management to private sector operators.

A BRT can be designed and implemented within an extremely short time frame. The best BRTs in the world were implemented in two to three years. For instance, the Guangzhou BRT went from a firm political commitment to implementation within eighteen months. In Bogota, Mayor Enrique Peñalosa was able to build and begin operations for the Transmilenio BRT system in three years. A typical timeline can be found below. Many activities occur concurrently, so BRT projects require excellent coordination between stakeholders.

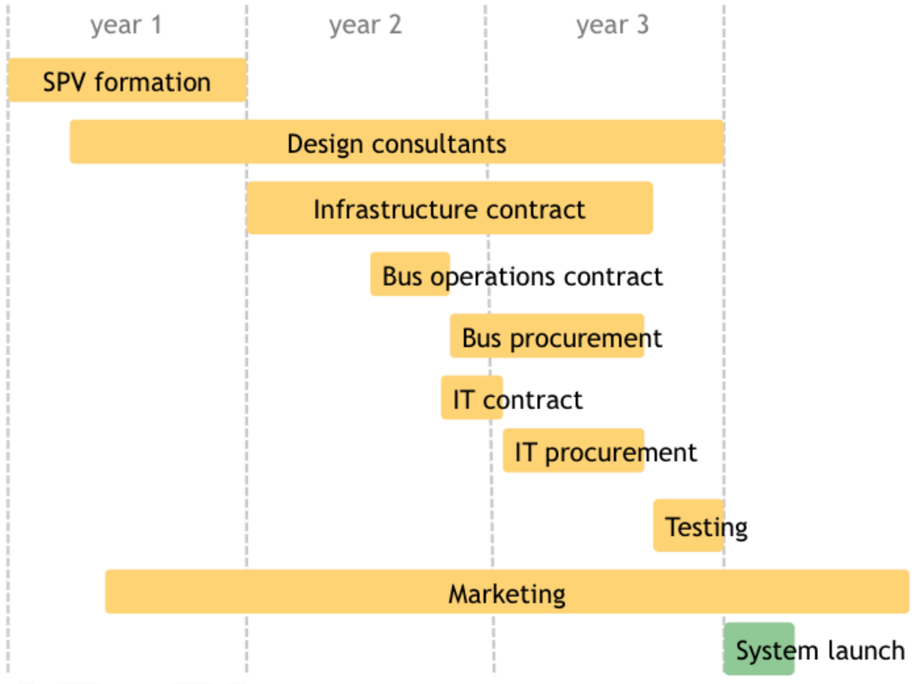


Figure 5: The BRT planning process

2. Introduction

Greater Cairo is a dense, sprawling metropolis known for its daunting traffic jams. A lack of sufficient rapid transit options and rapidly increasing ownership of private cars leads to daily traffic snarls on the many wide roads that criss-cross the metropolitan area. To solve this problem, authorities in Cairo and Giza have begun to look to bus rapid transit (BRT) as a cost-effective means of expanding the rapid transit network in a short time frame.

During the week of May 3, 2015, the Institute for Transportation and Development Policy (ITDP) made its first mission to Greater Cairo to perform a pre-feasibility study for BRT in Cairo, New Cairo, and Giza. The ten-day mission, supported by UN-HABITAT Cairo, included meetings with relevant planning bodies and preliminary data collection on road segments with significant public transport demand. These surveys revealed that sufficient existing demand to justify the construction of a multiple corridor network. There is also considerable interest in implementing BRT on the part of relevant government agencies.

The following report provides ITDP's technical, institutional, and financial assessments after completing its first mission. The technical assessment provides details on the results of surveys undertaken to estimate corridor demand in various parts of Giza and New Cairo. It also provides recommendations for Phase 1 corridors in both parts of the city. The institutional assessment reviews existing rapid transit projects and provides guidance on the institutional structure necessary to undertake a successful BRT planning process. The financial assessment provides indicative costs for the construction and operation of BRT systems. The final section describes the full BRT planning process and next steps for Greater Cairo.

3. Technical assessment

3.1 Public transport in Cairo

3.1.1 Existing services

Today, the public transport system in Cairo consists of a metro system and a network of bus, minibus, and microbus routes. The Cairo Metro network, operated by the National Authority for Tunnels, spans 78 km with three lines. The system caries around 4.1 million passengers per day, and is reported to have the highest number of boardings per km of any metro system in the world.[1][2] An additional 76 km are planned. These additional corridors will be built in the form of three new lines and with some extensions of existing lines.

The Greater Cairo bus network is made up of approximately 450 official numbered bus and minibus routes, along with numerous informal microbus services. The Cairo Transport Authority (CTA) operates a fleet of around 3,000 buses on 366 routes.[3] CTA's fleet consists of 12 m buses with a typical seating layout of 32 seats. The entire fleet has high floors, with two to three steps at entry. The minibus routes are run by private entities under route licenses issued by CTA. The minibuses have twenty-nine seats. The microbuses have 7, 8, or 14 seats. In the absence of a meaningful network of

[1] http://cairometro.gov.eg/UIPages/Statistics.aspx
[2] https://pedestrianobservations.wordpress.com/2015/03/31/metro-systems-by-ridership-per-kilometer/
[3] http://www.cairo.gov.eg/HaykalTanzemy/body/Disdetails.aspx

dedicated infrastructure, bus and paratransit services are subject to Cairo’s crippling traffic congestion, resulting in declining commercial speeds and less efficient fleet utilisation.

Figure 6: The Cairo Transport Authority (CTA) operates buses across routes in Cairo and Giza. While some vehicles were procured recently, the entire fleet consists of high floor buses with stepped entry.

Figure 7: Paratransit vehicles in Greater Cairo range from 7-seat vans to 29-seat minibuses.

Figure 8: The bus and paratransit system in Greater Cairo lacks supporting infrastructure such as bus shelters and terminals, so passengers are forced to wait in the sun to catch a bus. This lack of infrastructure also contributes to an unsafe environment for waiting passengers.

These public transport services struggle to meet the needs of Greater Cairo's 18 million people. The metropolitan area's Rapid Transit Ratio (RTR), a measure of km of rapid transit per million residents, will be only 8 km of rapid transit per million urban residents, even after planned metro lines 4, 5, and 6. This figure is well behind other global cities.

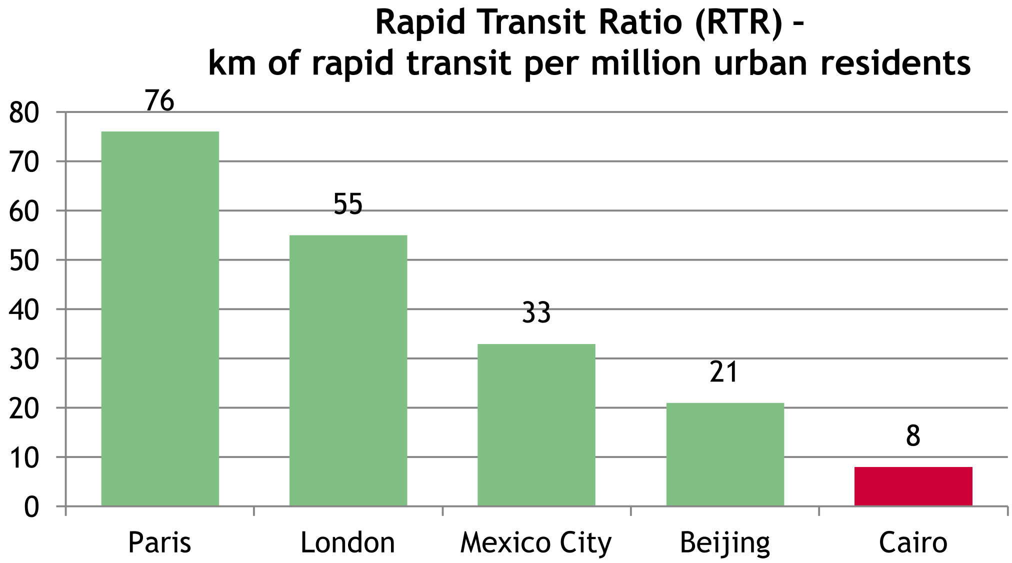


Figure 9: Greater Cairo will have a low supply of rapid transit even after completion of proposed metro lines 4, 5, and 6.

One notable public transport corridor in Cairo is the Mostafa El Nahaas busway running through Nasr City. The median aligned busway was built in the right-of-way of a former tram line. While the busway does free riders from the burden of traffic jams, it lacks many features of true bus rapid transit (BRT) (see section 3.5). Busway segregation is poorly enforced and it is not uncommon to see private cars and tuk-tuks using the corridor. No form of off-board fare collection exists. Level boarding is not achieved anywhere along the corridor. Most bus stops on Mostafa El Nahaas do not have a shelter and shelters that do exist are in poor condition. Pedestrian access is poor and the placement of the shelters along the corridor forces passengers to walk in the busway to enter them.

Figure 10: The Mostafa El Nahaas busway in Nasr City offers dedicated, median-aligned bus lanes (top left), but lacks other essential features of BRT, including level boarding and off-board fare collection. Passengers struggle to board buses with multiple steps (top right). Shelters are poorly designed (bottom left) or entirely absent (bottom right).

3.2 Public transport proposals

A number of projects are underway to improve public transport service in Greater Cairo:

- A pre-feasibility study for BRT in New Cairo under the auspices of the General Office for Physical Planning (GOPP) and the New Urban Communities Authority (NUCA). While the initial geographical scope for this study was limited to New Cairo, consultants Menarail and Logit have proposed to extend the corridor along the Mostafa El Nahaas busway, potentially upgrading the Nahaas to fully featured BRT. This project is supported by the European Bank for Reconstruction and Development (EBRD).
- CTA restructuring and busway project. The World Bank is providing funding to the Cairo Governorate to prepare a plan for the restructuring of CTA and to identify 50 km of busways in

Cairo. The government has hired local consultant ACE and Danish consultant COWI for this work.

- Pending the outcome of the CTA restructuring study, the World Bank has proposed to fund the purchase of 500 new buses, consisting of 300 high-floor buses and 200 low-floor buses. As of now, these vehicles are slated for regular city bus operations and are not BRT-compatible.
- Construction of Metro Line 4 on Al Ahram Street. This project being implemented by the National Authority for Tunnels (NAT). The lead consultant is Nippon Koei. The funding agency is the Japan International Cooperation Agency (JICA). Construction is set to begin in January 2016 and will last for five to six years.
- 6th of October monorail project. Few details are available on this 52 km monorail project, which was recently announced by the Ministry of Housing.[4] The project is being implemented by the General Organization for Physical Planning (GOPP) under a public private partnership arrangement with Bombardier, Orascom, and Arab Contractors.

3.3 Preliminary data collection and results

As a first step toward assessing the potential for BRT in Greater Cairo, ITDP reviewed information on bus and minibus route itineraries provided by the World Bank in the form of an ArcGIS shapefile. The data included information on 366 bus routes and 98 minibus routes (Figure 11). The route database is incomplete and contains some errors. However, the data allowed ITDP to get a sense of the extent of the existing network and make informed decisions on where to locate frequency and visual occupancy (FVO) survey points.

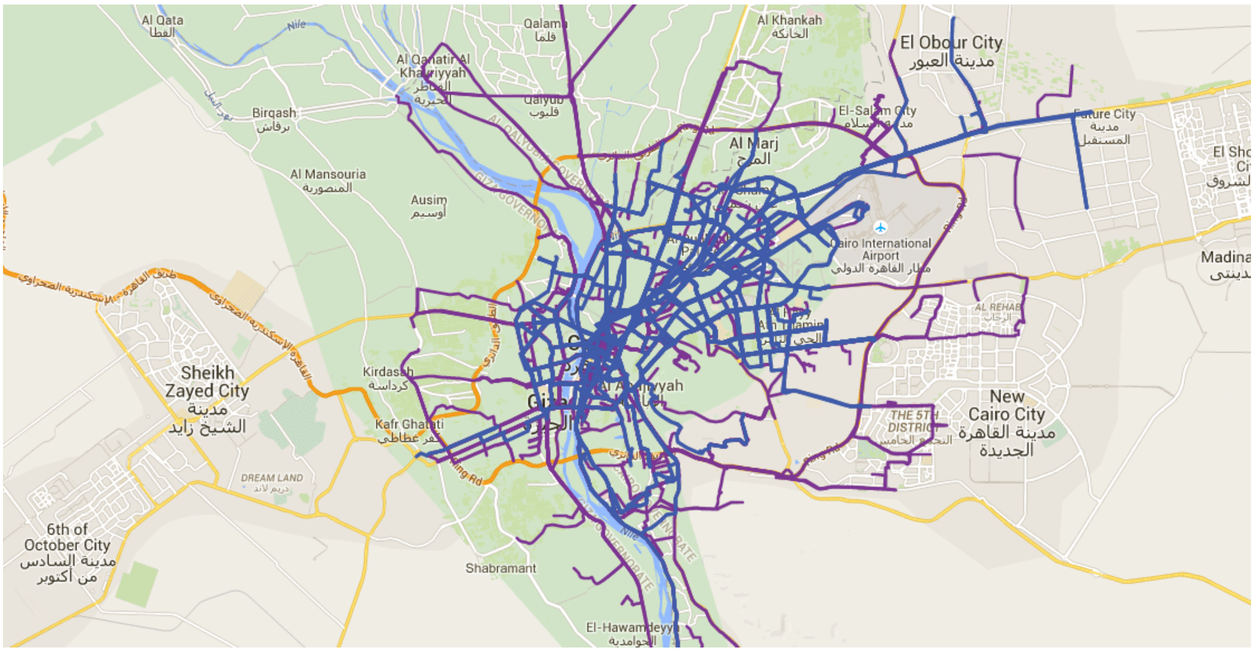


Figure 11: Existing bus (purple) and minibus (blue) routes in Greater Cairo.

[4] http://egyptianstreets.com/2015/05/02/first-monorail-to-be-launched-in-egypt-in-2018/

To provide an initial estimate of the potential demand for improve public transport services, ITDP conducted a frequency and visual occupancy (FVO) survey in Giza, Cairo, and New Cairo. An FVO survey indicates how frequently each bus route runs and the approximate occupancy of each vehicle. The purpose is to get a sense of existing bus demand on public transport corridors in order to determine where BRT in Greater Cairo could be most successful. Over a period of one week, the FVO survey was performed at 23 different points with two surveyors for each direction of traffic. Surveyors were students at the University of Cairo, and managed by UN Habitat and ITDP. Surveyors recorded observations over the morning peak period, from 8:30 to 11:30 a.m. The FVO data provide information for estimating the total bus and minibus frequency and loads on each road surveyed.

Figure 12: Surveyors recorded the number of passengers on each public transport vehicle during the morning peak period.

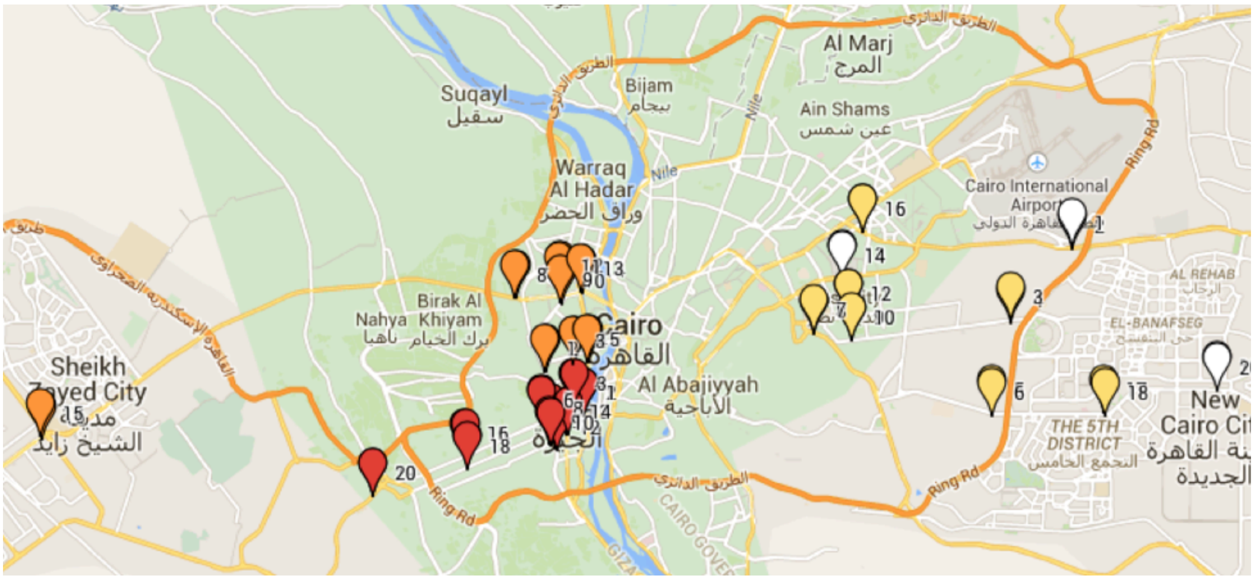


Figure 13: Frequency-occupancy survey locations.

After analysing the survey results, ITDP determined that the busiest hour during the peak period was from 8:45 to 9:45 a.m. Passenger loads were calculated for the peak hour at each survey location

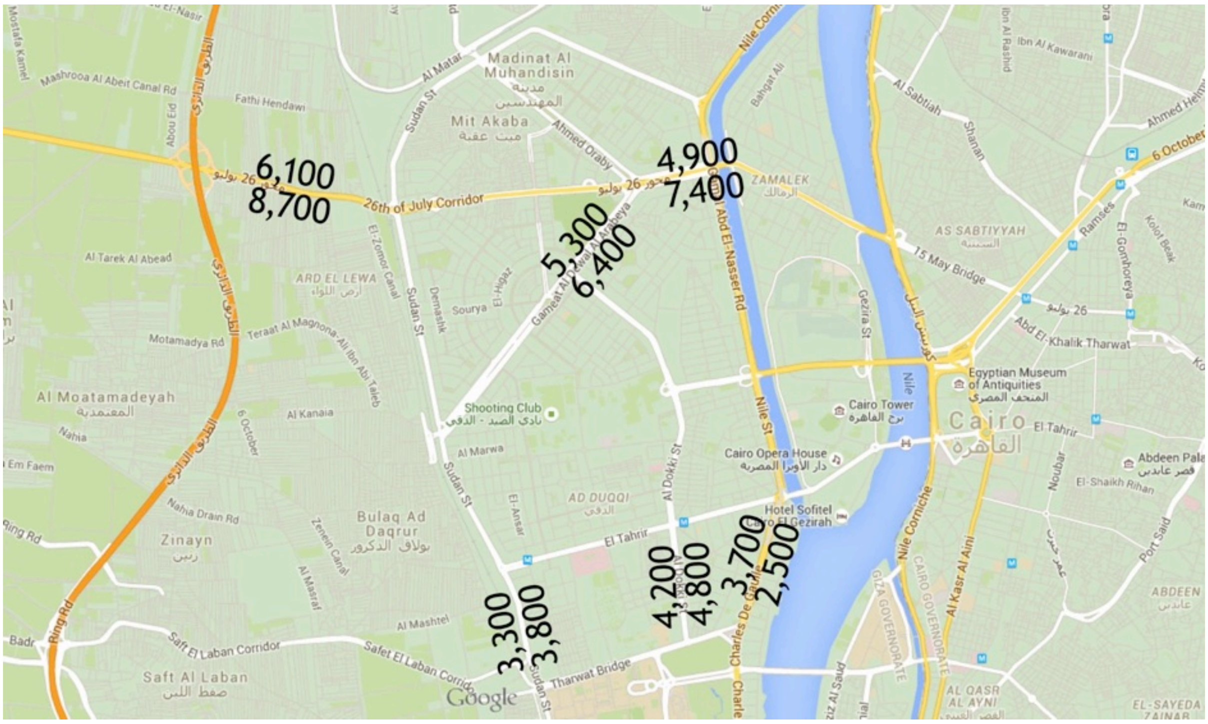
(Table 1 and Figure 14). An existing public transport demand of 3,000 passengers per hour per direction (pphpd) is generally the minimum demand needed to justify a BRT investment on a particular corridor. The FVO survey found sufficient demand for a BRT corridor on several roadways in Giza, Nasr City, and New Cairo.

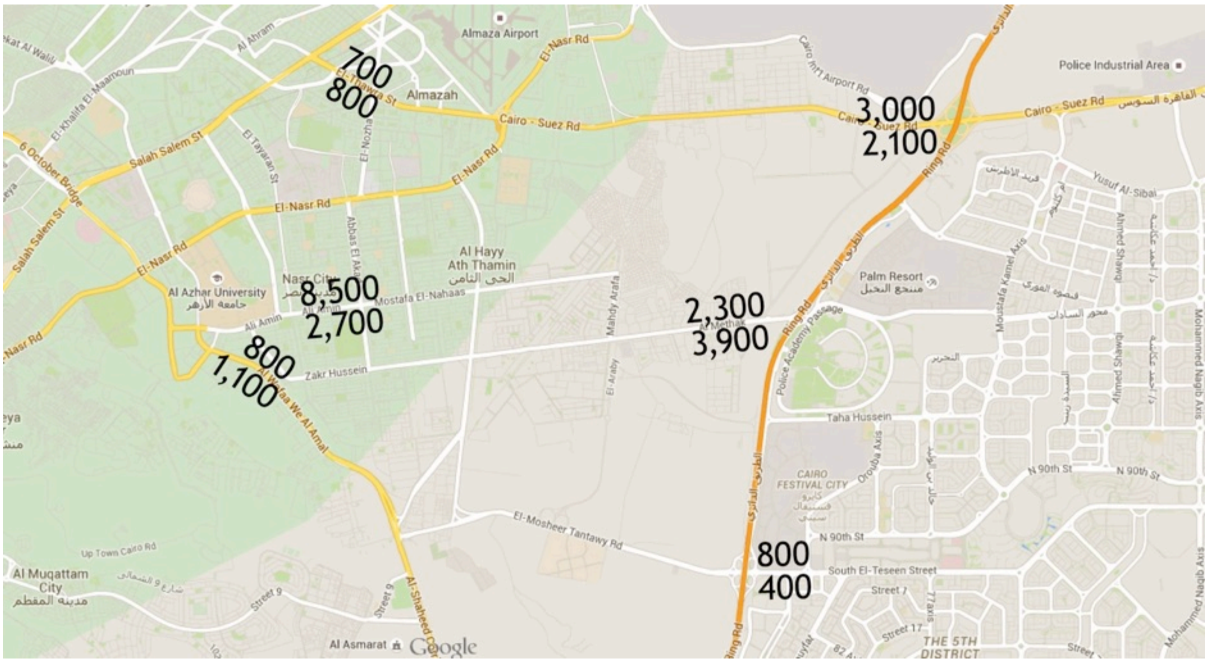
Table 1: Observed public transport and paratransit demand

Street	Direction	Passengers per hour per direction (pphpd)
Abbas Bridge	Eastbound	3,400
Abbas Bridge	Westbound	4,000
Cairo University Rd	Northbound	8,900
Cairo University Rd	Southbound	3,800
Faisal St east	Eastbound	5,200
Faisal St east	Westbound	4,200
Al Ahram St east	Eastbound	4,500
Khatem El Morsaleen	Westbound	2,000
Khatem El Morsaleen	Eastbound	1,100
Tala Mohammaed Saed Allah	Southbound	2,100
Tala Mohammaed Saed Allah	Northbound	3,000
Salah Salem	Southbound	6,800
Salah Salem	Northbound	5,300
Faisal St west	Westbound	4,000
Faisal St west	Eastbound	3,200
Al Ahram St west	Westbound	5,700
Al Ahram St west	Eastbound	5,200
El Faoum Desert Rd	Westbound	5,100
El Faoum Desert Rd	Eastbound	5,500
Sudan St	Southbound	3,200
Sudan St	Northbound	3,700
Al Dokki St	Southbound	4,200
Al Dokki St	Northbound	4,800
El Giza St	Southbound	3,600
El Giza St	Northbound	2,400
26th of July east	Westbound	6,000
26th of July east	Eastbound	8,700
Gameat Al Dewal	Southbound	5,300
Gameat Al Dewal	Northbound	6,300
15 May Bridge	Westbound	4,800
15 May Bridge	Eastbound	7,300
Ahmed El Zomor	Westbound	2,300
Ahmed El Zomor	Eastbound	3,900
Tantawy Rd	Westbound	800

Street	Direction	Passengers per hour per direction (pphpd)
Tantawy Rd	Eastbound	400
Al Mokhaym Al Daem	Westbound	800
Al Mokhaym Al Daem	Eastbound	1,100
Mostafa El Nahaas	Westbound	8,500
Mostafa El Nahaas	Eastbound	2,700
El Teseen St	Westbound	3,000
El Teseen St	Eastbound	600
Cairo-Suez Rd	Westbound	3,000
Cairo-Suez Rd	Eastbound	2,100
El Thawra St	Westbound	700
El Thawra St	Eastbound	800

Figure 14: Observed public transport and paratransit demand (passengers per hour per direction) (continues on next page).





3.4 Corridor selection

Opening the first phases of BRT in Cairo in areas in which there is high demand will help demonstrate the viability of BRT. Specific BRT corridors for Cairo and Giza were determined after carefully evaluating a number of parameters including:

- Existing conditions peak hour passenger travel demand patterns
- Future year travel demand and proposed projects
- Right-of-way (ROW) availability along various corridors
- End-to-end connectivity and ease of access

- Potential to serve users across all socioeconomic groups
- Minimal passenger transfers
- Minimal land acquisition

Peak hour passenger travel demand patterns were analysed and high demand corridors were determined. Next, the ROW of major roads was determined using information available from official sources and Google Earth.

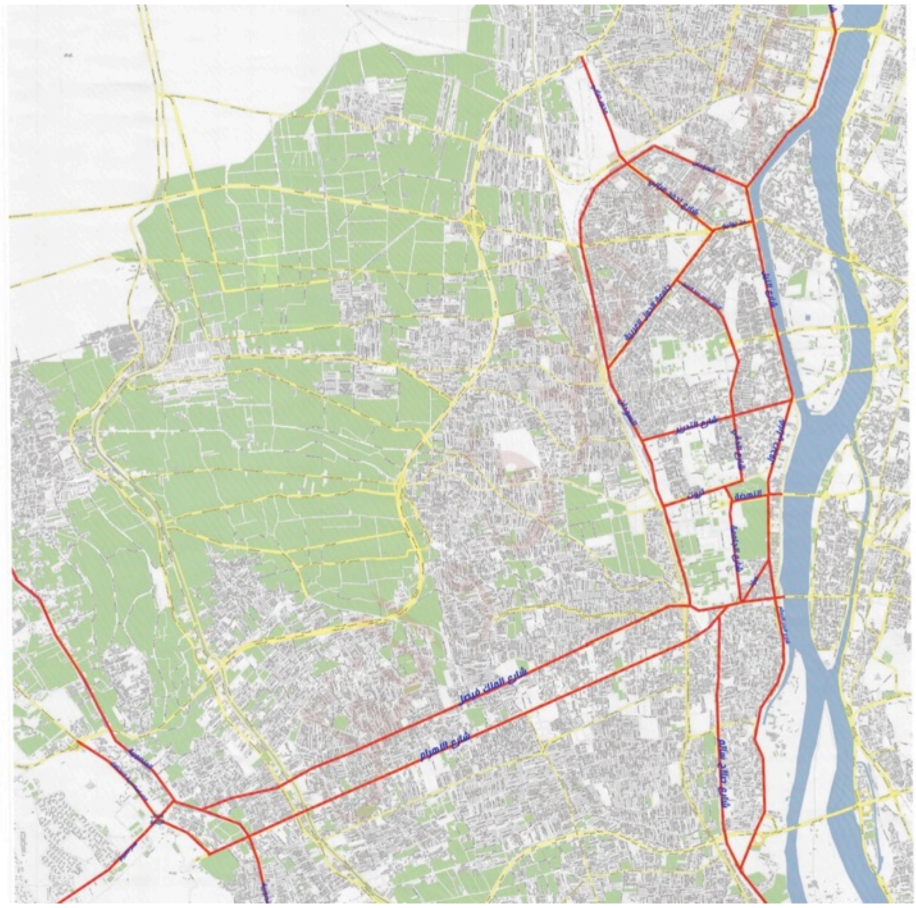


Figure 15: Map showing streets with a right-of-way of 30 m or above in Giza

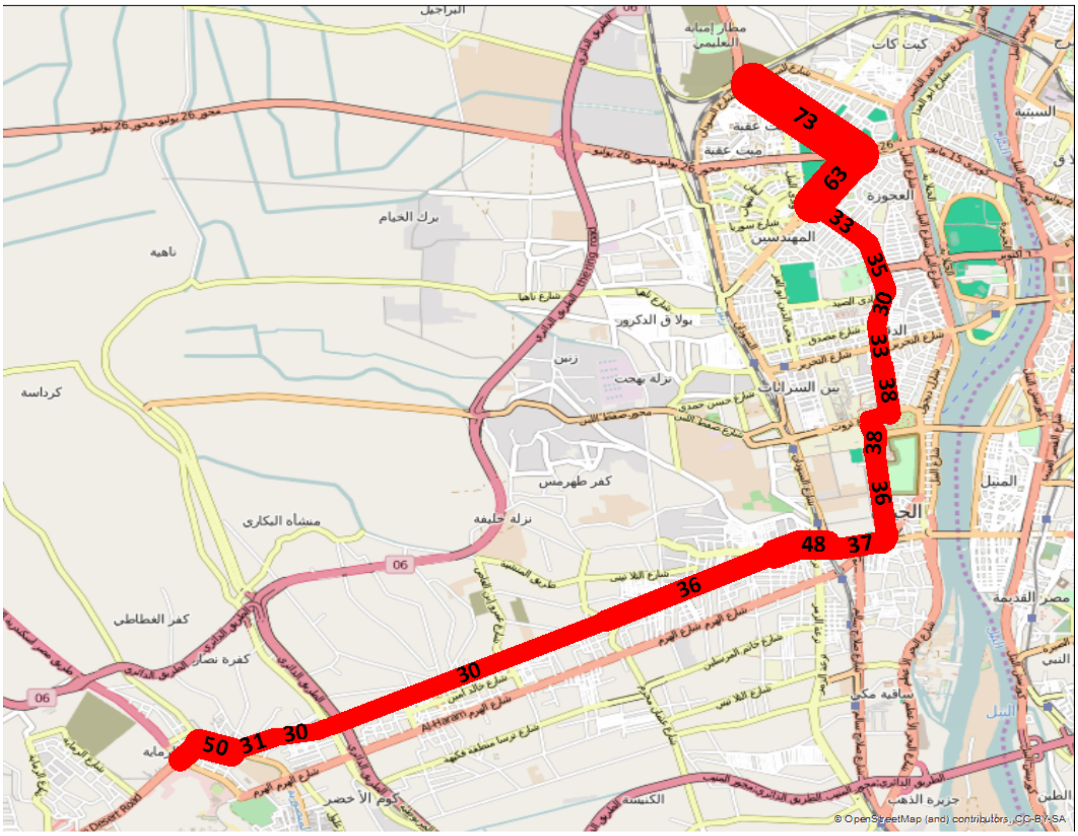


Figure 16: Map displaying street widths (m) on segments of the Faisal Corridor

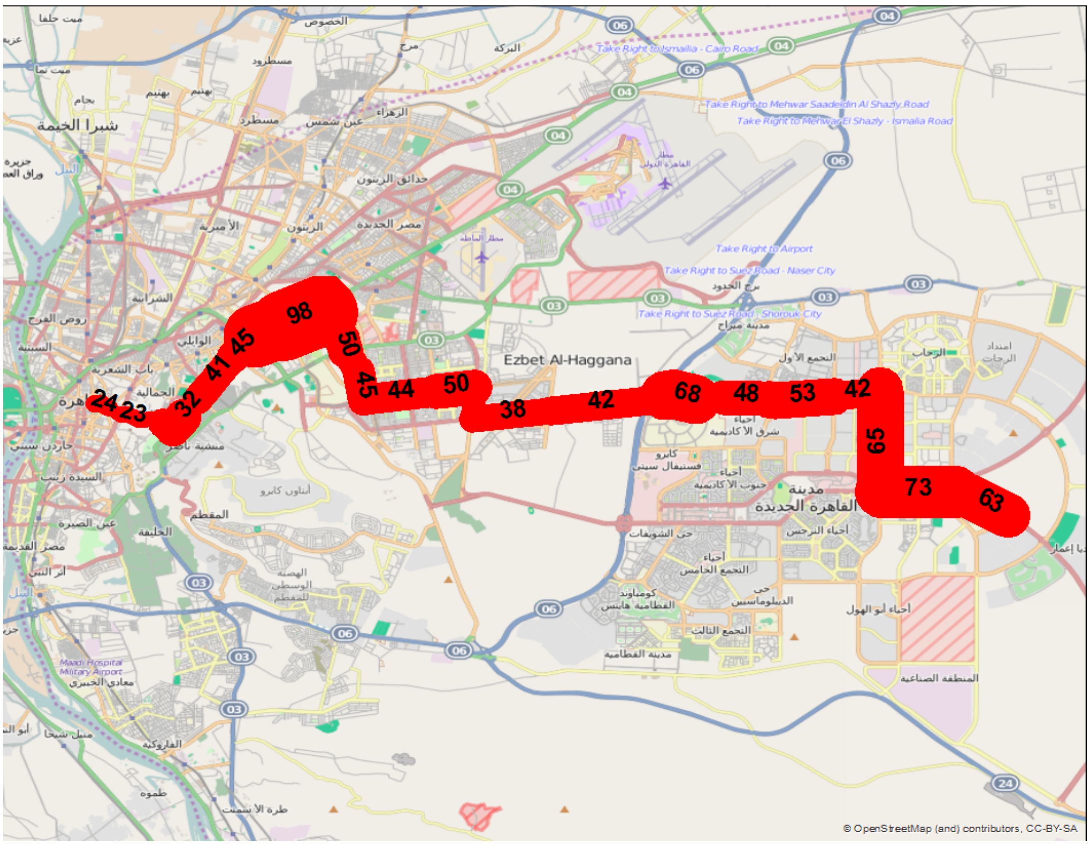


Figure 17: Street widths (m) on segments of the proposed corridor in New Cairo.

In Giza, ITDP worked with the Giza Governorate to identify a potential BRT corridor running from Remaya Square on King Faisal Street, Cairo University Road, Al Dokki Street, and Gameat Al Dewal Al Arabeya before terminating at Ahmed Oraby. This corridor alignment has a total length of 16.1 km and will provide service to many of the segments at which high passenger volumes were observed during the FVO survey. The observed pphpd reached as high as 5,200 on King Faisal Street, 6,400 on Gameat al Dewal, and 9,000 in Cairo University road. This would lead to significant demand on opening day. The roads used in this alignment also have ample ROWs.

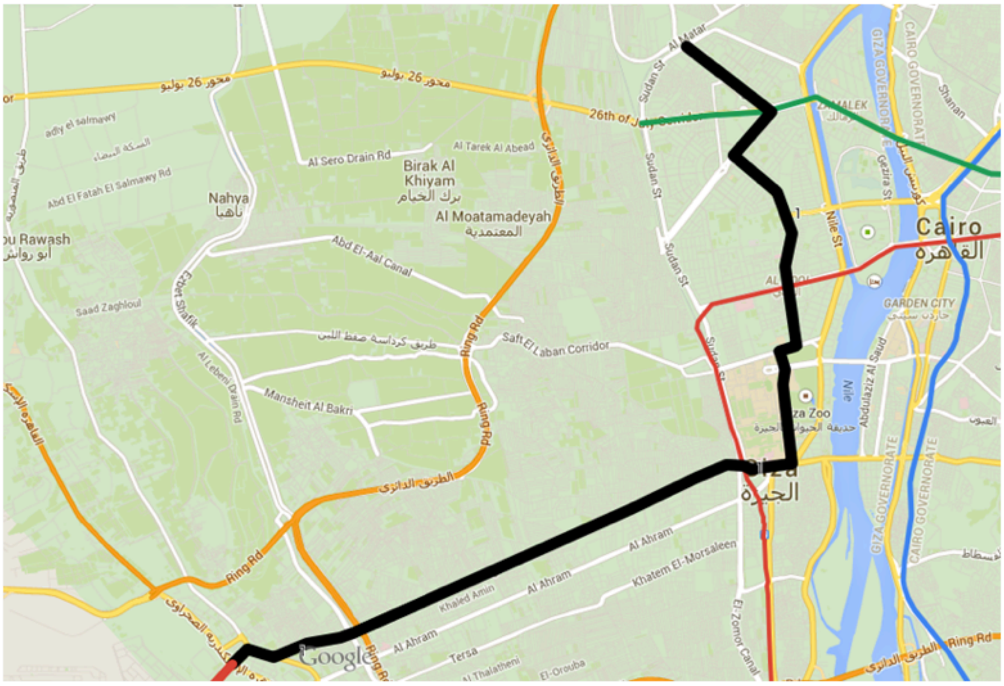


Figure 18: Proposed Phase 1 Corridor in Giza

On the eastern side of Cairo, ITDP studied the various access routes to New Cairo in order to determine which corridor would provide optimal connectivity to New Cairo while also serving intermediate destinations such as Nasr City. It is crucial that any such corridor takes advantage of the existing demand and dedicated right-of-way on Mostafa El Nahass.

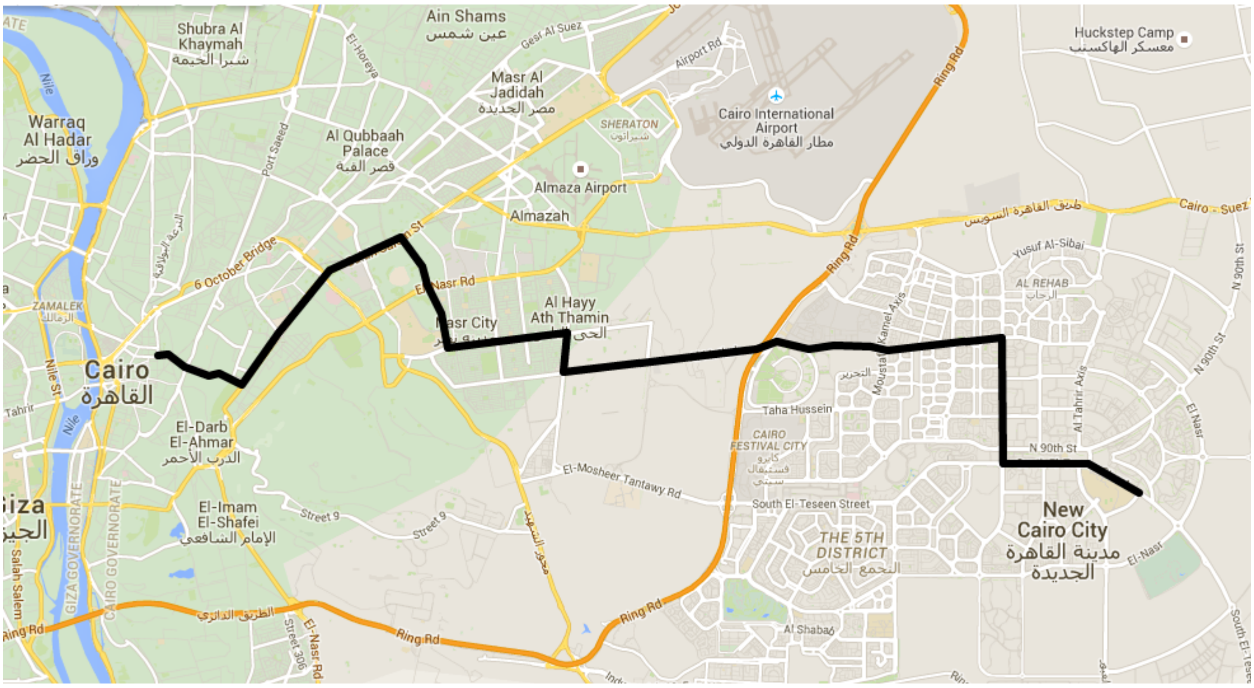


Figure 19: Proposed phase 1 corridor connecting the new American University in Cairo campus to Al-Ataba Metro station where Lines 1 and 3 meet

At 34.1 km, this corridor would provide a connection from New Cairo City in the east, through Nasr City before terminating in Cairo. It will travel on South El Teseen Street, Mohammed Nagib Axis, Al Methak, Mostafa El Nahass, Youssef Abbas, Salah Salem St, and Al Azhar. This alignment would meet the Ministry of Housing's General Office for Organization for Physical Planning's desire to build a BRT connecting New Cairo to the Cairo while serving significant existing demand on key stretches. Among these key stretches are Al Methak and the existing busway on Mostafa El Nahaas. A pphpd of 3,900 was seen on Ahmed El Zomor and a pphpd 8,500 was recorded on the Mostafa El Nahass busway.

3.5 Achieving gold standard BRT

As implementing agencies begin the planning process for BRT, it is essential to establish consistent design standards to ensure that Greater Cairo's new BRT corridors meet international best practices in BRT design. One resource that can guide this process is the BRT Standard,[5] which was developed to create a common definition of bus rapid transit and recognize high-quality BRT systems around the world. It also functions as an evaluation tool to guide municipalities as they move through the design process.

The Technical Committee of the BRT Standard comprises globally renowned experts on BRT. This committee serves as a consistent source of sound technical advice with respect to BRT and is the basis for establishing the credibility of The BRT Standard. The BRT Standard will serve as the basis of ITDP's corridor design recommendations for Giza and New Cairo. These corridors should, at the very minimum, include the BRT Basics as outlined in the BRT Standard 2014. The BRT Basics are essential features of a BRT system: dedicated right-of-way, median busway alignment, off-board fare

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[5] http://www.brtstandard.org

collection, intersection treatments, and platform level boarding. These elements are described in more detail later in this section.

ITDP recommends that Greater Cairo aim higher than just achieving the Basics: all corridors in the city be built and operated as gold-standard BRTs. Gold standard features are fully justified in the high-demand corridors in Giza and New Cairo. These projects have the potential to become an important catalyst for expansion of the BRT system and other sustainable transport projects in Greater Cairo.

3.5.1 Dedicated right-of-way

A dedicated right of way is essential to ensure that buses can move quickly and without interruption by traffic movement. The separated right-of-way should be segregated from mixed traffic lanes with physical delineators. The BRT Standard awards eight points to corridors with dedicated lanes and full enforcement or physical segregation applied to over ninety per cent of the busway corridor length.

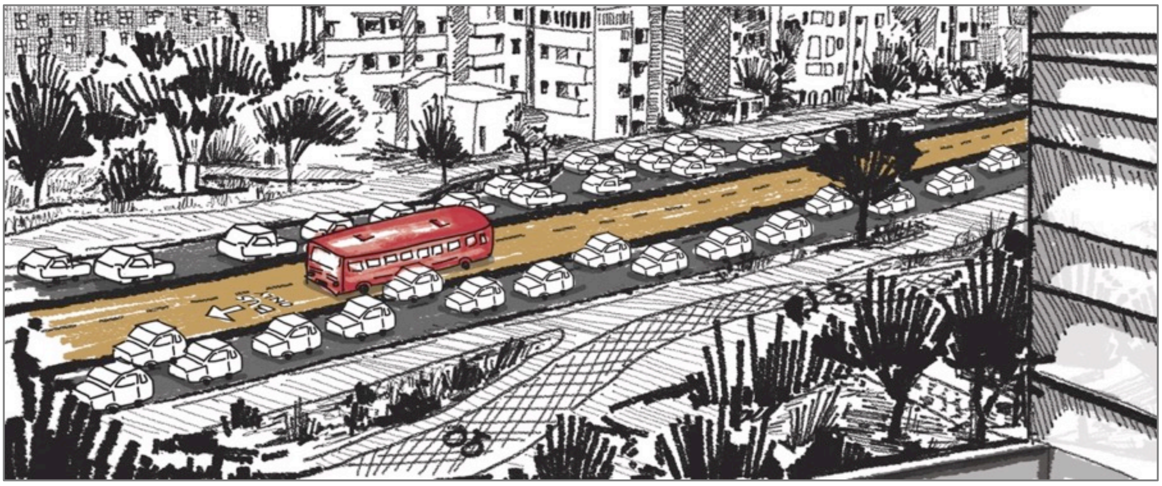


Figure 20: A dedicated right-of-way increases bus speeds and improves reliability.

3.5.2 Median busway alignment

The busway should be located where there is minimum conflict with mixed traffic, turning movements, on-street parking, and property entrances. Kerb-aligned bus lanes face many conflicts with mixed traffic. Right-turning vehicles and vehicles needing to access the kerb will be a constant presence in a curb-aligned bus lane. The central verge alignment is recommended as it remains free of obstructions, reduces turning conflicts and delay, and increases the speed and capacity. A two-way, median-aligned busway in the central verge of a two-way road receives eight points in the BRT Standard. A curb-aligned busway on a two-way road would receive no points.

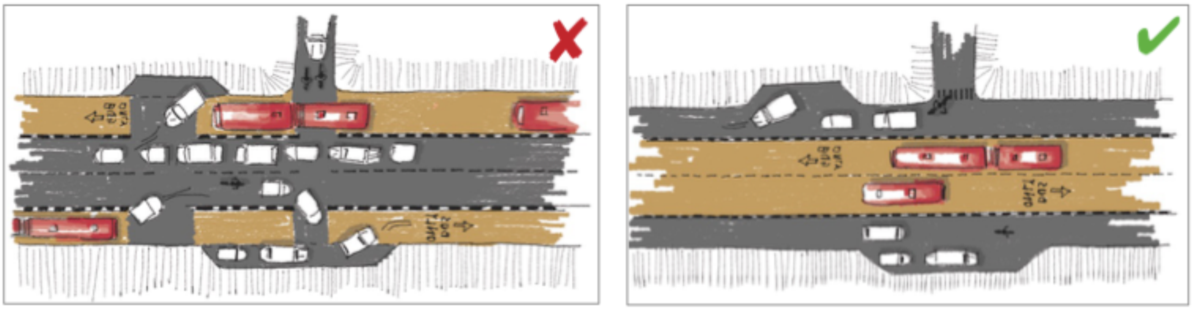


Figure 21: Median alignment of the busway minimises conflicts at intersections and property entrances and reduces the risk of encroachment on the busway by parked vehicles.

3.5.3 Platform-level boarding

Having the BRT station platform level at the same level as the bus floor is one of the important ways that BRT systems reduce boarding and alighting times at station. The platform should be at the same level with a minimal gap between vehicles and the platform. Level boarding makes the system accessible to seniors, disabled, and people with luggage. Reducing the boarding and alighting times means the buses can move more quickly, saving operating costs and therefore, making the system more financially stable. Having 100 per cent of buses with platform level boarding at BRT stations and system-wide measures to reduce the boarding gap account for 7 points in the BRT Standard.

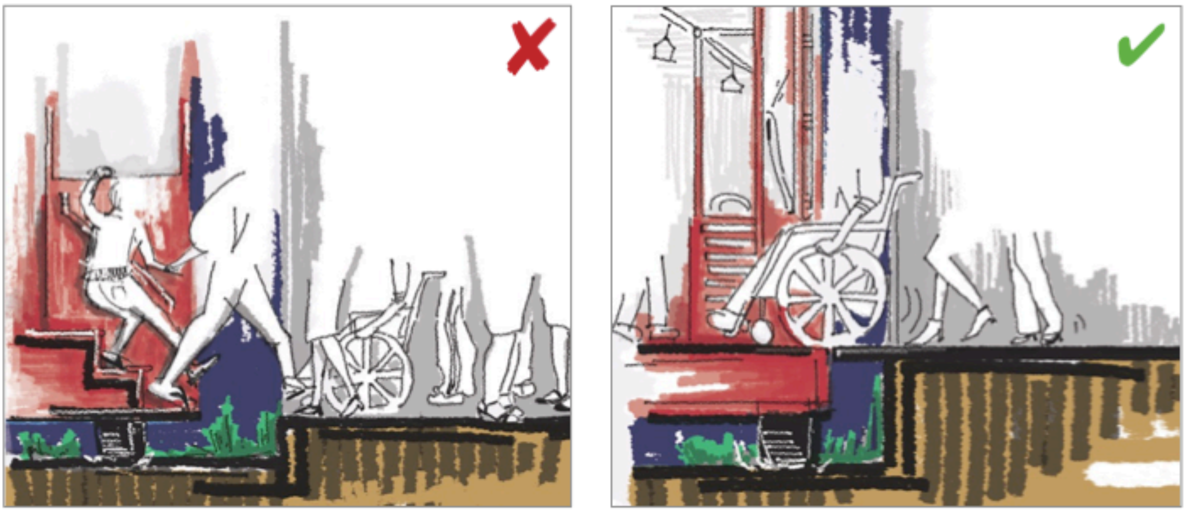


Figure 22: Stepless boarding between buses and stations reduces delays and makes the system accessible to all users.

3.5.4 Off-board fare collection

Off-board fare collection reduces travel time, improves the customer experiences, and prevents revenue leakage. A barrier-controlled system with turnstiles allows access when a user taps his/her smart card. The BRT Standard gives eight points to corridors with electronic off-board fare collection and seven points to corridors with proof-of-payment fare collection.

Figure 23: Off-board fare collection reduces boarding delays and revenue leakage.

3.5.5 Intersection treatments

Intersection treatment is another important element for ensuring bus speeds in the BRT lanes. Forbidding turns across the bus lane, minimising the number of traffic signal phases and activation of signal priority are some of the ways to reduce the delay and increase bus speeds. A corridor with all turns prohibited across the busway is rewarded with seven points.

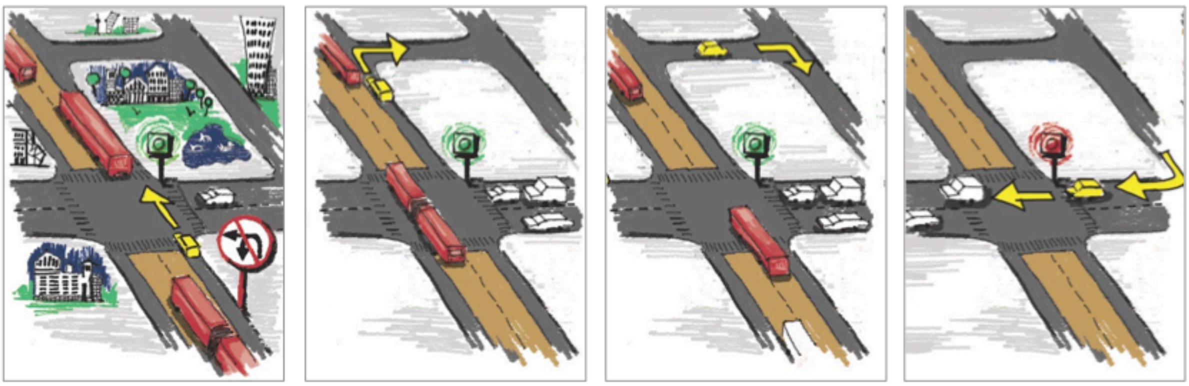


Figure 24: Preventing left turns and U-turns across the busway reduces delays and improves safety. As shown in the sequence here, three right turns can substitute for a left turn.

While the BRT Basics will create dramatic service improvements for bus riders in Giza and Cairo, the Phase 1 corridor should push to achieve Gold Standard BRT. Gold Standard BRT systems are consistent in almost all aspects with international best practice. These systems provide a high quality of service while operating at the highest level of efficiency. Gold Standard BRT systems can be found in Guangzhou, China as well as Bogotá and Medellin, Colombia. These systems have inspired cities across the globe to implement BRT and served as catalyst for further improvement of urban spaces in their home cities.

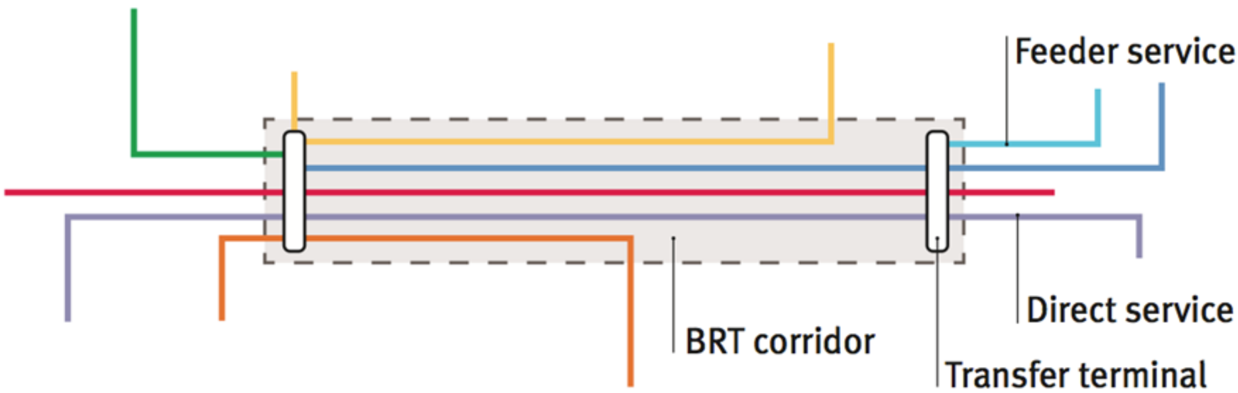
3.6 BRT service planning

In cities around the world, buses are the main form of public transport. This is true even in cities with extensive rail systems, including London, Mexico City, Hong Kong, and Singapore. Similarly, city buses form the backbone of Cairo's public transport network and will remain so even after a BRT system is implemented. Therefore, it is important to evaluate how easily the BRT system can be integrated with the city bus system. In this respect, BRT has a definite advantage over rail-based systems. Not only can the system provide cross-platform transfers between BRT and non-BRT services at integrated terminals, but BRT services themselves can leave the corridors to reach closer to passenger destinations. Such "direct services" bring the system closer to the user's doorstep, eliminating the need for transfers to intermediate modes or feeder buses. In the Guangzhou BRT system, all but one of the 40 BRT routes provides direct service outside the segregated corridor.[6]

It is especially important that the city's public transport system avoid increasing the number of transfers that customers are required to make. Any intervention that adds a transfer in such a short trip is likely to increase overall travel time, even if a new mode of transport offers somewhat higher commercial speeds. Thus, a BRT service plan for the Faisal-Oraby and New Cairo corridors should improve speed and reliability while minimising the need for transfers. A hybrid BRT system with a dedicated fleet of buses that operate in the network of dedicated lanes and as well as service extensions can help meet these objectives. BRT routes must operate as "direct services" that travel a distance outside the dedicated BRT corridors to reach important destinations. In doing so, the system can offer one-seat journeys for as many customers as possible.

A full service plan will indicate precisely which services should operate as part of the Cairo BRT system. The service planning process should consider all of the following types of services:

- Trunk services: Operating in trunk corridors
- Direct services. Operating in trunk corridors and then extending beyond the trunk corridor in mixed traffic lanes to provide better connectivity and attract ridership
- Feeder services. Operating in mixed traffic, bringing passengers to terminals and stations on BRT trunk corridors



[6] http://www.chinabrt.org/en/cities/guangzhou.aspx

Figure 25: The Cairo BRT should offer direct services to minimise passenger transfers.

Using the World Bank data, ITDP was able to identify nine existing bus routes that operate on Faisal Road (Figure 26) and 43 that operate on various segments of the north-south section primarily on Cairo University Road. Knowing which services are currently operating on the BRT corridor is an important first step and one that, in many other cities, takes a significant amount effort to determine. These routes more or less represent the existing demand patterns of public transport passengers. BRT services that mimic these routes should be tested in the BRT service planning exercises. Some will be converted into BRT services, while others will be shortened, or eliminated. When planning on the BRT project begins, the first step should be to test a number of possible service scenarios—at least ten—in a public transport model to determine the best service plan. The best service plan is the one that brings the most passengers to the BRT system at the least cost.

In order for the BRT project to be successful, existing bus routes cannot operate in parallel to the BRT services that have replaced them. There are a variety of tools for managing the elimination of bus, minibus, and microbus routes. Most importantly, it will be necessary to decide whether and how the BRT project will integrate the operators of these existing services into the BRT operations and provide accommodation for routes that remain off-corridor.

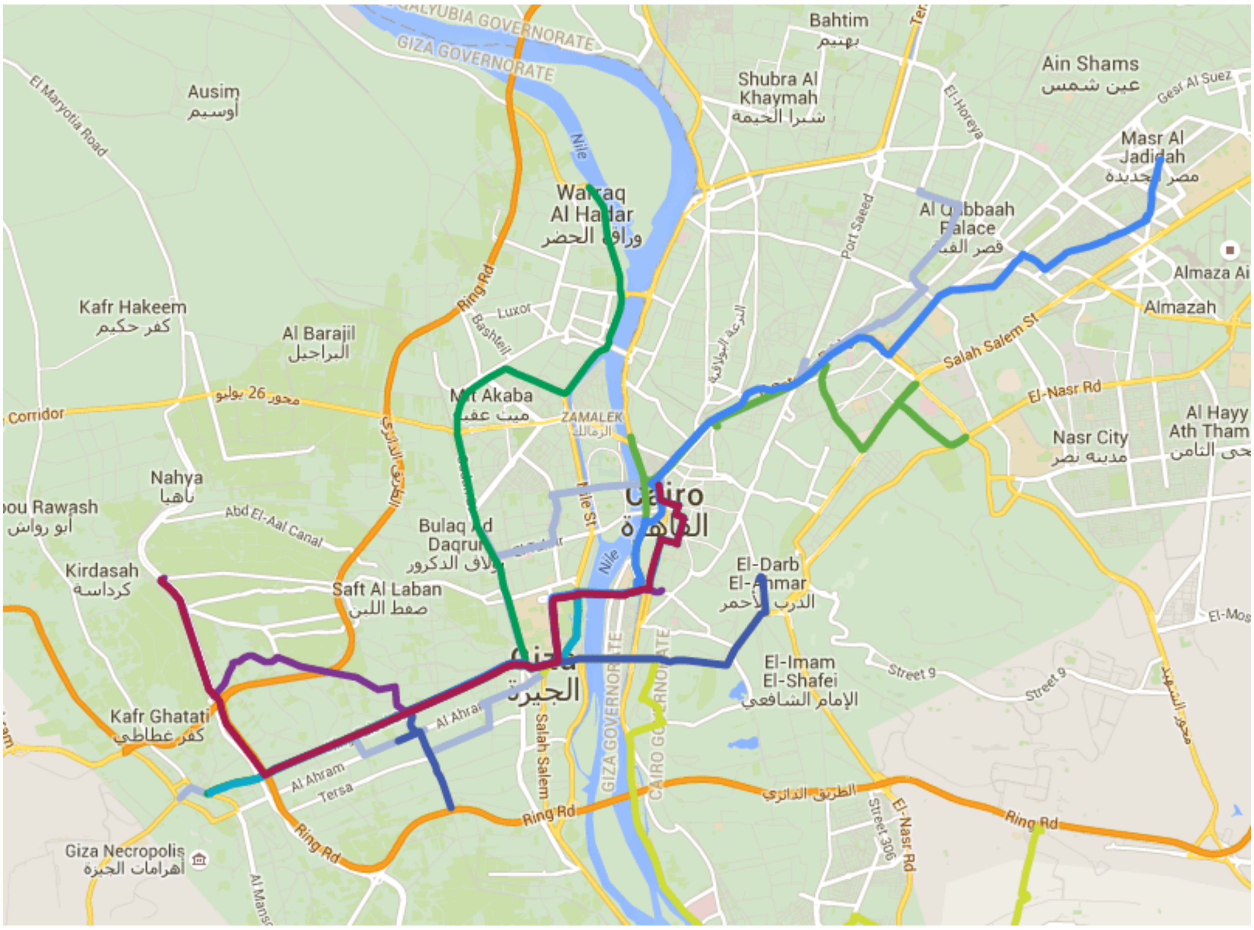


Figure 26: CTA bus routes that ply on Faisal Street

Based on observed passenger volumes, the BRT corridors in Giza and New Cairo warrant the introduction of high capacity articulated buses. The use of larger vehicles is necessary to maintain corridor frequencies below 50-60 buses per hour. Above this level, high frequencies may lead to bus bunching and saturation at BRT station. The corridors in Giza and New Cairo will require a fleet of 80 and 160 articulated buses, respectively.

Figure 27: Minimum required services (additional buses to be added depending on alignment of direct services)

Corridor	Corridor length (km)	Expected passenger load (with mode switching)	Required frequency (18 m buses)	Fleet size (18 m buses)
Faisal-Oraby	16.1	7,600	47	80
New Cairo-Nasr City-Central Cairo	34.1	New Cairo: 4,600 Nasr City: 10,000	New Cairo: 29 Nasr City: 63	160

3.7 Physical design

Physical design not only includes infrastructure construction but also requires careful planning towards addressing accessibility for passengers, traffic management, integration with other infrastructure, and provision for public utilities and landscaping.

3.7.1 Corridor cross section

A right of way with 30 m wide is available on many sections of the proposed corridors, allowing for two-way median BRT lanes, two carriageway lanes per direction, large footpaths with shade trees, and area for parking and for social uses such as public plazas or vending. The 3.3 m for single BRT lane in each direction and a 6 m carriageway width for two lanes each direction is taken as standard even for larger ROWs. Even as larger ROWs are available, it is recommended that this dimension be frozen and the additional space be prioritised for other uses besides traffic (such as pedestrians and cyclists). Keeping consistent carriageway widths will help prevent traffic bottlenecks.

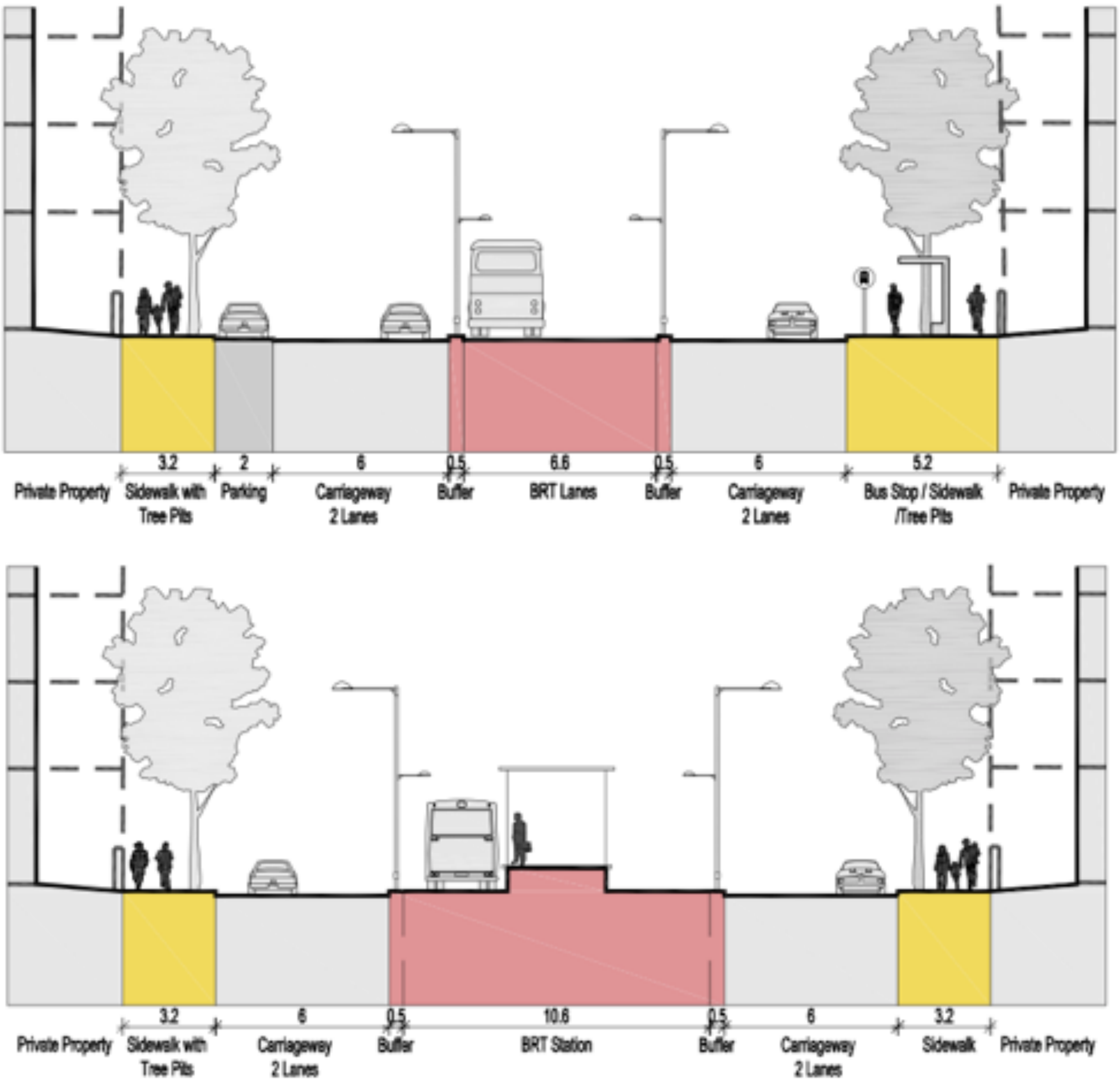


Figure 28: 30 m BRT corridor sections: without station (top) and with station (bottom).

Figure 29: Existing (top) and proposed (bottom) views of Faisal Street

3.8 Station design and engineering

An experienced architect should be hired to create beautiful stations that bring pride to Giza and New Cairo. The aesthetic design of a station is important as they demonstrate to the public that BRT is a lasting investment that providing tangible benefits to the area in which it is implemented. Each station will serve as a point of introduction for the system so it is important to leave riders with a lasting positive impression. A prominent, attractive station has the potential to inspire the communities around it while encouraging further improvement in the surrounding neighbourhood.

Figure 30: Iconic station designs, such as those in Rio de Janeiro's TransOeste corridor, can raise the profile of the BRT system.

In addition to aesthetics, stations and terminals must be carefully planned together with the vehicle design to ensure that level boarding is provided for all customers. This means that important vehicle characteristics such as interior floor height and vehicle width must be identified and verified as the station is being designed. Similarly, station platform dimensions must be determined well in advance of the bus fleet procurement to ensure that the floor levels of bus and station platform are sympathetic. Construction error tolerance is equally important, and must be vigilantly monitored so that the detailed project designs are appropriately implemented. Finally, once the system is operational, all vehicles must be consistently maintained so that tire-pressure and vehicle suspension performance do not create gaps between the vehicle floor height and the boarding platform level.

Figure 31: The design of stations and buses must be coordinated to provide level boarding.

It is important that Cairo plan for the infrastructure required by all BRT phases. Phase 1 terminals should be designed with extra capacity to accommodate future public transport demand. Stations and terminals should be designed in a modular format to facilitate future expansions.

BRT station design requires including basic aspects like platforms, transition areas and integration infrastructure to access stations. The station design and size can vary based on demand. In general, BRT station design is largely a function of user requirements:

- **Comfort**: Seats, leaning bars, and space for passenger movement
- **Safety**: Adequate lighting, visible interiors
- **Accessibility**: Minimal level differences and ramped access from street level
- **Aesthetics**: Attractive to passengers, giving a sense of ownership
- **Provision of customer information**: Both static and real-time

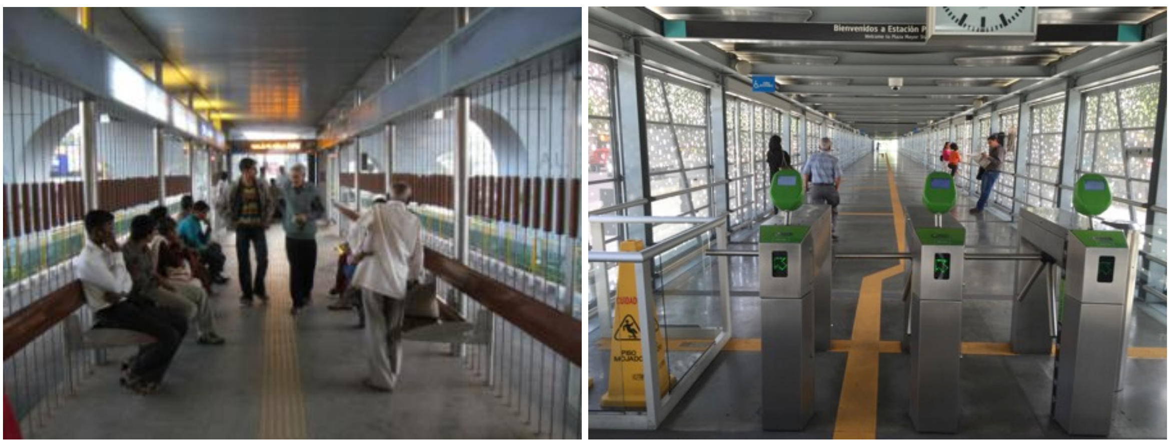


Figure 32: Station interiors should provide sufficient space for boarding, alighting, passenger circulation, and waiting.

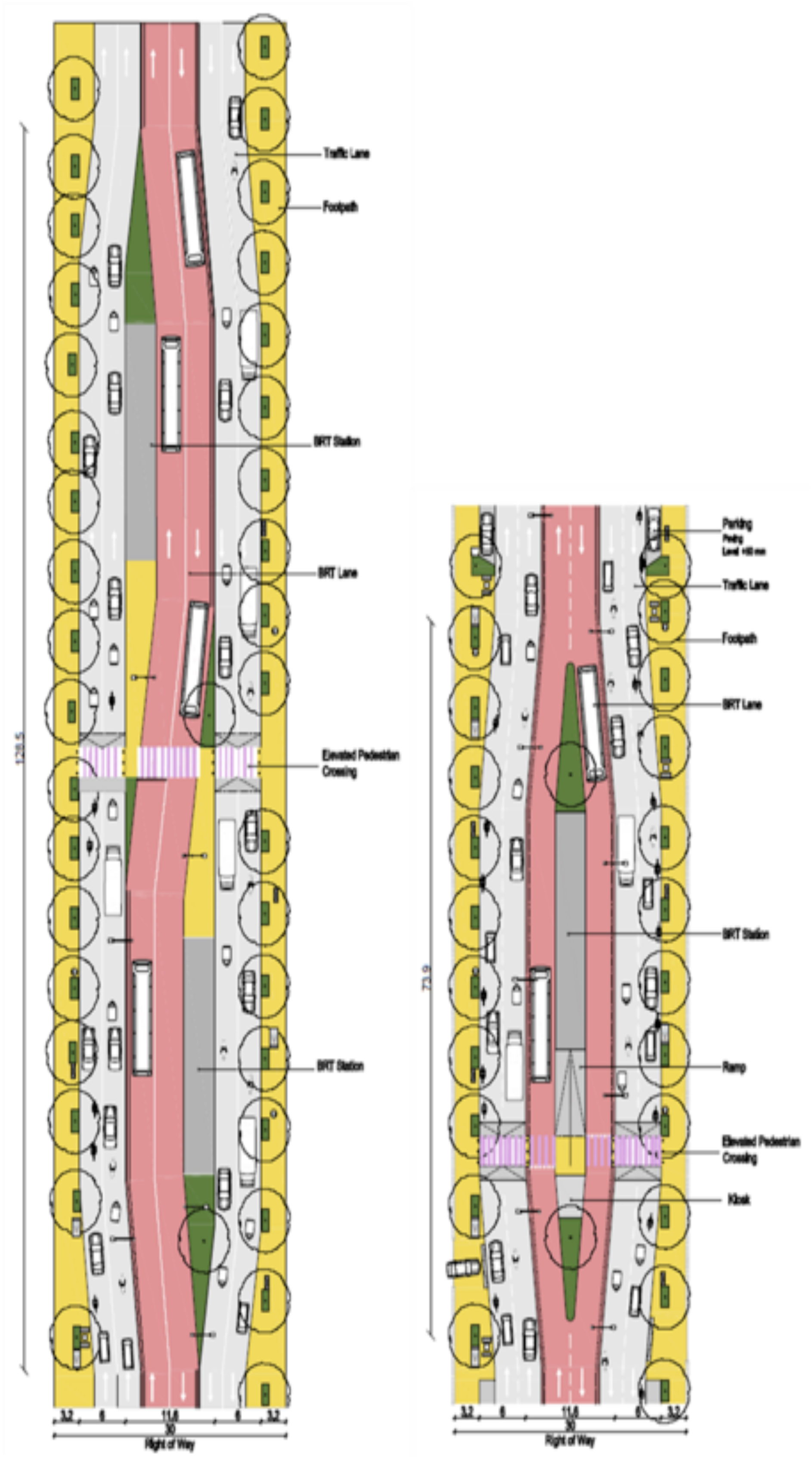


Figure 33: Curb aligned stations split for each direction take away more road space (left). Median stations serving both directions make transfers easier and tend to reduce both construction and operating costs (right).

High performance BRT systems utilise a single centrally located common station for both directions (like a typical railway platform) rather than having two bus stops, one for each direction. Such stations are positioned in the verge between the two directions of movement and offer access to buses moving in both directions. To access these stations, BRT buses with doors on the right side and no steps are required. More details on the vehicles are provided below.

There are many advantages of central stations:

- **Cheaper to construct and maintain**: Central stations are smaller and are up to 40 per cent cheaper to build and operate than two bus stations on either side of the central bus lanes.
- **Optimal use of street space**: Central stations require a single entry area and single set of turnstiles; whereas the two bilateral stations each require their own entry.
- **Easier customer transfers between routes:** Central stations make it easier for customers to transfer from one bus route to another without having to exit the station and cross a street, irrespective of the direction of the two routes.
- **Facilitates two-way bus access**: Platforms in each direction allow two buses to dock simultaneously at any given time.

Station sizing will largely be a function of peak passenger load expected for the future years. Stations in Cairo will generally require two docking spots per direction, one behind the other. Both docking positions must be able to accommodate 18 m articulated buses. Since Cairo will have 12 m and 18 m buses on proposed corridors, the recommended station length shall be 75 m with three main components: an access area (with wheelchair accessible ramps), a fare collection area, and a passenger circulation / boarding / alighting module.

Passing lanes at stations would allow some buses to bypass others at stations. Such a station would have multiple docking spots, called sub-stops. Each of the sub-stops may be independently accessed from the overtaking lane, without being obstructed by a bus docked at an earlier sub-stop. This feature expands BRT's capacity from 12,000 pphpd to 45,000. It also allows for the creation of express services that bypass certain stations. While it may be difficult to introduce passing lanes on corridors that have an ROW of 30 m or less, they should be included on corridors that have a width of 36 m or more.

Thus, depending upon the location and peak passenger demand, the length of stations, width and number of boarding platforms will vary. To allow greater flexibility, BRT stations are typically designed in such a way that new modules can be added as passenger demand increases. Extra space should be reserved in the median for adding additional modules in the future. Modules of 4.8 m x 4 m are the most appropriate to accommodate both 12 m and 18 m buses. Stations that provide connectivity between BRT corridors or between BRT and feeder services may require additional modules to handle expected passenger demand. The sizing of these stations will be determined after a detailed service plan is prepared.

Figure 34: Where possible, BRT corridors should be designed with passing lanes to increase system capacity and speeds.

It is recommended that stations be at least 4 m wide to provide room for waiting and circulation. In case of a single direction or one-way BRT lane, the station should have minimum width of 3 m and the station length depends on the number of docking bays and bus type. Key to the effectiveness of this station design is the staggered nature of the boarding areas. This maximizes the use of interior space and prevents customer congestion that may occur when vehicles travelling in opposite directions arrive at the station at the same time.

3.9 Intersection and signal design

The design of the intersections should facilitate the implementation of BRT by allowing two-way BRT movement in median lanes on all of these corridors. In particular, intersection designs should allow turning movements of BRT buses between phase 1 and future corridors. The BRT lanes generally should be planned at-grade to increase station siting options. The alignment of some tunnels from the original design proposal has been adjusted in the concept plan to accommodate these at-grade BRT lanes.

To prevent conflicts between mixed traffic and BRT buses, corridor designs should minimise weaving movements between mixed traffic and BRT lanes. Such movements introduce safety risks and result in slower speeds for BRT buses. Therefore, tunnels or bridges for mixed traffic should be designed as split tunnels that leave space in the median for BRT lanes. The concept plan ensures that mixed traffic can enter these tunnels without having to cross the BRT lanes.

Signal delays can lead to irregular arrivals of buses, or bus bunching, which reduces the reliability of a BRT system. Therefore, the design of intersections along the BRT corridors should minimise cycle times in order to reduce such delays. In general, this is done by limiting signal cycles to two phases. There are a number of possible ways to reduce the number of signal phases:

- Provide a two-phase "squareabout" in which vehicles that combines straight and left-turning movements in a single phase. BRT buses circulate along with mixed traffic during the same phases.
- Remove left turns at intersections and replace them with a series of right turns or right turns plus U-turns in the adjacent road network.
- Introduce grade separation of particular movements to simplify the remaining movements to two phases.

ITDP prepared a conceptual plan showing how these concepts can be implemented in the Orman Garden area of Giza.

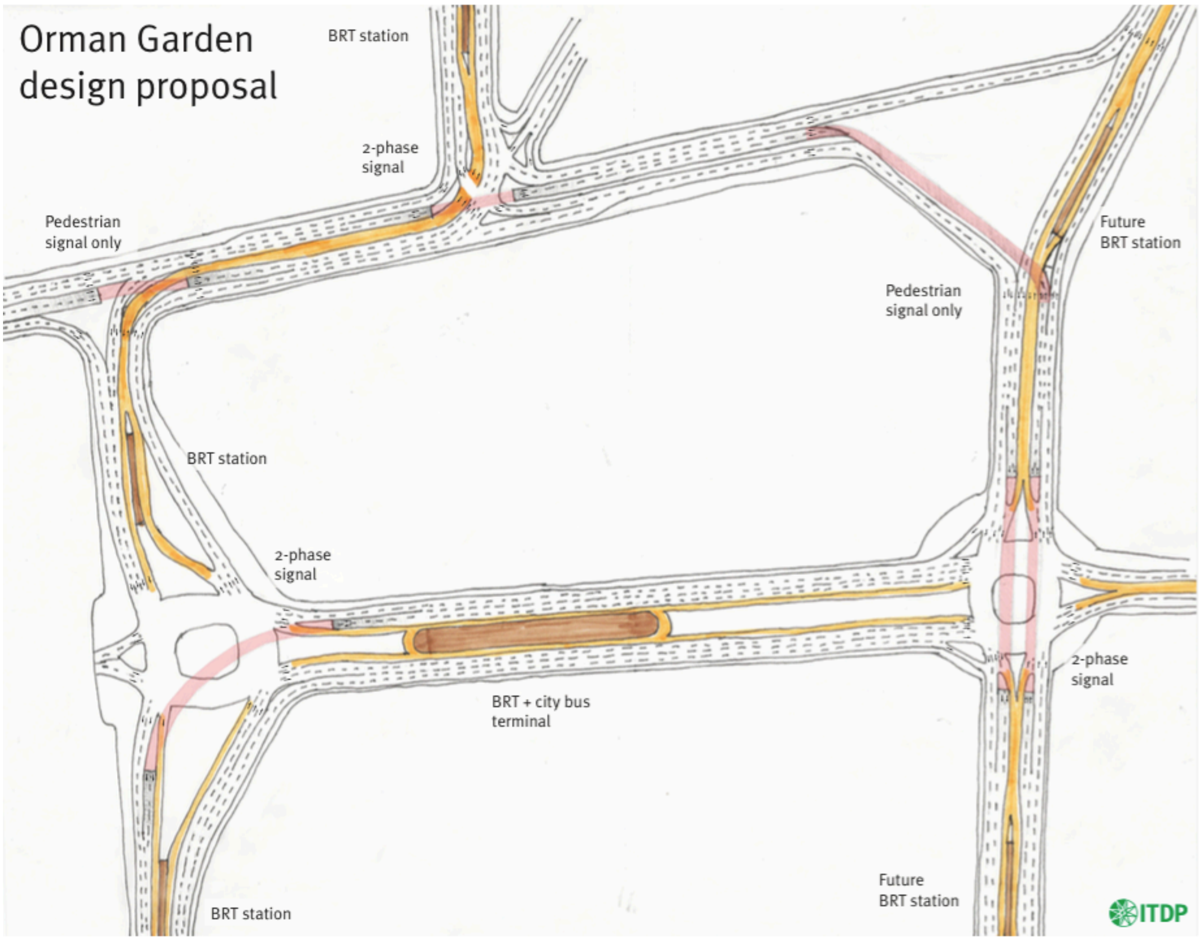


Figure 35: A circulation concept prepared for the Giza area of Orman Garden shows how intersections can be configured to facilitate BRT movements.

Figure 36: Two-phase squareabout intersection in Ahmedabad, India.

Figure 37: Signal phases in a squareabout intersection.

3.10 Pedestrian access

The design should promote safe, at-grade pedestrian access throughout the network. Continuous footpaths must be constructed along all streets. Intersections require pedestrian elements such as crosswalks, median refuge islands, and pedestrian signals. Pedestrian crosswalks can be constructed as “tabletop crossings” at the same height as nearby footpaths.

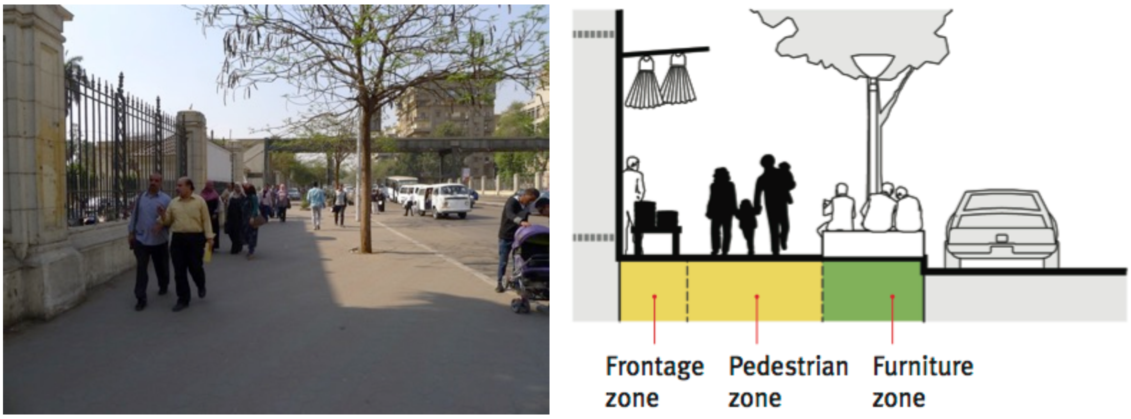


Figure 38: Footpaths along the BRT corridors should follow the zoning system, providing adequate clear space for pedestrian movement.

Figure 39: Access to midblock BRT stations should be provided through tabletop crossings at the same level as the adjacent footpath to improve accessibility.

3.11 Bicycle infrastructure

A BRT corridor is an ideal place to construct a bike lane. The primary reason is that the corridor is typically designed to facilitate through traffic. Turns are banned and signals are timed to give priority to the BRT vehicles, which in turn results in more green time for cyclists. The BRT corridor can double as a new spine of the bicycle network, especially if none exists. Lastly, integrating bike and BRT routes helps facilitate access to the corridor. A cyclist riding to the BRT station may enter the corridor at a number of points, then ride along the corridor to the station. He or she might choose to bypass a local or crowded station in favor of an express station. In general, physical separation of the cycle lanes is recommended. This provides cyclists with a clearly defined, safe space to travel. Ideally, bicycle lanes on the BRT corridor will be a part of a larger, connected cycling network.

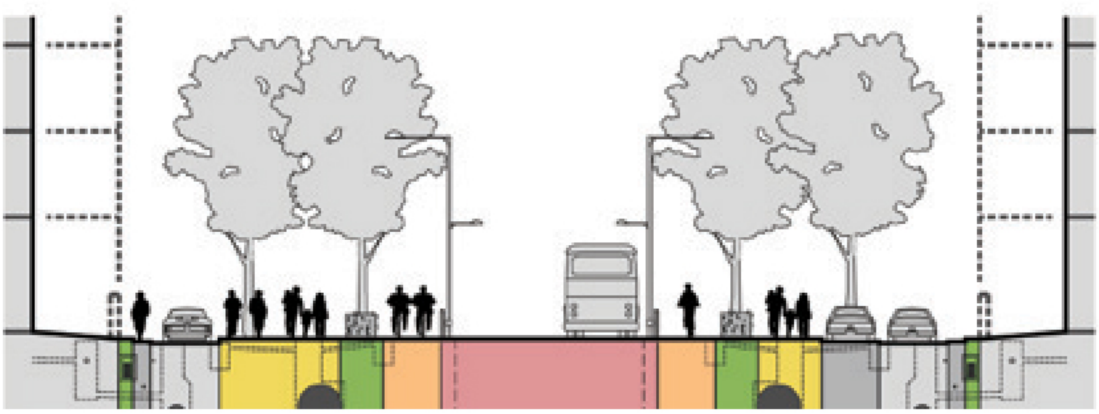


Figure 40: Example of 30m BRT corridor with physically separated bicycle lanes. In this example, bicycle lanes are aligned in the median. Private cars travel in a service lane.

3.12 Multimodal integration

The Faisal-Ahmed Oraby corridor will be located near existing Metro Line 2 and to-be-constructed Metro Line 4. Metro Line 4 is scheduled to begin construction in January of 2016. There will be an anticipated five to six years of construction to follow. It will mostly run under Al Ahram Street, approximately 1 km from the proposed Phase 1 BRT corridor. It is expected to have 680,000 daily passengers a day at opening. The Japanese International Cooperation Agency is funding the project.

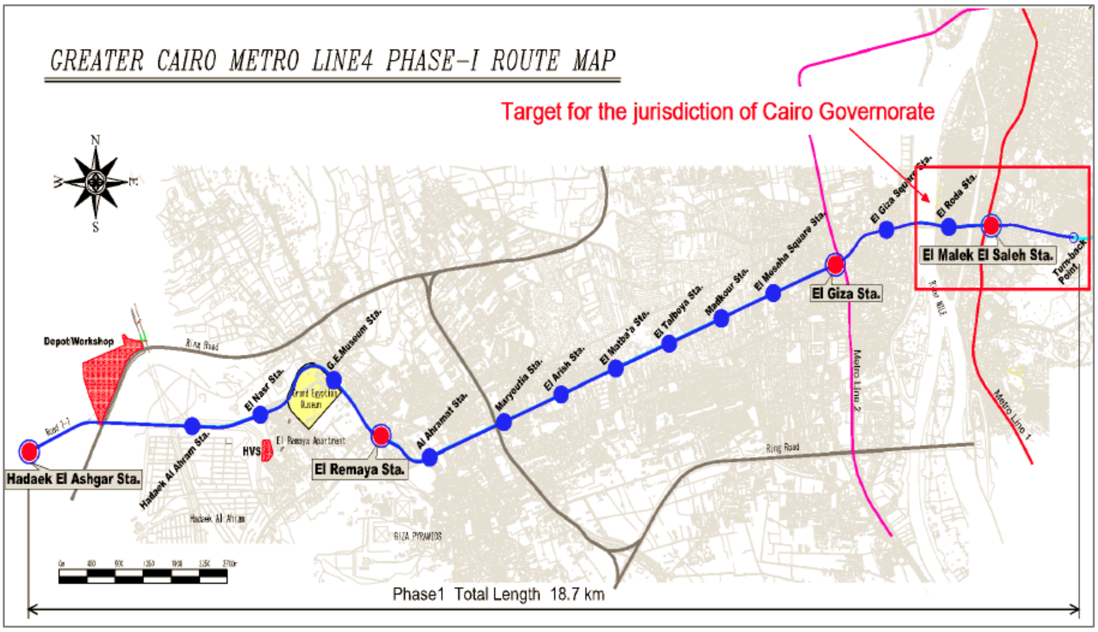


Figure 41: Map of planned Cairo Metro Line 4

It is important the proposed BRT corridor function as a part of the full public transport network in Greater Cairo. Therefore, efforts must be taken to ensure convenient transfers to the nearby metro lines. BRT-Metro transfer facilities should be implemented in at least two key locations: Metro Line 2’s El Dokki Station and Metro Line 4’s El Remaya Station. An example of how a metro-BRT interchange can function is demonstrated by Medellin’s Hospital transfer station where riders can transfer from the gold-standard Metroplús BRT to the Metro system. This ease-of-access creates a better experience for the passenger as it eliminates the need to cross lanes of traffic or face exposure to weather to make the transfer. The design of such transfer stations can be complex and the BRT team will need to work with the Metro Line 4 stations designer to create such a feature.

Figure 42: Passengers are able to easily access the elevated metro line via staircase without leaving the station.

3.13 Parking management

The supply of parking plays an important and unique role in the demand for travel as well as the basic functioning of transport system. Free parking in particular has adverse effects on public transport as it facilitates more and more usage of personal vehicles. Free parking or pricing below market rates is the leading cause of parking shortages, haphazard parking, pollution, and congestion due to extra driving in search of parking space. It is very necessary that local administrative bodies take control of public street space by managing parking as a service that comes with a price and is only permitted in clearly defined spaces.

Figure 43: Unorganised on-street parking occupies a large amount of road space and compromises pedestrian access. Defined parking areas and performance-based pricing can help improve

4. Institutional assessment

4.1 Integrated transport planning in Greater Cairo

Several agencies were found to be planning BRT and other rapid transit projects in Greater Cairo. These agencies include the Ministry of Housing’s General Organization of Physical Planning (GOPP), the National Authority for Tunnels (NAT), the three governorates of Greater Cairo, the Cairo Transport Authority (CTA), and the Ministry of Transport. However, at present there is little communication between the various agencies, ministries, and three governorates. It is crucial that these government bodies create a framework for cooperative action. An integrated transport system will require an integrated planning effort. Each new kilometre of rapid transit built will have to function as part of a network if they are to improve public transport in Greater Cairo. To facilitate cooperation, a BRT steering committee should be formed to bring together all of the agencies that are involved in BRT planning. This committee should meet on a regular basis (i.e., at least once per month).

For BRT, specifically, GOPP, the Cairo Governorate, and the Giza Governorate all have plans to implement BRT or busway projects. In order to provide coherent services spanning the entire city, the individual corridors will have to function as a network. Each line cannot stop at the boundaries between the governorates and the new communities. Not only do the corridors need compatible infrastructure and rolling stock, but operational elements such as scheduling, fare collection, customer information, and marketing should be coordinated over the entire network. Toward this end, a special purpose vehicle (SPV) should be formed to plan, implement, and operate BRT across Greater Cairo.

4.2 Special purpose vehicle for BRT

In order to facilitate the planning, implementation, and operation of BRT, it is essential to create a professional, robust management body to oversee the system. The primary mission of the SPV is to promote and implement a high quality BRT system. It is created as a separate government entity that oversees the planning and execution of the BRT system. The SPV will not operate the BRT directly, but will engage a number of private contractors to construct and maintain various elements of the system.

The articles of incorporation and by-laws of the SPV should facilitate technical autonomy and enable the possibility of receiving financing from public transport fare revenues, user fee (such as parking) as well as public funds. It is critically important that revenues received by the SPV be ring-fenced—that is, that all revenues received by the SPV be legally dedicated to that agency and not be permitted to be apportioned elsewhere. Also, given the level of specialisation and the quality of the personnel necessary to ensure efficient operations, the SPV should not be constrained by civil service pay scales. The SPV must ideally be permitted to hire and fire its own staff, outside of normal governmental hiring and firing procedures in order to ensure that the most qualified staff are employed by the SPV and working as efficiently as possible. The scope of work for the SPV must be exclusive and focused on towards successfully implementing the BRT system. That means that as the SPV is likely to have highly qualified staff, they must be dedicated solely to the implementation and management of the BRT and not be pulled away from their BRT-related duties to work on other projects.

4.2.1 SPV functions

The SPV will have the charge of the planning, creating sustainable infrastructure through increased mobility via the BRT system. In addition, once the SPV has become fully successful in the management of BRT operations, it may then take on the responsibility of overseeing the implementation of any future mass transport projects in the city. However, this should be a longer-term goal for the SPV. In the next several years, it is critically important that the SPV place its focus solely on the implementation of the BRT project. In general, the SPV will aim to maximise the quality of service at the minimum possible cost. The SPV will have a range of responsibilities, including the following:

- Operations management:
    - Monitor the operations of the BRT system, assuring adherence to service level standards.
    - Ensure safety and security on the BRT.
    - Oversee the collection of fare revenues from the BRT and issue payments to service providers.
    - Enforce penalties as detailed in the quality of service contracts for operators.
- Planning and regulation:
    - Plan for integrated operations of city buses, paratransit, and future mass rapid systems, including route definitions, schedules, fleet sizes, and physical infrastructure requirements.
    - Manage fare structures for the BRT.
    - Undertake regular assessments of travel patterns in order to expand as well as optimise BRT services.
    - Frame policies towards promoting sustainable transport and controlling the growth of private motor vehicle use.
    - Ensure that public transport vehicles satisfy the pollution control standards.
    - Ensure that the BRT right-of-way is well enforced and dedicated to BRT vehicles only.

    - Ensure that the traffic signals on the BRT corridor(s) remain functional and timed according to design
    - Ensure that buses, minibuses, and microbuses do not continue operating in parallel to the BRT except where the service plan allows it
- Project implementation and contracting of services:
    - Execute requests for proposals for the design and construction of various components of the BRT project, including but not limited to construction contracts, bus operator contracts, and fare collector contracts.
    - Procure services from private sector service providers for operating various services through fair competitive bidding process.
- Financial management:
    - Prepare financial plan for BRT operations.
    - Manage funds generated by the BRT system
- Marketing:
    - Employ print, radio, social media, and other mechanisms to promote the use of public transport.

4.2.2 SPV structure

An SPV should be created in the form of a government owned company with a young and dynamic team of specialists hired based on competence in management and transport planning. The SPV and its board should be seen as an impartial, autonomous body. The senior management of the SPV, including the CEO and heads of key departments, shall have autonomy to make routine decisions relating to planning and operations, as detailed in the previous section. The SPV shall have four primary departments: planning and design; operations; administration and finance; and communications and marketing.

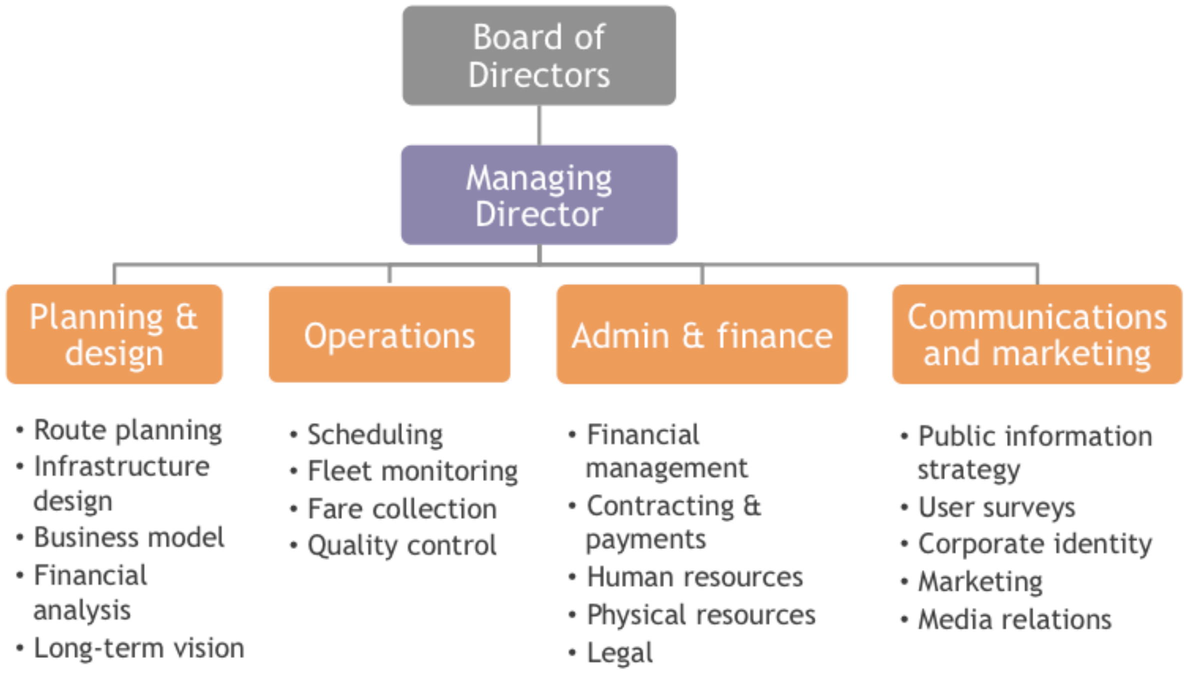


Figure 44: Special purpose vehicle structure.

A Board of Directors, potentially chaired by the Minister of Transport, will oversee the SPV management. The Board will play a role only in very important decisions on fare structure, system expansion, fleet procurement, and the implementation of policy-level decisions. The board of directors will include of the heads of various state and local entities including the Governorates, GOPP, and the Ministry of Interior's traffic division.

The Board may constitute an Advisory Panel comprised of technical experts as well as representatives of local academic institutions. Direct involvement of private transporters (bus or commercial vehicle operators) is not recommended as it can create conflict of interest during competitive bidding for operating contracts.

The SPV staff will function under special hierarchical structure only and each position of the staff will have a definite set of responsibilities and duties as well rights within the SPV organisational structure (Table 1).

Table 2: Roles and responsibilities of SPV staff

Position	Staff/Members	Responsibilities
Board of Directors	Minister of Transport Governor of Giza Governor of Cairo Representative, traffic division, Ministry of Interior Representative, GOPP	Take important decisions for improving the transport system (e.g. system expansion, fleet procurement, annual budget, implementation of infrastructure, etc.)
Managing Director (Full-time position)	Senior officer of the Government	Team leader of the SPV Financial approvals Putting proposals for major operational changes,

		system expansion, and expenditures to the Board of Directors.
Department Managers (Full-time positions)	Hired professional staff for Planning Operations Admin & Finance Communications & Marketing	Oversee day-to-day operations and planning activities, as per respective departmental responsibilities Report to CEO about functional and financial status of the SPV Identify bottlenecks, constraints in urban transport and propose solutions to CEO Execute contracts Assign responsibilities to the SPV staff
Other SPV staff (Full-time positions)	All the staff of SPV under Managers	Follow instructions and responsibilities allotted by directors Manage and execute day-to-day operations and planning activities, as per respective departmental responsibilities Monitor contracts

The SPV requires technically skilled and highly professional staff with field experience in similar areas of work. Department Managers should have managerial expertise and the ability to take strategic decisions. Staff at the deputy manager level and those under them should have technical expertise in the specific area of work (e.g. transport planning, transport engineering, economists, accounting, etc.). Within the sub-divisions, it is recommended to have a second rung of post-graduate trained professionals who would develop their careers within the SPV.

Table 3: Qualifications for SPV staff

Post	Required skills and experience
Managers	Managerial experience, understanding of technical and financial issues, excellent communications and public speaking skills, human resources experience. Capable of setting a vision for the organisation. Experience of at least 7 years is required.
Deputy Managers (Planning, Operations)	Post-graduate degree in relevant field. Operations scheduling, infrastructure implementation, ITS, management and monitoring capabilities. Experience of at least 4 years is required.
Deputy Managers (Finance, Admin)	Post-graduate degree in relevant field. Financial management, budget preparation, audits. Experience of at least 4 years is required.
Deputy Manager (Communications)	Post-graduate degree in relevant field. Public relations, media relations, marketing. Experience of at least 4 years is required.
Support staff	Experience of 2 to 4 years.

Some of the suggested positions need not be filled immediately; the structure described above represents the full operational structure of the SPV. However, key positions such as the CEO and core support staff should be established immediately. It is important to recognise that the SPV requires a different type of expertise from that available in CTA or the respective Governorates at present. The positions described above should not be assigned as the part-time responsibility of existing staff of CTA, the Governorates, or any other government department or agency. The SPV requires dedicated, full-time, professional staff members whose only job is managing the public and paratransit systems.

4.2.3 SPV finances

All the revenues from the BRT system will be controlled by the SPV. The SPV will be responsible for setting public transport fares at levels based on a pre-set formula that takes into account inflation and increases in other input costs. Covering the SPV's expenses through its own revenue is central to ensuring the economic autonomy of the body and retaining high quality staff. The SPV should seek other sources of non-fare-box revenue, such as revenue generated from charging market-based parking fees along the BRT corridor, to supplement farebox revenues, as needed. Economic independence will help insulate the Directors of the SPV from making decisions heavily affected by political considerations contrary to the SPV's interest of maintaining excellent service quality.

4.2.4 Creating the SPV

The SPV should be registered as a limited company per the Egyptian law. The Company's mission will focus cover the management of public and paratransit operations in the city. In order to carry out its functions, the SPV will require legal authorisation and the power to execute contracts. Such authorities include:

- Acquire, use, or alienate all kind of properties.
- Obtain credit to finance infrastructure projects.
- Acquire patents, commercial names, brands, and other rights of industrial or intellectual property.
- Acquire or to give concessions for operation.
- Execute all kind of contracts, acts or operations over its property.

Once the SPV is registered, the government can initiate the process of hiring of staff for the dedicated team of the SPV (as per the qualifications listed in Table 2). During the initial stage of at least 5 years, the SPV will require dedicated funds until it has achieved stability in terms of revenue streams. The SPV will require a dedicated office space, possibly at the existing government campus. The government should supply required infrastructure for the SPV office.

4.3 Industry transition

Most successful BRT projects have turned over the operations of the BRT systems at least in part to the affected operators of existing services, but under a new business model that requires them to provide a high quality of service. ITDP worked on taxi industry transitions in both Johannesburg and Cape Town, and has drafted proposed policy and implementation guidelines for Dar Es Salaam. We've also documented best practices around the world.

The implementation of BRT services that are fast, efficient, and comfortable can draw riders away from using standard bus, minibus, or microbus services. For the minibuses and microbuses, this loss of ridership means loss of their primary source of income. To prevent putting people out of work, many cities have incorporated those taxi routes affected by the implementation of BRT into the new bus operating companies. Affected operators are determined by mapping minibus taxi routes against the BRT service plan. Typically, an "affected route" is defined in the service plan. In the case of the Faisal-Oraby corridor, some or all of the nine routes that currently operate along the corridor could be considered affected. An industry transition policy states how operators on affected routes will be treated.

There are many ways of incorporating the affected operators into the BRT system. International best practice has been to create multiple companies of the affected operators and hold an open tender, with the most points in the bidding process awarded to companies with a management team that has experience operating a BRT or at least a major bus (or trucking) operation, and additional points awarded to companies that have affected operators in their shareholding structure.

It is of critical importance that the government hold a competitive tender with such incentives for including the existing industry, rather than negotiating with the affected operators directly. A direct negotiation, as was done in Johannesburg, may be tempting to the government as a way of avoiding political unrest but will mean that the affected operators have the upper hand in the negotiations. The result is likely to be much higher prices and a much longer negotiation period. In Johannesburg, the government paid a 30 per cent premium for their decision to negotiate with the affected operators and negotiations lasted for years.

Ideally, there should be multiple BRT operating companies so that there are quality incentives for superior operations and financial penalties for poor operations. Further, if one company fails to deliver on its contract, having another company available to step in will mean that the BRT services may continue.

Engaging with the existing industry is a long process that must be done carefully. The most important first step is for the government to agree on a policy on how to handle the affected industry. This must happen before engagement with the industry begins. If, for example, the government decides to negotiate with the existing industry, rather than hold a competitive tender, this will have important ramifications on how the industry should be consulted. So the government must first agree on a policy before beginning engagement.

Then, the government must take all of the critical steps needed to register affected operators on the affected routes, assist them in company formation, and introduce them to qualified management teams. ITDP has been intimately involved in minibus taxi transitions and can assist with these steps if needed.

5. Financial assessment

5.1 Capital costs of BRT systems

Most BRT systems can be built for under USD 5 million per km, with costs ranging from USD 500,000 to USD 15,000,000 per km. By comparison, at-grade trams and light rail transit (LRT) systems can range from USD 13 to 40 million per km. Elevated systems can range from USD 40 to 100 million per km. Finally, underground metro systems can range from USD 45 million to as high as USD 1.24 billion per km. The significant range of costs indicates, to some degree, the local nature of costing. Additionally, the range depends upon the individual features selected within each system (i.e. quality of stations, number of vehicles, etc.). Assuming a mid-range cost of USD 5 million per km, the proposed 16.1 km line in Giza would cost around USD 80 million, while the 34.1 km corridor linking Cairo and New Cairo would cost around USD 170 million. A feasibility study that determines the precise infrastructure requirements for these BRT lines is necessary to prepare a detailed cost estimate.

Many BRT systems procure the rolling stock through a public-private partnership arrangement with private bus operators. The service provide procures the buses, and the SPV reimburses the service provider for the operating expenses as well as the cost of bus procurement through a per-km fee. Such an arrangement reduces the total capital expenditure faced by the government in the initial stages of the project, and creates an incentive for the operator to maintain the buses. Km-based payments result in safer driving conditions on the road, because drivers no longer need to compete for each passenger.

Figure 45: Capital costs for different BRT systems

Country	City	Corridor length (km)	Implementation cost (USD per km)
China	Guangzhou	23	4.9
China	Changzhou	25	1.8
India	Ahmedabad (Janmarg)	88	3.0
India	Indore (iBus)	11	4.9
Brazil	Belo Horizonte (Antonio Carlos-Pedro 1)	7	4.0
Brazil	Curitiba (Linha Verde)	34	7.1
Brazil	Rio de Janeiro (TransOeste)	55	15.2
Colombia	Bogotá (Transmilenio)	83	25.9
Colombia	Cali (Mio)	49	17.0
South Africa	Johannesburg (Rea Vaya)	30	10.4
South Africa	Cape Town (My Citi)	17	23.8
Mexico	Monterrey (Ecovia Ln 1)	30	4.3
Mexico	Mexico City (Metrobus Ln 1-4)	93	6.3

5.2 Operating costs of BRT systems

The long-term financial sustainability of a public transport project is highly dependent upon the ability to minimise the on-going operating costs of the system. These costs can include vehicle amortisation, labour, fuel, maintenance, and spare parts. If a system requires subsidies, the financial strain can end up affecting the ability of the municipal government to provide a quality public-transport service. The level of required operating subsidy is also related to fare levels, and therefore touches issues of affordability and social equity. Some successful BRT systems, such as Transmilenio in Bogotá, set their fares so as to operate without operational subsidies. Transmilenio uses a fare adjustment process to update the customer fares automatically if there is a change in the cost of fuel or other inputs.

Public transport operating costs are more variable and harder to measure than capital costs. Not every city measures operating costs in the same way. The exact components of operating costs will vary somewhat depending on the technologies adopted. However, the table below provides a general listing of these types of costs.

Table 4: Operating cost categories

Category	Elements
Repayment of Capital	Vehicle depreciation
	Cost of capital
Fixed Operating Costs	General overheads (rent, utilities, etc.)

	Salaries of management, administrative personnel and supervisors
	Other administrative expenses
	Leases and/or real estate taxes on depots or other facilities
	Insurance
Variable Operating Costs	Driver / operator salaries
	Information staff salaries
	Security staff salaries
	Mechanic salaries
	Fuel / electricity
	Spare parts
	Maintenance

Once the government in Cairo has decided on a contractual structure for the BRT system, a financial model should be developed to determine the on-going operating costs to the SPV, the bus operating companies, and the other contractors (fare collectors, station managers, etc.). Bus operating companies should ideally bring in a profit and should be able to do so without subsidy from the government. The financial model will create guidelines for setting the BRT fare as well as determining what types of buses should be purchased and other pertinent decisions. The financial model also goes hand-in-hand with the BRT service plan. One service plan may bring in more passengers than another but may require more buses. The financial model will help to determine which is the most financially reasonable service plan. Oftentimes, a financial model and service plan will be done iteratively such that if the inputs in one changes, it will affect the other.

6. Planning process

A BRT can be designed and implemented within an extremely short time frame. The best BRTs in the world were implemented in two to three years. For instance, the Guangzhou BRT went from a firm political commitment to implementation within eighteen months. In Bogotá, Mayor Enrique Peñalosa was able to build and begin operations for the Transmilenio BRT system in three years. A typical timeline can be found below. Many activities occur concurrently, so BRT projects require excellent coordination between stakeholders.

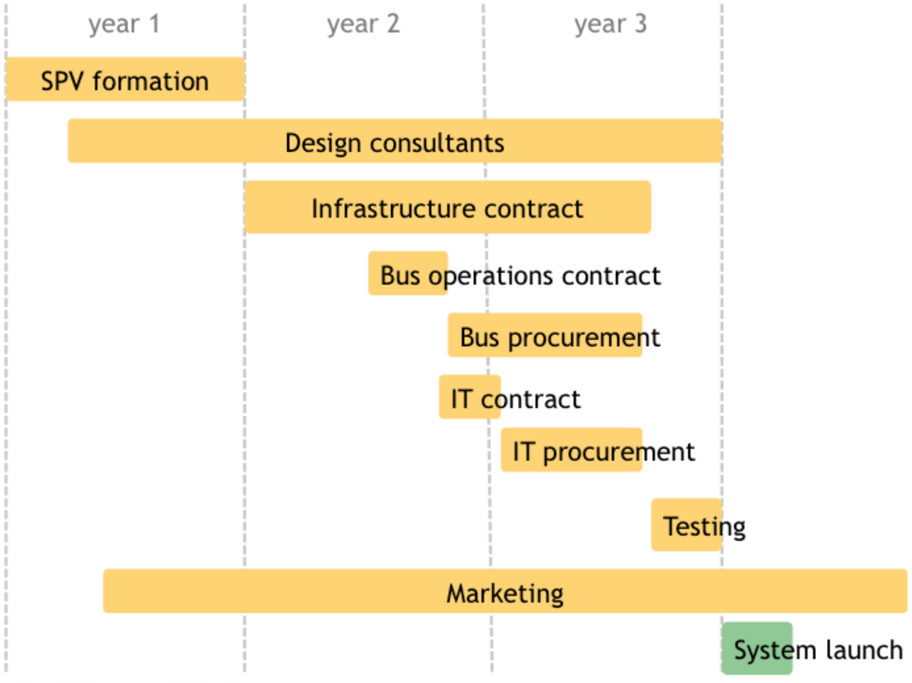


Figure 46: The BRT planning process

Figure 47: Mexico City's initial BRT corridor was implemented in 2 years (left), while the TransCarioca BRT in Rio de Janeiro was built in 3 years (right).

6.1 Preliminary assessment and data collection

6.1.1 Review of existing plans

The preliminary assessment should begin with a review of existing plans for transport projects. This review will ensure that the BRT projects will be built to work with any existing or planned infrastructure in the project area. As seen in Giza, the BRT project will need to fit into existing plans for a system of traffic tunnels near Cairo University. Without a proper review, projects currently under planning or implementation may lead to challenges for BRT operations.

6.1.2 Transport surveys

Transport surveys must be undertaken in order to assess the demand for BRT services. Important types of surveys necessary for these purposes are a public transport frequency and visual occupancy (FVO) survey, a boarding and alighting survey, a transfer survey, and traffic counts. While some FVO surveys were conducted as part of the present study, these should be supplemented with counts at additional locations to develop a more detailed picture of public transport usage in the study area. The data collected in the surveys will be used in travel demand modelling and service planning exercises undertaken during the next step. This modelling will use the survey data to predict ridership patterns on the future BRT system.

6.2 Detailed service plan

With the data collected from during the preliminary assessment and surveys, a service planning exercise can begin. The service plan will provide information needed for intersection and station design, bus fleet requirements, and financial modelling.

6.2.1 Travel demand modeling

Using the data collected in the transport surveys, travel demand modelling can begin. A travel demand model will use the demand data collected in the surveys to estimate the potential demand for a BRT corridor and the infrastructure needed to meet that demand. These surveys can include on-road surveys of the public transport system such as those conducted for the present study, as well as household surveys, which can help reveal the travel patterns of people who are not presently using public transport or paratransit.

The existing Cairo Extended City Model should be shared with the planning team to save time in preparing the model. The model's road network route database must be updated to reflect current conditions on Cairo's roadways. Similarly, the public transport route database must be updated with information from the public transport surveys conducted in the previous step, above. The network will also include the potential alignment for the BRT corridor.

With the network in place, a stop-to-stop trip matrix should be created for public transport trips. This matrix will be inferred from the passenger movements obtained from the on-board BA survey. From the transfer survey, a set of adjustment factors will be applied to the trip matrix previously inferred from the BA survey to develop a more realistic representation of the full trips taken on the public transport network. Once this adjustment is made, the OD matrix will be then calibrated to the existing conditions using speeds, ridership counts, and route frequencies observed in the field. It should be noted that the process outlined here is more detailed than the typical multi-modal modelling process, which usually focuses on personal motor vehicle movements. Service planning for BRT requires fine-grained information in order to accurately inform the design of infrastructure elements.

6.2.2 Proposed service typology

Drawing from the information about existing bus frequencies and itineraries, a service typology can be proposed. As a rule, existing services with a frequency and significant overlap with the proposed corridor should be including as a service. The example below from Zhongshan, China, shows the cut-off point used for that system. Routes that overlapped with fifty per cent or more of the corridor while running more than a set number of buses per hour during the peak were used. A similar metric will need to be used in Greater Cairo. Routes that have high frequencies and have high significant overlap with the proposed corridor serve as a good baseline of services that will prove successful. Their integration into the BRT service plan contributes to the corridor's success as the passengers on these routes are likely to switch to the BRT services once they begin operations. These routes will serve as the baseline service scenario in the service planning model. Several scenarios will be tested using the demand model in order to determine the optimal service plan. This is an iterative process in which small adjustments are made until an optimal set of routes is found. This optimal plan generally seeks to maximise load factors while keeping passenger transfers to a minimum.

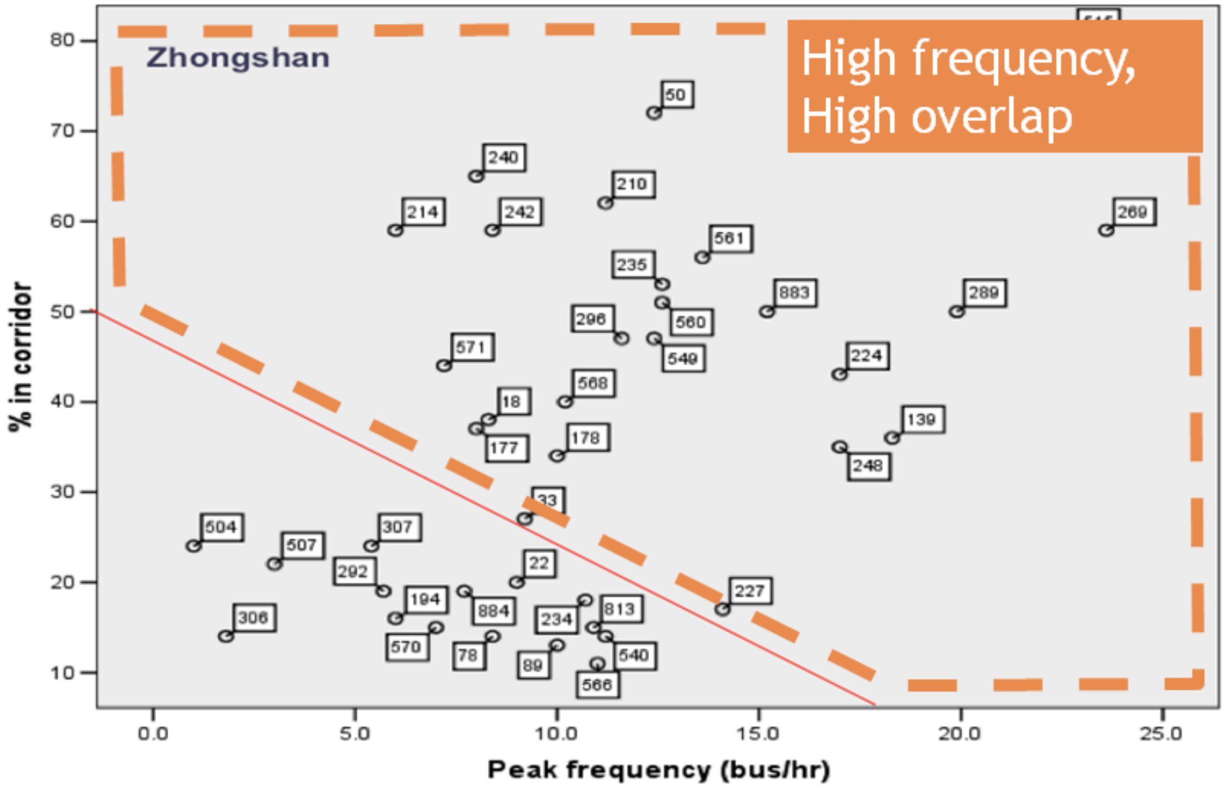


Figure 48: Criteria used to determine whether specific bus routes should become part of the BRT service plan in Zhongshan, China. As a general rule, existing services with a high frequency and significant overlap with the proposed corridor should be included as BRT services.

6.2.3 Conceptual designs

With the travel demand modelling completed, conceptual designs for corridors, stations, and bus-station interfaces can begin. A high-quality BRT design includes fully dedicated median-aligned lanes with centre stations, passing lanes at stations, and priority at intersections. Such treatments are likely to be warranted on any high-demand corridor in Cairo and will be key to providing a truly rapid and high-quality BRT experience. The service planning exercise will help identify the needed infrastructure build-out to accomplish this.

The conceptual designs will need to meet the demand forecasts observed in the model. It is essential that these designs are able to handle the estimated opening day demand plus eventual ridership growth. Conceptual design will take into account any trade-offs that are necessary in order to build a robust BRT, such as reallocation of a parking or a travel lane and may propose land acquisition where necessary.

The demand shown in the model will help determine whether or not the BRT corridor will need passing lanes to handle the demand on the corridor. If demand estimates find that a corridor will exceed 12,000 passengers per hour per direction (pphpd) then passing lanes will be necessary. The ability to incorporate passing lanes in a corridor is one of BRT's great strengths. A passing lane increases a corridor's capacity from 12,000-14,000 pphpd with a single lane to 45,000 pphpd. Even if this capacity is not needed, passing lanes will also for the creation of express services. Passengers travelling great distances will see higher trip time savings as express services overtake local services via the passing lane.

Station siting and spacing will also be determined in the conceptual designs. Stations should generally be placed, on average, 0.3 to 0.8 km apart, but the travel demand model will inform the placement of each station. At this phase of the project, the proper sizing of stations must also be determined. If a station is too small, it will quickly begin to overcrowd and dissuade riders from using the BRT. At high demand stations with passing lanes, a certain number of sub-stops will be necessary. Sub-stops allow for more than one bus to board and alight for a single direction at a time.

6.3 Financial plan

The BRT service plan will provide the basic information that the government needs to have a rough idea of likely ridership, the likely number of buses needed and their size, their likely speed, and other factors. With this information, a financial model can be built to determine whether or not the system will be profitable enough to cover the cost of the bus procurement and other operational costs from the fare revenue. With this basic information, critical decisions about which elements of the project the government may have to subsidise (if any), how much private investment might be attracted, and how the system might be financially ring-fenced to help ensure that high quality operators can be attracted to the system as investors.

Detailed financial modelling will need to be done by a business consultant to strengthen the government's hand during the negotiation of operating contracts. The basic financial model would need to be populated with local data about the tax treatment of imports, currency risks, local labour costs, local fuel costs, and other variables.