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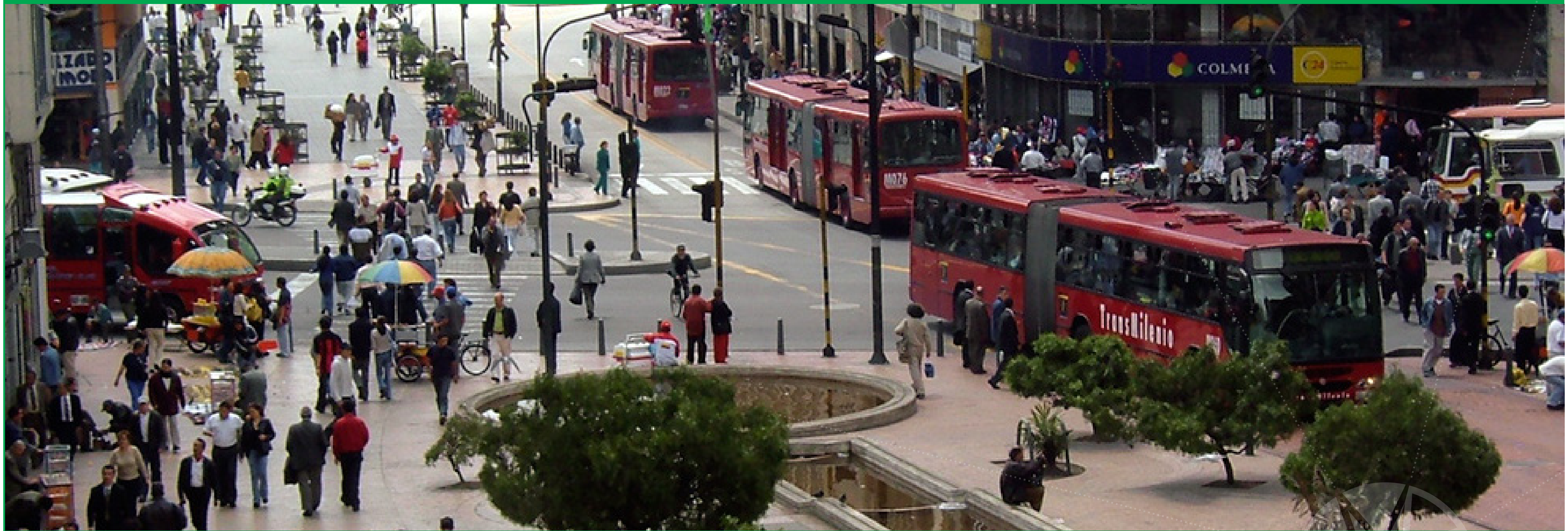

BRT in Chennai- Towards a new paradigm in urban mobility

Feasibility report- July 2011

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CHENNAI: THE PATH TO SUSTAINABLE MOBILITY

1.0 Chennai: The path to sustainable mobility

1.1 Introduction

Chennai stands at a crossroad in its history and development. The city has the potential to become a global commercial and cultural centre that affords its citizens immense benefits in the form of jobs, opportunities and improved quality of life. For this opportunity to become a reality, the city will have to develop adequate infrastructure and services to facilitate development and improve the quality of life of all its citizens, both rich and poor.

Many indicators of quality of life—better education, better nutrition, access to better healthcare—improve as cities grow and becomes wealthier. By contrast, transportation is one indicator that deteriorates with prosperity. [1] As cities grow, transportation needs of its citizens grow. People need to move around to meet others, explore opportunities, learn, and have a good time. People buy personal vehicles in their quest for more comfortable transport. However, the increase in private vehicles, while improving individual comfort and mobility, ends up causing congestion and pollution, ironically diminishing collective quality of life in the city.

While some cities, both developed and developing, struggle with these problems, others have managed to solve this conundrum by implementing high quality public transport systems—well integrated systems that provide excellent connectivity, easy access, mobility, comfort, attractive fares, brand appeal, and civic pride. These public transport systems are responsive to growing and changing travel needs and can be expanded quickly and economically.

Chennai must respond proactively to the transport needs of its citizenry, in anticipation of increasing public expectations. Failing to do so will set off vicious cycles. A frustrated citizenry exerts pressure on elected representatives and bureaucracies, who then scramble to deliver solutions. Some solutions while appropriate, take time to plan and execute and hence increase the level of frustration and chances of failure. Other quick fix solutions, while quickly delivered, fail to solve the root cause of the problem, worsen the situation and breed cynicism.

1 Enrique Peñalosa (visionary urban thinker and former Mayor of Bogota, Colombia)

1.2 Grappling with growing congestion and poor mobility

Often city governments widen roads or build flyovers to facilitate the movement of motor vehicles. But even if a road widening or flyover reduces congestion, the improvement is usually short-lived. The reason is simple: expanding the available road space initially increases speed and comfort and thereby encourages more people to travel in private motor vehicles. More and more users take to the route until the wider road returns to its original level of congestion—but with significantly more vehicles stuck in traffic. A city government in turn may feel pressure to widen the road once again, but it is not possible to solve traffic jams by building larger and larger roads indefinitely. In fact, no city in the world has solved its mobility crisis by simply building more roads. On the contrary, some of the cities with the most elaborate road networks, such as Los Angeles, also have the worst congestion.

Chennai faces rapid expansion of its official and unofficial city limits. Tamil Nadu is already the most urbanized state in India with Chennai as its largest city. As Mr Enrique Penalosa, world renowned transportation expert and ex-Mayor of Bogotá, Columbia, observed during his maiden visit to Chennai, "As per my calculations based on my study of other developing cities of the world, especially comparable cities of Latin America, 70 percent of the future Chennai has not yet been built." This is an astounding claim. We fret about exploding city limits and population growth but what we see today is just a glimpse of what is yet to come.

In developing cities like Chennai, proven and easy-to-implement transport solutions are required. These solutions should integrate with other public transport systems easily, without the need for massive restructuring of existing infrastructure and services.

Key challenges for Chennai include:
How does the city provide rapidly unfolding infrastructure, keeping pace with the increase in city limits and population?

What system of transportation can be rapidly deployed to growing suburbs while tightly integrating with the systems of the city's core?

How does the city—regularly starved for funds—afford a world class system that keeps up with the growing aspirations of its citizenry?

1.3 Public transport for all – not just the poor

While it is understandable and eminently noble to strive for a better public transport for the poor, it would be folly to ignore the rich and the increasingly well-to-do while designing a modern public transportation system. As prosperity of citizenry increases, people increasingly expect better services that can be competitively benchmarked to other systems around the world. Expecting citizens to continue to patronize existing services that are not up to par would be naïve and counterproductive.

In all cities around the world with advanced transportation systems, buses play a key role. Buses are flexibile and can be deployed in almost all locations in any city, keeping up with changing land use and travel patterns. Consider Hong Kong and Singapore, both Asian economic giants with two of the most advanced and admired public transport systems in the world. Ninety percent of all motorized trips in Hong Kong are made by public transport. In Singapore, figure is 63 percent. Both these cities have extensive rail based transit. Yet 50 percent of public transport trips in Hong Kong are made by bus while only 37 percent are by rail (Metro & LRT). (Ferry & tram account for 3 percent and taxis, 9 percent). In Singapore, 52 percent of public transport trip are made by bus. Rail (MRT & LRT) accounts for 33 percent. Taxis account for 15 percent.

In an increasingly congested city, a traditional bus system competes with all modes of transport for space on the road. As service quality of the bus system declines, it becomes an increasingly unattractive way to travel, especially to the well-off. In such a scenario it is not the poor—who have no choice but to use the buses—who become part of the problem, but the well-off who can afford private vehicles. And as private vehicles take up a disproportionate amount of road space, each new additional car or SUV, especially during peak hours, reduces road space considerably.

Solutions like road widening, elevated roads, flyovers, and congestion charges/ road pricing have severe limitations. Singapore's bus system works efficiently because of a well designed congestion pricing system and expensive, restricted parking that dissuades people from using private cars, thereby reducing street congestion. But congestion pricing is extremely complicated to implement and requires sophisticated governance and administration systems.

Developing a better road network by adding missing links, and even widening roads in sections, if done as part of a well planned road map to achieve mobility for all, is important in any city. But as standalone, disparate pieces, these interventions cannot solve citywide transportation issues. Experience from car-centric United States cities, such as Atlanta, Houston, and Los Angeles, whose ability to design and engineer road systems are unparalleled, suggests that any new road space—even if well-designed—is quickly occupied by private vehicles, simply resulting in more congestion. This results in poor mobility for all—those in cars and motorcycles as well as the millions who travel in buses.

While car ownership per se may not be the problem, the simultaneous use of cars during peak hours is the cause of congestion and traffic jams. Public transport systems must provide a viable alternative to private vehicles, both for the poor and the increasingly well off.

1.4 Why not just improve the bus system?

It is the strong opinion of the authors of this report that implementing a high quality Bus Rapid Transit (BRT) system is a critical step toward improving the overall public transport system in Chennai. BRT is a robust and flexible system that leverages the strength of the existing bus system—MTC already carries 55 lakh passengers per day—while providing faster and more reliable service that establish a unique brand identity. BRT will be a game-changer for the status of public transport in Chennai.

But why not just improve the bus system? In cities like Hong Kong and Singapore, the availability of excellent public transportation and policies like congestion charging, market-based parking fees, and controls on vehicle registration mean that there are very few private vehicles on the road. Hence, there is little congestion and buses move at reasonable speeds. These cities also have very strong enforcement mechanisms, so a simple yellow line dividing a bus lane from the rest of the traffic may suffice to give buses priority. Private vehicle drivers resist crossing over to the other side leaving plenty of space for buses.

In Indian cities like Chennai where the private vehicle population is already high, such arrangements will not work. Buses stuck in congested mixed-traffic lanes cannot provide a competitive public transport service. Given the lax enforcement system, painted bus-only lanes will easily be crowded by private cars, making a mockery of the concept. BRT offers a solution to these challenges by providing physically separated bus lanes that are not easily encroached by private vehicles. But BRT is not just about putting city buses on dedicated lanes—it requires meticulous, comprehensive planning, as explained in the following chapters.

1.5 Viability of rail-based systems

The viability of huge rail projects is often exaggerated and the number of passengers who will switch from other modes is overestimated. Since projects like Chennai's MRTS are expensive and cannot be implemented over a large network in a short time, they are only able to serve a small percent of the population. To ensure viability of Chennai's upcoming metro system, complementary network of BRT is needed. The quality of service on a BRT, including speed and capacity, can match that of a metro system in a way that regular bus service cannot.

The metro rail, MRTS and suburban rail systems in Chennai are widely spaced and comprise a somewhat disjointed network. BRT will help them become part of a more tightly knit public transport network that is easily accessible to all. An interconnected public transport system will generate much higher ridership than separate, independent lines.

1.6 Providing mobility for the growing suburbs

The suburbs of Chennai are growing rapidly. Haphazard growth patterns in these parts make it a challenge to supply cost-effective mass rapid transport coupled with a well-connected grid network of streets.

In such conditions, the city needs a public transport solution that can be implemented quickly and BRT clearly fits the bill. BRT systems have a wide range in capacity, starting at as low as 4,000 and going up to 45,000 passengers per hour per direction. System capacity can easily be increased in stages in a modular fashion. By implementing BRT corridors on both existing arterial roads and—more critically—all future roads, Chennai can provide world-class transportation to the suburbs while also encouraging transit oriented development (TOD) along these corridors.

The recommended approach is to rapidly deploy BRT as a core and complementary network across the Chennai Metropolitan Area (CMA). Implementing BRT in the outskirts is comparatively straightforward because most new roads like Outer Ring Road (ORR) have built-in space for public transport. In more congested areas, the advice of competent transport experts will be helpful to find solutions to implement BRT in constrained rights-of-way, as has been done in Quito (Ecuador), Guayaquil (Ecuador), and Mexico City.

1.7 Expanding paratransit's role as a feeder service

Efforts must be made to study and develop practical models for using paratransit vehicles like shared autos and Tata Magic vans as feeders to the formal public transportation system. Developing and implementing a robust revenue sharing system that gives incentives paratransit entrepreneurs to cooperate and feed passengers into mass and rapid transit systems is vital. Paratransit systems already perform a crucial role by filling the gaps in the existing transport system. Much of the increasing travel demand in Chennai is being satisfied by paratransit system despite the unfavourable conditions of excessive regulation and other barriers. There is an urgent need for a friendlier regulatory environment based on the premise that paratransit is a complementary service to the region's core public transport systems.

1.8 Parking and public transportation

Another neglected topinc in discussions about public transport is parking, or, more precisely, the adverse effect of free parking on public transportation. Free parking is an enemy of good public transport because it subsidizes the use of private 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 a parking space. Hence is vital that local bodies take control of public street space by managing parking as a service that comes with a price.

1.9 Funding public transport improvements

The current funding model for public transport is wholly inadequate to support Chennai's growing population. In this model, the government-owned bus company subsidizes passenger trips—a very commendable and essential feature. This makes public transportation affordable to all and helps reduces congestion and pollution in the city. But as a consequence, the company does not have sufficient revenue to improve operations and services. The bus company is perennially at the verge of bankruptcy and must approach the state government every year for bail-outs. In recent times, the city has had an influx of new buses through the Central government's JnNURM scheme. Otherwise, the constant refrain is that there is no money for procuring additional buses or anything else.

This model needs to change. The need for world-class public transportation is urgent and the pace of urbanisation is rapid. One key solution is the "value capture" model, as implemented in Hong Kong: a self-sustaining public transport system that employs competition to improve services while generating revenue from a variety of sources, including advertisements and real estate, to cover capital and operational costs.

Similarly, the Corporation of Chennai (CoC) should expand its use of advertisements and parking fees to collect revenue that can be used to improve pedestrian and other facilities that aid public transport. The Chennai Metropolitan Development Authority (CMDA) and other agencies must facilitate use of real estate and development tools like FSI bonuses to capture the value in real estate around the public transportation corridors and stations. These funds should be utilized to fund public transport systems like BRT and high quality city bus service.

CMDA offers higher FSI around major transport corridors in order to promote densification near public transport. But these policies need to be further refined to include the implementation of world class pedestrian and other amenities to facilitate access to public transport. CoC must also strive to create public spaces and plazas to provide comfortable and easy access to pedestrians and public transit users. New York's pedestrianised Time Square and Nanjing Road in Shanghai exemplify this kind of improvement.

Each transport hub in Chennai must be a joint effort of all relevant agencies—including CoC, Highways, CMDA, Metro Rail, BRT, Railways, MRTS, and MTC—to improve footpaths, manage parking. Operationalising the Unified Metropolitan Transport Authority (UMTA) as well as learning and emulating advanced counterparts like Land Transport Authority (LTA) of Singapore will hasten the day when Chennai can be ranked alongside with the great cities of the world that afford world-class, sustainable mobility to all their citizens—both rich and poor.

The Ministry of Urban Development, Government of India, is committed to

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finding sustainable solutions and has drawn up the National Urban Transport Policy, which supports cities in pursuing projects compatible with sustainable urban transport principles. While the national policy offers guidelines to states, it is for the respective states to foster and adapt people friendly transport systems.[2] There is a growing understanding at development banks such as the World Bank and Asian Development Bank that Indian cities will only achieve a positive future through the creation and effective management of great public transport systems. Urbanization in India is just starting. Chennai will be many times larger than what it is now. There is a great opportunity to take affirmative action and create a sustainable future.

2 Dr M Ramachandran, Former Secretary to Government of India (Urban Development)

MASS RAPID TRANSIT OPTIONS

2.0 Mass Rapid Transit Options

2.1 Overview

Mass Rapid Transit can be defined as publicly accessible transport in urban areas that can transport quickly a large number of people from one place to another. Trams were amongst the first forms of public transport and became prevalent by mid 19th century after widespread use of electricity started. Practically every large city in the world, including Chennai, had trams.

The need for mass transit was realized by this time when cities became places of great activity and concentration due of the industrial revolution. London Underground was the first of these mass transit systems and started operations in 1864. These early systems were rail based. Internal combustion (IC) engines and automobiles were still in their infancy. Historically, only rail based systems i.e. underground/ elevated/ surface rail were considered mass transit.

With the advent of the automobile, many people took to personal mobility. Even public transport shifted from trams (also called street cars) to buses that were compact and ran on diesel powered internal combustion engines. Their main advantage was their flexibility. Buses did not require tracks or electric lines and were unrestricted in their movement and reach. They were considered modern and attractive form of public transport as compared to trams and more or less eliminated trams from most cities across the world. Bus based public transport has remained the mainstay of public transport in most cities across the world, even ones where large investments have been made in rail based systems.

In recent times, tram systems have resurfaced in the form of surface light rail as well as elevated Light Rail Transit (LRT). Grade separated LRT systems such the ones in Hong Kong have a peak capacity of around 15,000 persons per hour per direction (pphpd).

Monorails have existed for many decades now but have found limited application in city public transport except for in a few cities in Japan and Kuala Lumpur. Most monorails are short length services, mostly restricted to airport shuttles and amusement parks. Monorails have limitations in capacity. The highest known systems carry approximately 8000 pphpd. Technology for higher capacity monorails is currently under development.

2.2 Buses and their role in a city's public transport network

Buses in cities carry more passengers than urban rail

In cities around the world, buses are the main form of public transport. Even cities which historically invested heavily into rail systems, including London, Mexico City, Hong Kong and Singapore which have extensive rail networks. The figure below shows mode share of bus and rail passengers in a few cities across the world. In Sao Paulo, one of the largest metropolitan areas in the world, 6million passengers use 15000 buses for their daily transport while 3.5 million use an extensive train system of 320 km (60 km Metro and 260 km suburban rail). [1]

Hong Kong is known for its very high public transport use. Eleven million people use public transport daily which accounts for 90 percent of all motorized trips in the city. In its peak demand section, MTR metro rail carries more than 80,000 passengers per hour in peak direction. However, only 37 percent of transit trips are made by rail systems (MTR +LRT) while 50 percent is by buses (large and small buses). In Singapore, 63 percent use public transport. Two million trips are made by rail systems and 3.1 million by buses. In these cities, buses have been

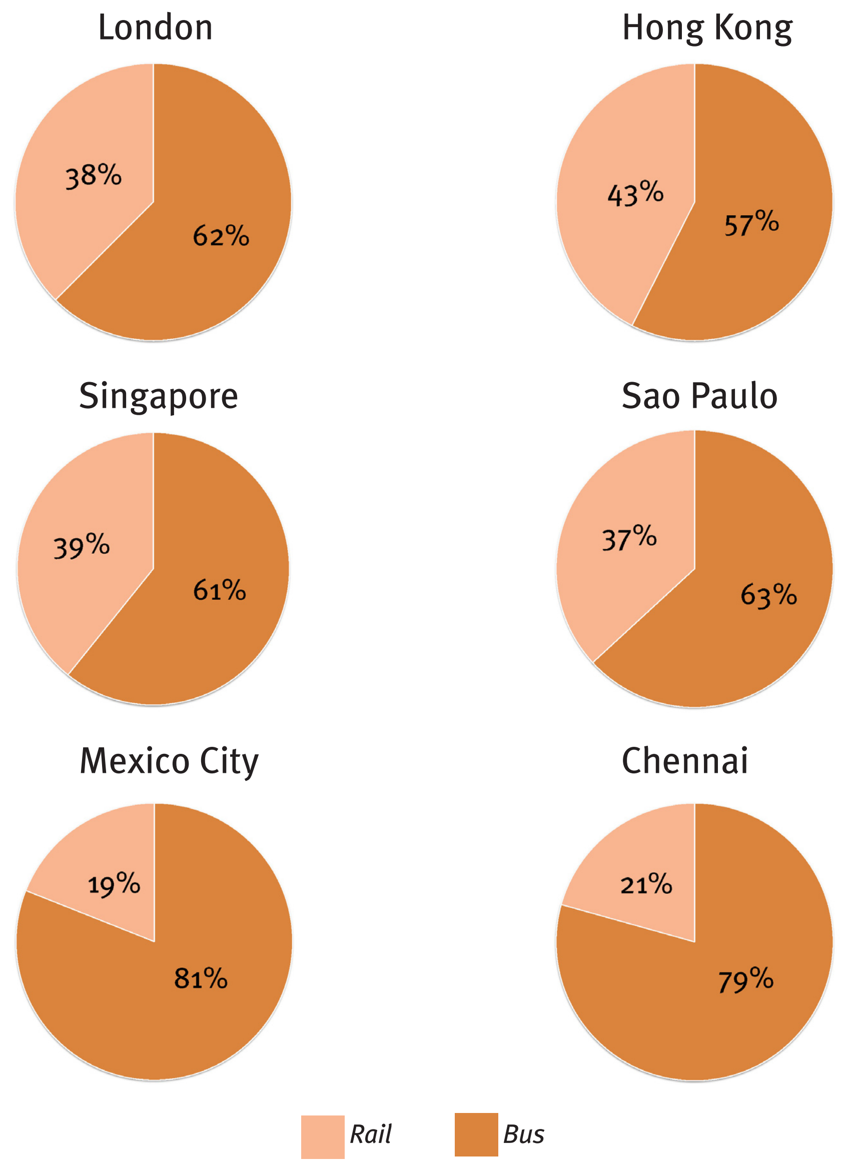

Figure 2.1 -Even in cities with large rail networks, buses remain the dominant form of public transport. London has 1,800 km of rail, including the suburban rail and underground systems. Mexico City has 550 km of rail.
The mode split for Chennai reflects the projected ridership of the metro system, and assumes that all of the metro passengers will come from buses.

1 http://www.sptrans.com.br/a_sptrans/

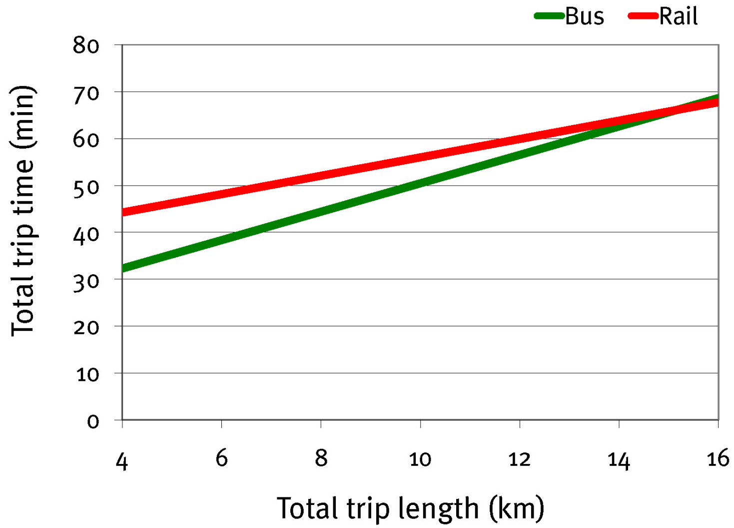

Figure 2.2 -Graph of travel time in bus vs rail

given priority through active private vehicle use restriction. This has been part of a clear strategy on the part of the government to provide efficient mobility for all.

Even in cities with very high rail usage, such as Mumbai and New York City, bus services remain an important component of the public transport system. In these cities, buses and rail have a symbiotic relationship, feeding into each other. While the rail system serves 6.3 million passenger trips daily, buses aren't far behind at 4.5 million trips per day. In New York City, rail system accounts for 5million trips each day and 2million trips happen on buses. It must be noted that rail systems function very well in these cities because of geographic peculiarity.

Closer home, in Chennai, MTC is the backbone of public transport in the city. Buses serve 5.5 million passenger trips daily. This is over five times more than the one million made by suburban rail and 85,000 trips by MRTS.

Why are buses so widely used?
There is a reason why buses are so popular. They are very flexible and low in cost. Unlike rail, their movement is not restricted to tracks. Therefore, they can reach closer to places where people live or work. Flexibility, and frequent stops which are 300-500m apart, make buses more accessible as they are within walking distance for most users. Buses can be accessed on the street without having to climb stairs to reach an elevated or underground boarding platform. Therefore, buses have been a predominant form of mass transit since their inception.

Buses, being smaller than rail, also have the ability to provide frequent service even in low to medium demand corridors. They can provide direct service thereby removing the need for transfers. This reduces passenger waiting time and overall trip time.

In comparison, rail systems typically have stations that are over a kilometre apart. Passengers have to walk a longer distance to reach a rail station. They also usually have to climb stairs to reach boarding platforms and for transfers from one line to the other. While urban rail systems are nearly twice as fast as buses, buses are still preferred over rail for the same journey when trip lengths are less than approximately 15 km. A shorter walk reduces trip time as well as discomfort. Rail systems are only useful when trip lengths are long, making their high speed reduce total trip time.

Bus speeds are adversely affected when

they have to move with other vehicles on congested streets and they start losing their advantage over rail. In contrast, grade separated rail systems like metro, elevated LRT and monorail are not affected as congestion grows on streets. Therefore, if buses are to be effectively used as a means of mass transit that can carry large numbers of people at competitive speed, they have to be removed from congested traffic so that they can operate smoothly. This was the idea behind creating Bus Rapid Transit (BRT) systems. BRT, a special form of bus based public transport system, has emerged as a form of mass rapid transit system in recent times. There are many successful examples of BRT across the world.

2.3 Busways: First generation of BRT

BRT systems are not new. The first busways were created in Europe. They gained prominence with the creation of Curitiba busway in early 1970s. The BRT in Curitiba was created as part of a larger plan for transit oriented development. Land use was planned to work well with the BRT system network. While dedicated bus lanes have existed for over four decades now, they were not widely considered a means of mass rapid transit till 1990s.

Some busway systems, such as the one from Sao Paulo from 1970s and Bogota from 1980s, carried large number of passengers (25000-30000 pphpd) but they operated at low commercial speeds (10-15kmph). This was due to poor design and interface, lack of system coordination and ineffective management structure. It resulted in bus bunching, poor load factor and congestion within the dedicated lanes. BRT was not seen as a competitive mass rapid transit mode.

2.4 Second Generation BRT design and widespread adoption

Advancements in design and operations of bus based systems happened in the 1990’s. The most prominent amongst these is the Transmilenio system in Bogota that set a new benchmark in quality and capacity of BRT systems. It achieved passenger throughput as high as 45000 per direction in one hour at average travel speed of 26 kmph. Such capacities employing buses as a rolling stock were unheard of in the past. This put BRT firmly in the league of mass transit systems. It encouraged many cities to relook at their mass rapid transit plans and explore BRT as a smarter choice. The secret behind such high capacities of these second generation BRT systems lies in the fact

Figure 2.3 -Inefficient busways in Bogota in the 80’s

Figure 2.4 -The traditional view of public transport system capacity (above), and the contemporary view (below).

Figure 2.5 - Image of modern BRT

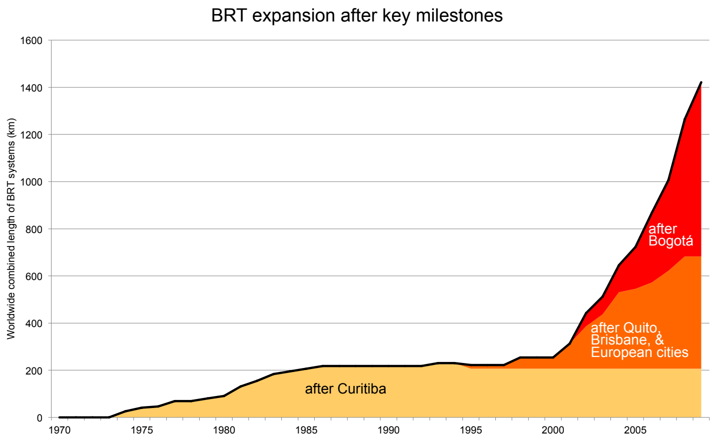

Figure 2.6 -BRT expansion after key milestones

that they took cues from metro rail systems to improve their capacity and speed.

Present day high quality, high capacity BRT systems use high capacity train like buses with multiple interconnected coaches (articulated buses). Stations have multiple docking platforms per direction. Express services are operated which bypass smaller stations. Step-less entry/exit into bus increased safety and speed of boarding. Ticketing is performed prior to boarding bus to save time. IT based scheduling and operations management techniques are employed. All these result in higher system capacity.

2.5 BRT around the world

The highly successful BRT systems of South America have engendered a paradigm shift in the way that mass transportation options are viewed. Cities around the world are realizing that BRT can provide high quality public transport service at a fraction of the cost of rail systems. Given the fast implementation time of BRT, successful models have been replicated quickly, as evident in the chart below.

The first gold-standard BRT system was constructed in Curitiba, Brazil in the 1970s. The late 1990s saw a sharp upward swing in the application of BRT, as successful projects in Quito Ecuador; Brisbane, Australia; and other cities established that the flexibility of BRT lent itself to a variety of different urban contexts. BRT planning received another boost in 2000 with the opening of Transmilenio in Bogotá, Colombia. Transmilenio established that BRT systems could carry passenger loads that many transport planners had previously thought could only be handled by rail systems.

BRT is now a truly global phenomenon, with systems now up and running on all continents. BRT is a mode of choice not only in the Global South, but in many developed countries as well, including the United States, Canada, Australia, and France. According to ALC-BRT, BRT systems and busways are now present in 120 cities. [2]These systems comprise:

- **280 corridors**
- **4,300 km**
- **6,700 stations**
- **30,000 buses**
- **28 million passengers per day**

In 2010 alone, 16 cities completed new BRT systems, and 49 more systems were under construction.

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2 "The Global BRT Industry," Across Latitudes and Cultures—Bus Rapid Transit, <http://www.brt.cl/the-global-brt-industry/>, accessed 15 Jun 11.

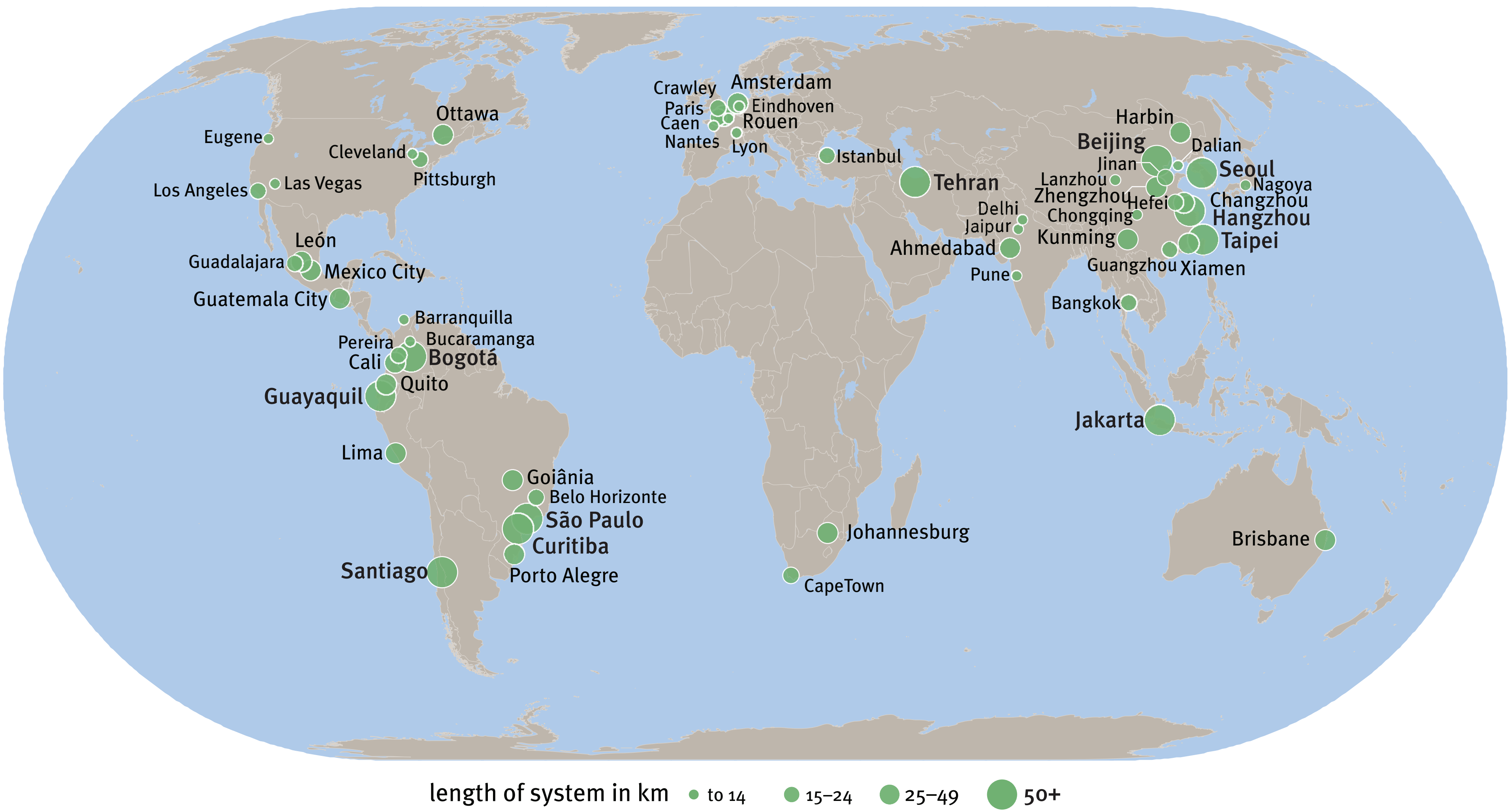

Figure 2.7-BRT around the world

AFRICA	47
ASIA	1,315
EUROPE	291
LATIN AMERICA + CARIBBEAN	1,330
OCEANIA	324
UNITED STATES + CANADA	993

Table 2.1 -Combined length of BRT and busways(km)
Source: "The Global BRT Industry," Across Latitudes and Cultures- Bus Rapid Transit

Several governments have adopted national policies to promote BRT. The success of the Bogotá system spurred the creation of BRTs in several other Colombian cities, including Pereira, Cali, Barranquilla, and Bucaramanga. In South Africa, the national Department of Transport's strong support of BRT has led the implementation of systems in Johannesburg and Cape Town. Pretoria and Port Elizabeth are also in the process of planning BRT systems. In the United States, the Federal Transit Administration created a new funding program, termed "Small Starts,"[3] to provide financial assistance to cities wishing to implement BRT systems in the world.

In India, the National Urban Transport Policy (NUTP) clearly identifies BRT as a mass transit mode. Presently, eleven cities in India are getting partial grant funding from the Union Ministry of Urban Development (MoUD) under the Jawaharlal Nehru National Urban Renewal Mission for developing a BRT system. Ahmedabad's Janmarg BRT has come up as a best practice example in India. In case of Delhi and Pune, there were deficiencies in BRT planning, design and implementation which resulted in poor public reception. There is however scope to improve them by a great extent such that they also become best practice examples. It must be noted that such fixes cost a lot more than proper planning and good implementation to start with.

2.6 Advantages of BRT systems over other forms of mass transit

BRT systems have many advantages over other forms of Mass Rapid Transit. BRT emulates many of the good elements of rail systems and removes the disadvantages of rail systems. One of the advantages a BRT system has over a rail-based system is its flexibility: buses are not restricted by tracks. BRT systems use the flexibility of bus to greatly enhance passenger convenience. BRT systems can be designed for a wide range of capacity. Flexible design allows adding capacity in a modular

3 "Small Starts," Federal Transit Administration, < http://www.fta.dot.gov/planning/newstarts/planning_environment_222.html>, accessed 15 Jun 11.

fashion. Safety is enhanced compared to business as usual bus service. Safety measures are simpler than rail based systems. They take a lot less time to implement than rail systems in general and can be built in less than three years from start of planning to commercial operations.

Wide range in capacity

BRT systems can be designed for a wide range of demands starting at as low as 4000 pphpd and going up to 45,000 pphpd. With small modifications to station design, bus fleet type and operations, the capacity can be enhanced in a modular fashion.

MUMBAI MONORAIL	8,400 pphpd (projected)
METROBUS, MEXICO CITY	9,000 pphpd
QUITO BRT	12,000 pphpd
CHENNAI METRO RAIL	16,000 pphpd (projected)
GUANGZHOU BRT	27,000 pphpd
TRANSMILENIO BRT, BOGOTA	45,000 pphpd

Reduce need for transfers

In a rail system, passengers need to navigate stairways, corridors, and multiple platforms if they want to switch between two lines that meet at a transfer station. In a BRT system, the bus itself can turn from one corridor to another, allowing passengers to stay on the same vehicle all the way to their destination. Since buses can move freely among multiple corridors, direct services can be provided for all of the major origin-destination pairs in the system.

Flexibility

In addition, buses are not limited to the dedicated BRT corridors—a bus can travel anywhere there is a road. With buses of the right specifications, the routes can go beyond the network of dedicated corridors, where needed. “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 provide direct service outside the segregated corridor.[4]

Safety

Because the dedicated corridor segregates buses from smaller vehicles, minor as well as major accidents come down dramatically. With appropriately spaced pedestrian refuges, conflict between BRT buses and pedestrians crossing the street reduces dramatically.

Extensive safety measures need to be incorporated in case of elevated and

4 http://www.chinabrt.org/en/cities/guangzhou.aspx

Figure 2.8 - Ground level access to BRT station- Metrobus, Mexico City

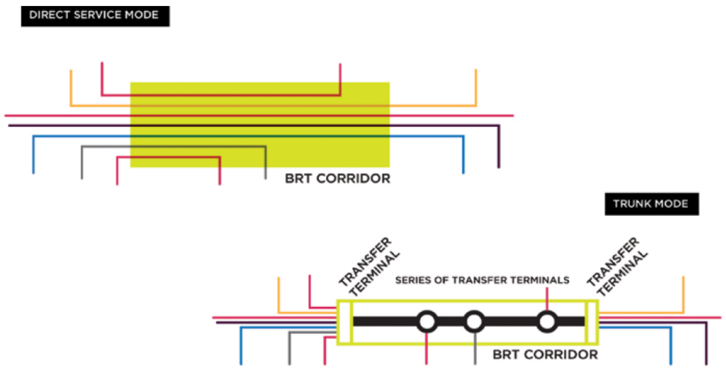

Figure 2.9 -Direct service mode allows the same buses to serve the BRT corridor and regular routes, without requiring passengers to transfer.
The trunk mode requires transfers from outside the BRT corridor in order to travel inside the corridor. Source: Streetfilms

underground rail systems, whether it is Metro-rail, LRT or Monorail. Catwalks are required in case of emergencies so that passengers are not stranded up in air. BRT systems do not have such complications. In case of an emergency, passengers can be easily evacuated.

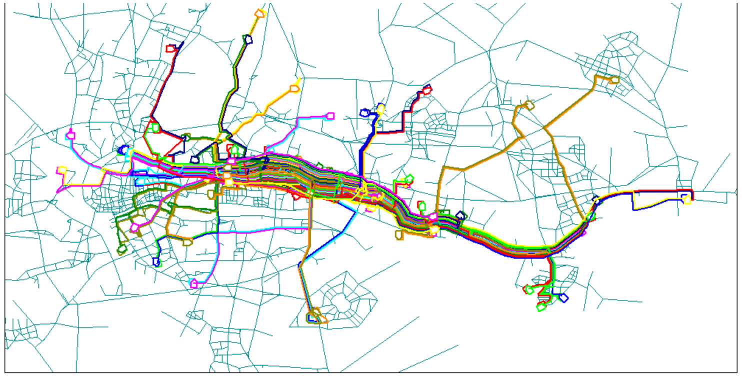

Figure 2.10 -The routes that comprise the Guangzhou BRT system extend beyond the segregated BRT corridor.

Smaller depots/ maintenance facilities

Since buses are flexible, greater freedom is available in locating maintenance and parking facilities. These depots are also much smaller than rail system depots and thus need smaller land resource to place them. Average BRT depot holds 100-300 buses and requires a space of 5-12 acres. A system of 1000 buses, which can serve around 1.5million passenger trips daily, can be managed out of 6-8 facilities spread across town. This reduces the number of dead kilometres (non-revenue earning km). The system can serve a larger distributed network.

Rapid implementation time

BRT can be implemented quickly. Given adequate political support, BRT can be implemented in under three years, from the planning stages through to construction and operations. The Janmarg system in Ahmedabad demonstrates how fast a BRT system can become the backbone of a city's transport network. What began as a 12.5 km pilot corridor in 2009 is expected to span 88 km by 2013, providing connectivity across the city.

Figure 2.11 -Transmilenio depot

Figure 2.11 -The evolution of Ahmedabad's Janmarg system: the initial 12.5 km pilot corridor, which opened in 2009 (left); the present 42 km network (centre); and the final phase, expected to be complete by 2013 (right).

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2.7 Cost of Mass Transit Systems and capacity comparison

The cost of different mass rapid transit systems remains an important criterion for choice. This has to be seen in the background of the capacities of these systems. Underground Metro Rail, though one of the highest capacity system, still remains as one of the most expensive forms of MRT. Average cost in Indian context ranges from 350-450 crore rupees/km. High end metro systems like the one in Hong Kong are known to have a capacity of over 80000 passengers/hour /direction. However, the systems in operations or under development in India have a peak technical capacity less than 30000 passengers/hour/direction.

Elevated Metro systems cost Rs. 150-250 crores per km depending upon site conditions and capacity. Monorail systems, which have a capacity of 8000 passengers per hour, cost 125-150 crores per km.

BRT systems cost between Rs. 12-18 crore per km for capacity of 6000-45000 passengers per hour. Cost of bus fleet and operating expenses are repaid through fare box revenue. Many BRT systems are financially sustainable from day one. Across the world, BRT systems have attracted private investment because of this.

No metro system in the world recovers its cost of operations from fare box revenue. Cost of construction is typically borne by provincial or national government. Some systems recover cost of development through large scale real estate development concession given to the system operator (MTR Hong Kong). In contrast, most BRT systems recover full cost of operation from fare box collection. Additional revenue can be generated through advertising and value capture on adjoining land along the corridors.

2.8 Efficient use of road space through BRT

BRT presents an opportunity to maximize the carrying capacity of existing road space. While a traffic lane for cars can handle a throughput of approximately 1,500 persons on cars, a simple BRT system with a single lane per direction can transport 9,000 passengers per hour per direction. With some modifications, like an overtaking lane at stations, the capacity of a BRT system can be substantially increased, matching and even exceeding the capacity of typical rail-based systems.

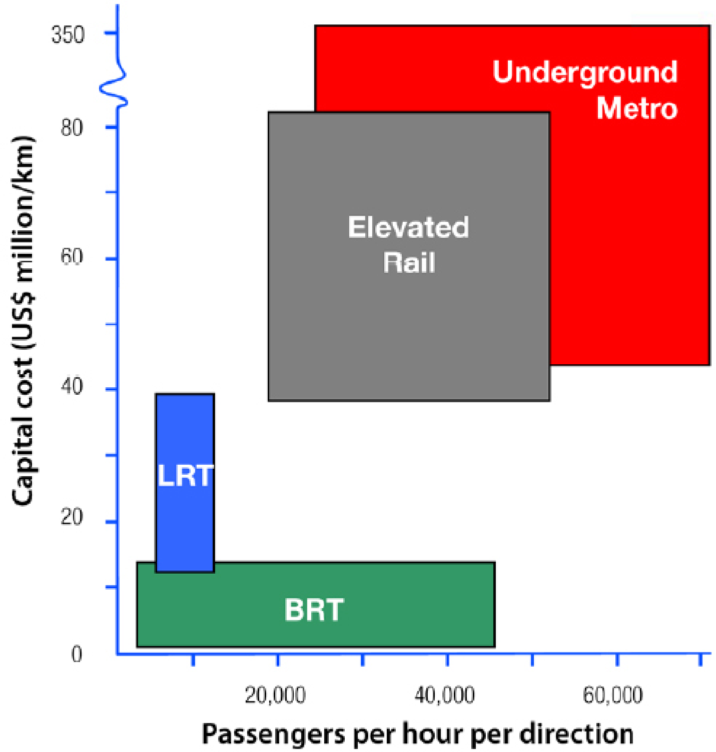

Figure 2.13 -The cost and capacity of mass transit options

2.9 Competitive with private modes

By providing fast, reliable service, BRT systems around the world have succeeded at attracting trips from private vehicles. Sixteen percent of BRT passengers in Ahmedabad previously used private vehicles.[5] The Transjakarta system in Indonesia gained about 20 percent of its ridership from private vehicles. In Bogotá, Colombia, about 10 percent of Transmilenio passengers switched from private vehicles. [6]

MTC's experience in Chennai already suggests that improved service quality has a good chance of spurring a mode shift toward public transport. A study by Anna University found that 24 percent of the passengers on MTC's new air-conditioned Volvo buses had switched from cars or two-wheelers.[7] If a change in the vehicle alone can attract car and two-wheeler users, the BRT can be expected to generate a further shift by offering better travel times, reliable service, and a comfortable waiting environment.

5 CEPT University, 14th month report, January 2011.
6 BRT Planning Guide (2007) p 147.
7 http://www.hindu.com/2011/05/10/stories/2011051060390200.htm

2.10 Pollution savings

BRT systems reduce emissions when they attract passengers from polluting cars and motorised two-wheelers. They also reduce emissions by making bus operations more efficient, such that the same number of buses is able to carry greater passenger loads.

Emission reductions due to BRT systems elsewhere in the world are well documented. Mexico City's Metrobus system has resulted in a significant decline in harmful local pollution, removing 690 tons of nitrogen oxide, 2.8 tons of particulate matter, and 144 tons of hydrocarbons per year.[8] These pollution savings improve local air quality and reduce the incidence of asthma, bronchitis, and other lung ailments. BRT systems also help reduce greenhouse gas (GHG) emissions, which contribute to climate change. Phases 2 to 4 of the Transmilenio BRT in Bogotá eliminate 79,000 tons of GHG emissions per year.[9] Transmilenio is a registered project under the Clean Development Mechanism and is able to sell carbon credits for these emission reductions. To date, the agency has earned Rs 11

8 http://www.embarq.org/en/project/mexico-city-metrobus
9 http://cdm.unfccc.int/UserManagement/FileStorage/96YVXI7FQ5JEC2GT1NDWR4MOUP8K0Z

crore from these sales.[10] The Guangzhou BRT is estimated to reduce emissions by 50,000 tons per year.[11]

10 http://www.eenews.net/public/climatewire/2011/04/27/1?page_type=print

11 http://www.itdp.org/index.php/news/detail/guangzhou_brt_to_be_featured_in_smithsonians_cooper-hewitt/

BUS RAPID TRANSIT: KEY FEATURES

3.0 Bus rapid transit: Key features

3.1 Introduction

Bus Rapid Transit (BRT) is high quality, customer-oriented public transport that delivers fast, comfortable, and low-cost urban mobility to all. BRT combines the flexibility of buses with the high performance and design standards of metros, giving it the nickname, Metro-Bus. The idea is to think metro-rail and do it with buses.

BRT is a successful marriage of good street design and infrastructure (stations, terminals, depots) with complementing bus fleet. It requires effective planning of operations to serve the needs of citizens and close monitoring of operations to make sure what is planned is in action. It is also an opportunity to bring in best practices into system management which can later be adopted by the entire city bus service.

The success of BRT depends on the implementation of a comprehensive package of physical infrastructure and operational systems that together provide a high level of customer service. This includes dedicated lanes that are meant for the exclusive use by BRT buses and no other vehicles. Exclusive lanes ensure that BRT buses do not get stuck in traffic and move rapidly at all times. Exclusive lanes are an important feature of BRT systems but other features are crucial to keep the system running efficiently.

As in a metro rail system, BRT design ensures that passengers can get in and out of a bus without having to climb steps, i.e, step-less boarding. This key feature ensures passenger safety and reduces delay at stops. Specially designed buses are required for step-less boarding. Often, these buses are high capacity articulated buses (vestibule buses).

Electronic ticketing outside the bus, called off-board fare collection, enhances passenger convenience, plugs revenue leakages, and increases system speed. Use of an automatic vehicle tracking system provides real-time information to passengers as well as to system managers.

The following sections describe the key features of BRT in greater detail.

Figure 3.1 -Locating dedicated BRT lanes in the median ensures that they remain free of obstructions.

3.2 Dedicated Central Bus Lanes

To ensure fast, reliable service, BRT systems provide exclusive lanes for buses. In an Indian context, it is essential to have dedicated lanes in the centre of the street for them to be effective and free of obstacles. In some cities, like Sao Paulo (Brazil), Seoul (South Korea) and Kunming (China), central lanes have been demarcated using painted lines. In the Indian context, these central lanes have to be segregated from other motor vehicle lanes with a continuous physical divider.

Street edges (left side) have many conflicts
Private vehicles slow down to park on the kerb side or turn left to access a side street or property at the edge. Slow moving vehicles like bicycles and pedestrians prefer the street edge. For a BRT system to be achieve its full capacity, the lanes have to be in the centre of the street to ensure that they remain free of parked vehicles and other encroachments.

Kerb side lanes should be avoided
Other forms of bus lanes, like painted lanes at street edge or physically segregated lanes at street edge, have been attempted in cities across the world with poor results. Such lanes have had limited success in cities such as Singapore (with congestion pricing and strict enforcement). It must be noted that in the context of India, where street discipline and enforcement is weak, such lanes have failed and should be avoided.

High capacity of dedicated lanes
A single dedicated lane per direction is sufficient for system capacity of up to 9,000 passengers per hour per direction (pphpd) at commercial speeds of 25km/h. Passing lanes are required only at BRT stations when demand goes above this level. (See section 3.10).

Treatment of dedicated lanes at intersections
While intersections can be a cause of delay for BRT systems, they can be designed and managed to reduce the delay. At intersections where BRT buses need not turn, a dedicated two lane grade separator (underpass or flyover) only for BRT buses can be created. In situations where a grade separator is proposed over intersections for private motor vehicles, a split flyover design should be employed. Such a design allows BRT lanes to continue at ground level between the split flyovers constructed for each direction of private vehicle movement.

Figure 3.2 -Curbside bus lanes suffer from encroachments by parked cars and delivery vehicles.

Figure 3.3 -A split flyover in Ahmedabad.

Figure 3.4 -A BRT underpass in Quito.

Figure 3.5 -Level boarding on Ahmedabad's Janmarg system.

3.3 Stepless passenger entry/ exit

The station-bus interface in gold standard BRT provides a metro-rail experience. Passengers can easily walk into and out of the bus, rather than having to climb narrow stairs. Through appropriate station and bus specifications, the levels of station floor and bus floor are kept the same.

Enhanced safety and accessibility for all

Stepless boarding greatly enhances safety and accessibility for all passengers — elderly riders, women and children. Passengers with special needs, like physically challenged, or those with luggage, who rarely have an opportunity to use public transit, experience a new found freedom in mobility.

Higher system speed

Stepless boarding also reduces the time a BRT bus has to stop for passengers to get in and out. Passenger entry and exit time is reduced by up to 80 percent, from around 2.5 seconds per passenger to 0.5 seconds. If all other conditions remain constant, this increases average bus speed by 18 percent, making it a rapid system. Higher bus speeds means the frequency of service can be increased without increasing bus fleet size and helps to reduce overcrowding.

Lower operating cost

Step-less boarding reduces the cost of operations. Fewer buses and staff are required to provide same frequency. Lower idling time reduces fuel consumption and emissions.

3.4 Fare collection at stations

Passengers buy tickets or pay with smart cards before entering a BRT station instead of paying inside the bus. This is usually termed "off-board fare collection." This is the standard means by which passengers access rail systems across the world, including in Chennai. A similar system has been proposed for the upcoming

	BOARDING TIME PER PASSENGER	ALIGHTING TIME PER PASSENGER	SPEED IMPROVEMENT
HIGH-FLOOR BUS	2.5 seconds	1.5 seconds	-
LOW-FLOOR BUS	1.1 seconds	0.9 seconds	13%
LEVEL BOARDING	0.75 seconds	0.5 seconds	18%

Table 3.1- Demonstrates how level boarding enhances higher system speed

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Chennai metro. Passengers are issued rechargeable smart cards, and they swipe their cards to open turnstiles to enter or exit the system. In recent times, the cost of smart cards has fallen substantially, making them an ideal form of payment in public transport systems.

Increase in system speed

In regular city bus service, buses get delayed at busy stops because the conductor halts the bus until all passengers are issued tickets. In a BRT system, since the process of fare collection happens at the station prior to boarding, bus delay at stations can be reduced up to 40 percent. This results in an increase in bus speeds of around 10 percent.

Enhanced passenger convenience

Passengers are saved from the hassle of purchasing a ticket every time they enter a bus. System image is greatly enhanced in the eyes of the users. Furthermore, since fare payment is electronic, fares need not be in slabs of whole rupees (e.g. Rs 4, 5, 6, etc) but can be decimal figures (e.g. Rs. 5.32, 6.17, etc). Special discounts can be offered to passengers depending on how frequently they use the system.

Reduced cost of operations

Off-board fare collection eliminates the need for conductors. These staff can be reassigned to manage fare collection activities at stations or to perform other duties. The fare collection cost per station then remains more or less constant as ridership increases, thereby reducing transaction costs per passenger. When new buses are deployed, additional conductors are not required.

Plugging revenue leakage

Passengers cannot travel without tickets or passes since they are checked by electronic gates at entry and exit points at stations. Other forms of revenue leakage during transactions between conductors and terminal staff can also be plugged. Savings from plugging revenue leakage may be as much as 20 percent.

Automated information on passenger travel patterns

All ticketing information, including the place where a passenger got into the system and where he/she exited, is available in an electronic format, giving system managers an excellent means to track passenger travel patterns. This information can be used in ongoing route rationalization to remove inefficiencies, enhance customer service and reduce the cost of operations.

Figure 3.6 -Off-board fare collection at a Janmarg station.

Figure 3.7 -A Janmarg bus docked at a median station.

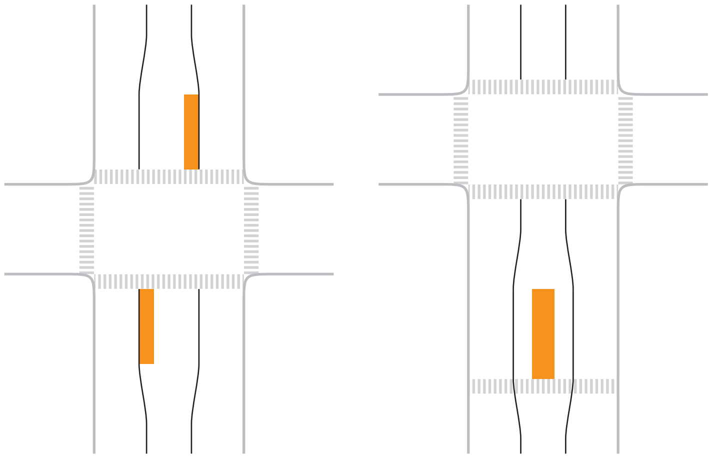

Figure 3.8 -Compared to bilateral stations (left), centrally located stations (right) are cheaper to build and allow passengers to transfer without leaving the station.

3.5 Centrally located stations

High performance BRT systems typically have a single common station for both directions—like a central railway platform—rather than having two bus stops, one for each direction. Such stations are located in the central verge between the two directions of movement and offer access to buses moving in both directions. Special BRT buses, which have doors on the right side with no steps, access such stations. There are many advantages of single central stations.

Central stations are cheaper to construct and maintain
Central stations are smaller and are up to 40 percent cheaper to build and operate than two bus stations on either side of the central bus lanes. The central station requires a single entry area and single set of turnstiles, whereas the two bilateral stations each require their own entry. They Central stations also optimize the use of street space.

Ease of passenger transfer between routes
Centrally located stations make it easier for passengers 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.

Unique system identity
BRT stations have strong identity and provide a great environment to passengers. In many developing countries, they are one of the best public spaces. Since only special buses with right side doors can access BRT station, the system retains a special image of efficiency.

Modular design of stations for future demand potential
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.

3.6 Distinctive buses with special features

BRT buses have special wide doors, with no steps. These wide, step-less BRT bus doors are aligned with the wide doors of BRT stations. On high-demand corridors, articulated buses can provide additional capacity and reduce bus congestion at station. It is important that investment be made in high quality buses and that a maintenance regimen be adopted to keep them in good operating condition. In addition to rapid travel, ride quality and ease of access define to a large extent how the system is received by passengers.

Bus doors and step-less entry
In case of a standard BRT bus (12 m long), there are two doors of 1.1 m each. In case of an articulated bus (18 m long), there are 4 doors of 1.1 m each.

Articulated buses
As the demand for BRT increases on any given corridor, articulated buses should be brought into service. Articulated buses are have twice the capacity of regular 12m buses. They increase capacity of the system, reduce congestion on the BRT corridor and require shorter stations, thus reducing the cost of infrastructure.

Use of AC buses
Ahmedabad's Janmarg system has shown that providing AC buses need not cost a fortune to the city and passengers. The private bus operator in the Janmarg system is compensated at a nominally high rate for AC buses, an increase of just 12 percent (Rs 38 per km, compared to Rs 34 per km for non-AC bus). Depending on the weather conditions in a city and the configuration of bus, the additional cost of AC buses need not be more than 20 percent over non-AC ones.

3.7 Frequent service

BRT service needs to be frequent and reliable so that passengers never need to wait long to catch a bus. Services are planned according to passenger demand to prevent overcrowding during peak hours. Real-time monitoring and feedback from an IT enabled control centre can help bus drivers stay on schedule.

3.8 Customer information

BRT systems offer clear route maps, schedules, and other forms of passenger information, just like those provided on most metro systems. Inside BRT stations, electronic displays inform waiting passengers when the next bus will arrive. On the buses, displays and audio announcements indicate the upcoming stop. Effective customer information systems help make the system accessible to all users, particularly people who are new to public transport.

Figure 3.9 -New buses acquired for the Pune Metropolitan Region's BRT system feature modern styling and right-side doors at 900 mm.

Figure 3.10 -The two front doors of an articulated bus in Mexico City's Metrobus system.

Figure 3.11 -Electronic displays in Transmilenio stations indicate when the next bus will arrive.

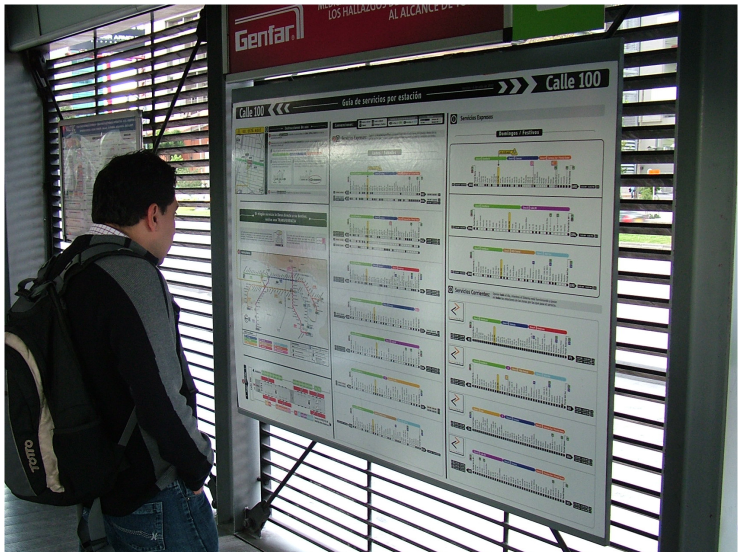

Figure 3.12 -Route map in Transmilenio station, Bogota

SYSTEM	ARTICULATED BUSES	PASSING LANES	MULTIPLE STOPPING BAYS	PASSENGER THROUGHPUT (PPHPD)
METROBUS, MEXICO CITY	Y	N	N	8500
CURITIBA	Y	N	N	12000
GUANGZHOU BRT	N	Y	Y	27000
TRANSMILENIO BOGOTÁ	Y	Y	Y	45000

Table 3.2- Comparison of passenger throughput in relation to design changes

3.9 High quality image through effective branding and outreach

Creative advertising, an attractive logo, and well-designed buses and stations can elevate the status of a BRT system. Effective branding is necessary to distinguish a BRT system from traditional buses, which carry the stigma of being unreliable, dirty, and dangerous. A consistent graphic style combined with effective messaging can help cultivate a modern, progressive image for BRT. (See section 5.4)

3.10 Change in design for increase in capacity

Travel demand will rise as Chennai grows, and it is important that the city's public transport system have the flexibility to respond as the passenger load increases. BRT offers the flexibility to achieve capacity increases through incremental modifications in infrastructure and rolling stock. Specific means of expansion include the following:

Articulated buses

While 12 m buses have a maximum crush load of 90 passengers, articulated buses can carry up to 160. Articulated buses require additional station doors and provision for this should be made in the initial station design.

Additional stopping bays

Station modules can be added to allow two or more buses to dock at the same time. Buses can then operate in convoys, in which two buses move together from stop to stop. While convoying can increase capacity significantly, station congestion leads to declining commercial speeds.

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Overtaking lanes
Overtaking lanes prevent busway and station congestion by allowing multiple stopping bays at a single station to function independently of one another. Through the use of overtaking lanes and multiple stopping bays, the GZ-BRT system in Guangzhou, China, carries 27,000 pphpd. The Transmilenio BRT system in Bogotá, Colombia, handles loads of up to 45,000 pphpd. Both of these figures are comparable to metro systems from across the world.

3.11 BRT corridor designs

BRT can provide high capacity and high quality service if the elements are designed appropriately. Treating BRT only as a road infrastructure improvement project leads to low capacity and poor system quality. Critical elements include system management, operations planning, a dedicated BRT bus fleet with easy boarding and alighting, and placement of stations.

Standard BRT configuration with no overtaking lanes
Segregated bus lanes are a primary requirement for the success of a BRT. A standard BRT lane requires approximately 3.5 metres of road width while stations are generally 4-5 metres wide. In some very narrow sections, station width can be brought down to 3m but should be avoided as a general practice. A standard busway with a single lane in each direction will require 8-9 metres road width in a mid-block section and 12-13 metres road width at a BRT station location. BRT stations should be designed to accommodate articulated buses even if only 12m buses are to be used to start with. Designing stations to accommodate articulated buses results in a marginal increase in cost (<10 percent) but increases system capacity by close to 50 percent. The length of such a bus station is approximately 55 m including access ramps, fare collection area and boarding area. Appendix 3 includes a sample design for a BRT station.

BRT can become a barrier to pedestrian and cyclist movement if at-grade crosswalks are not provided at reasonable intervals (maximum of 150 m intervals). Passengers may have trouble reaching bus stations unless pedestrian refuges and traffic calming measures improve pedestrian safety. A 1 m buffer between mixed traffic and a BRT lane as a pedestrian refuge at crossings is a necessity. The pedestrian access to the centrally located station via crosswalks is to be elevated to the level of the sidewalk (e.g. +150 mm) to ensure reduced vehicular speeds and safer crossings.

Figure 3.13 - Articulated buses add capacity and reduce congestion in bus lane

Figure 3.14 - Overtaking lanes and multiple stopping lanes increase capacity manifold

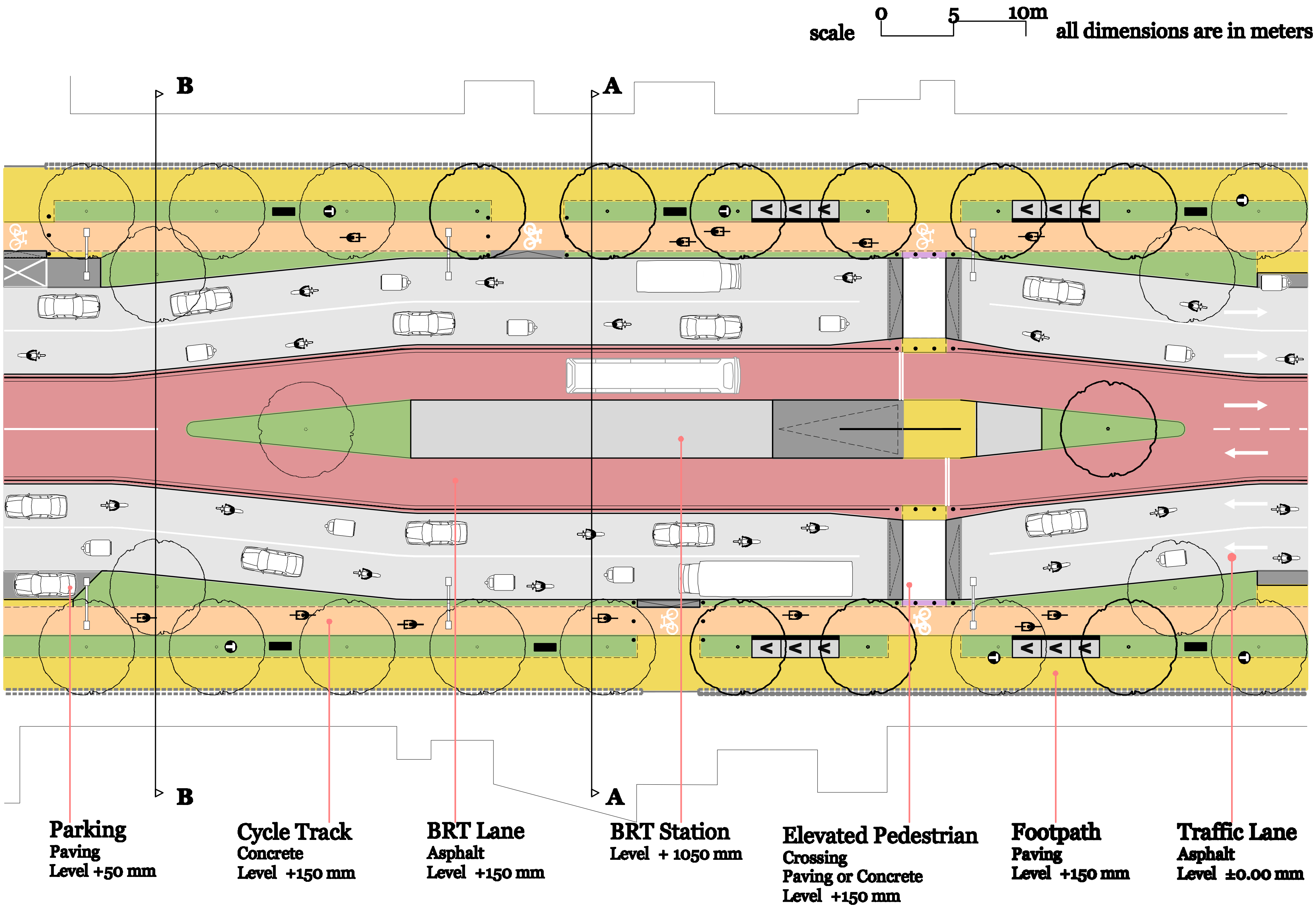


Figure 3.15 -Typical BRT alignment for 36m ROW with single lane bus way without overtaking lanes This alignment can already accommodate large passenger volumes of up to 6,000 passengers per hour per direction (pphpd) with 12 m buses. With articulated buses, a single-lane system can carry 10,000 pphpd.

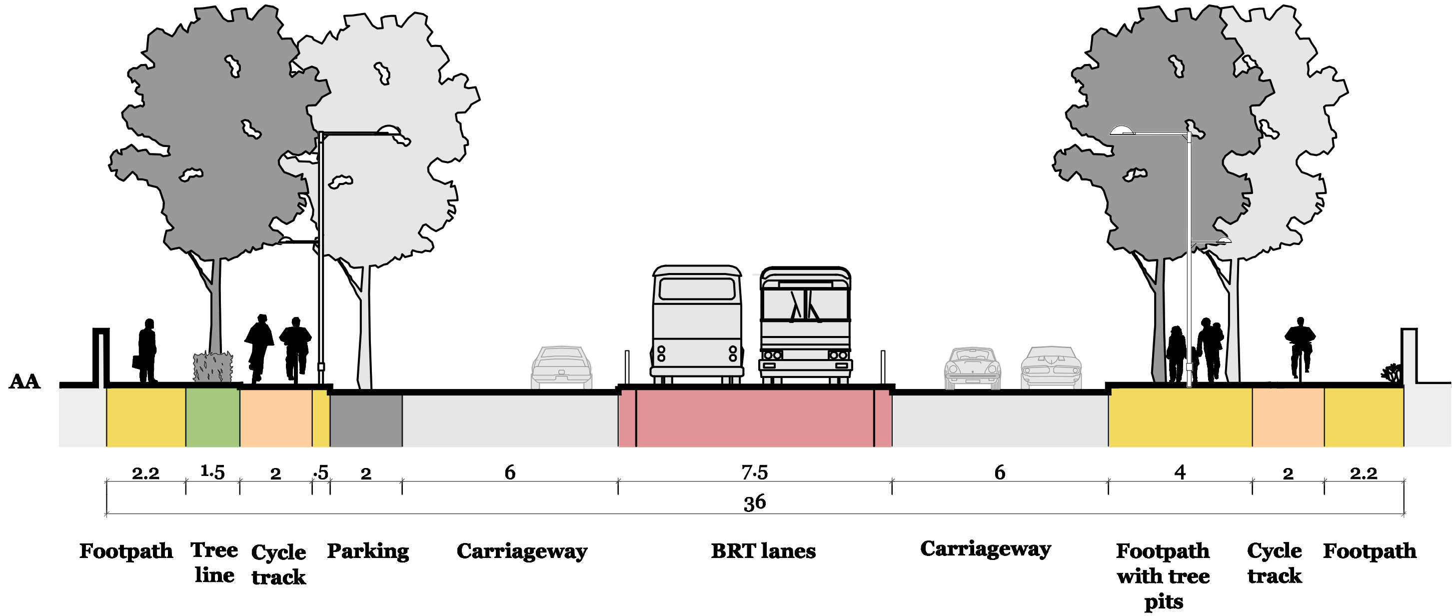


Figure 3.16 -Section through mid-block for a typical BRT alignment for 36m ROW with single lane bus way without overtaking lanes

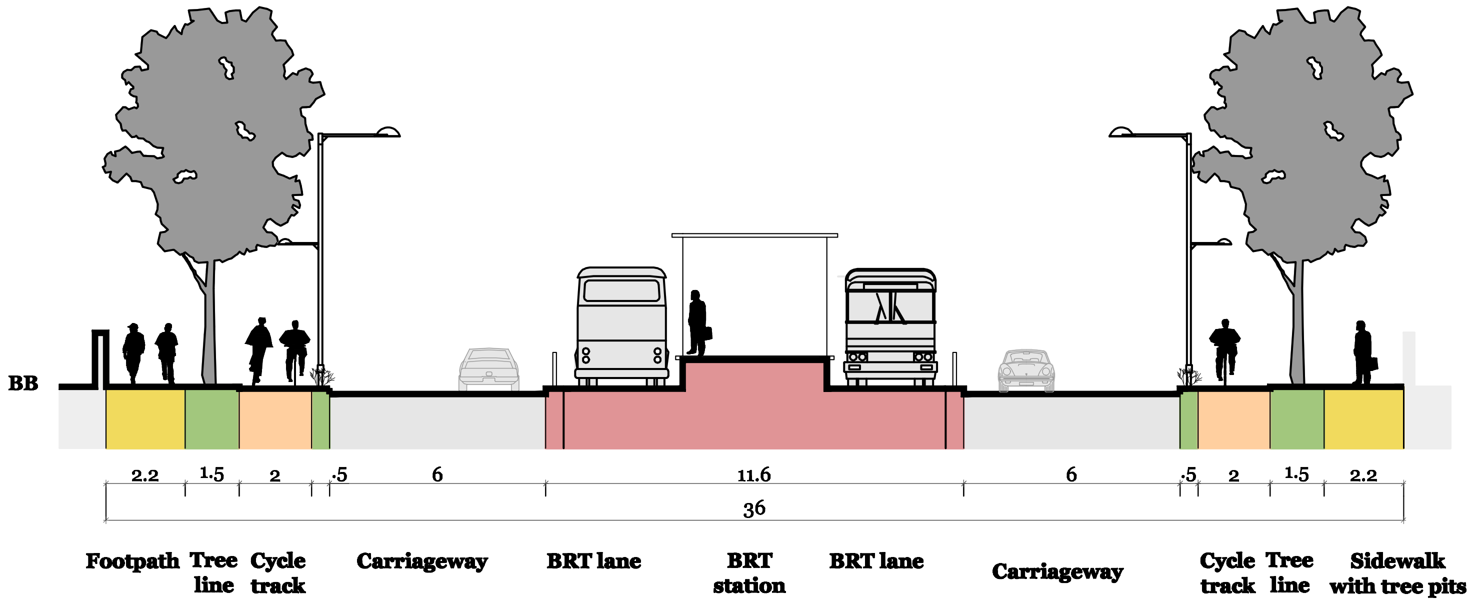


Figure 3.17 -Section through BRT station for a typical BRT alignment for 36m ROW with single lane bus way without overtaking lanes

Stations with overtaking lanes

Providing an overtaking lane increases the capacity of the BRT system to meet higher travel demand and allow flexibility to operate limited stop services/express services. This configuration will require 8 metres road width in a mid-block section and 17-20 metres road width along a BRT station.

The Transmilenio BRT system in Bogotá, Colombia, carries 45,000 pphpd through the use of passing lanes. Another system with overtaking lanes is the Guangzhou BRT system in China which carries 27,000 pphpd.

Some small stations with few passengers may omit a second docking bay. Most services that pass such a station will be express services and will not stop. Only a few local service buses will stop at such a location. On the other hand, some high demand stations may have as many as four modules.

Figure 3.18 -Transmilenio BRT overtaking lanes showing buses moving in and out of docking bay

scale 0 10 20 all dimensions are in meters

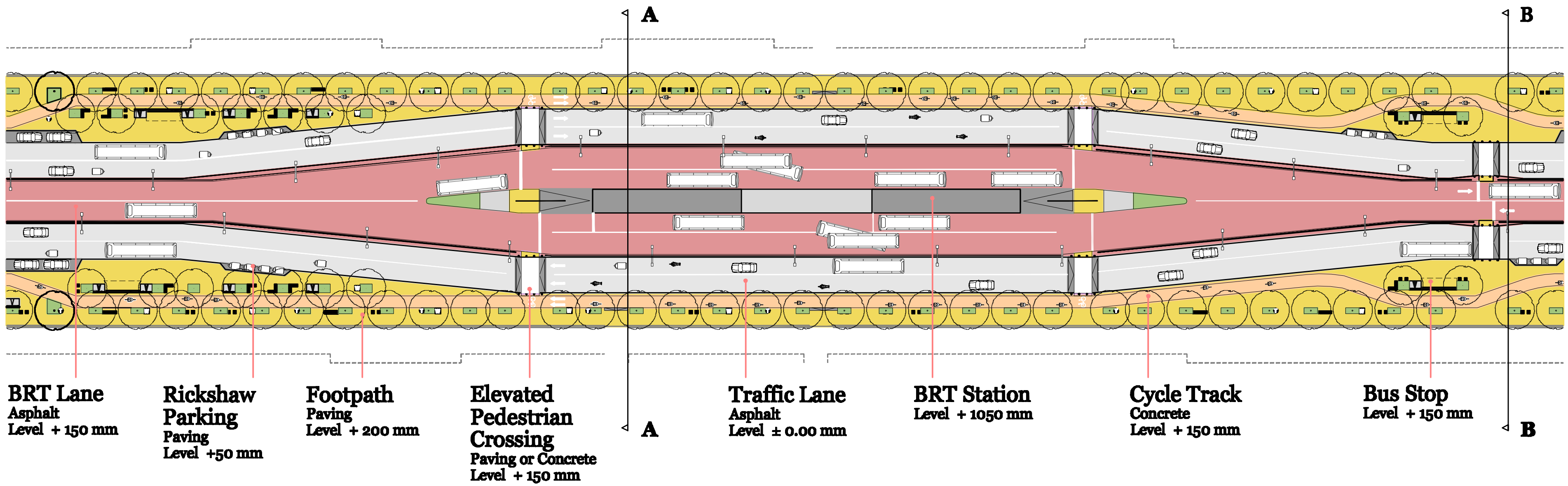


Figure 3.19 -In this drawing, the station is comprised of two modules. Each module has one docking bay per direction, plus queuing space for one bus behind the docking bay. The cumulative width of the stopping and passing lanes is at least 7 metres in each direction. A 21 metre gap between the two consecutive modules is provided. Then 7m width and 21m gap between modules allows buses to overtake a stopped bus and manoeuvre in and out of a docking point.

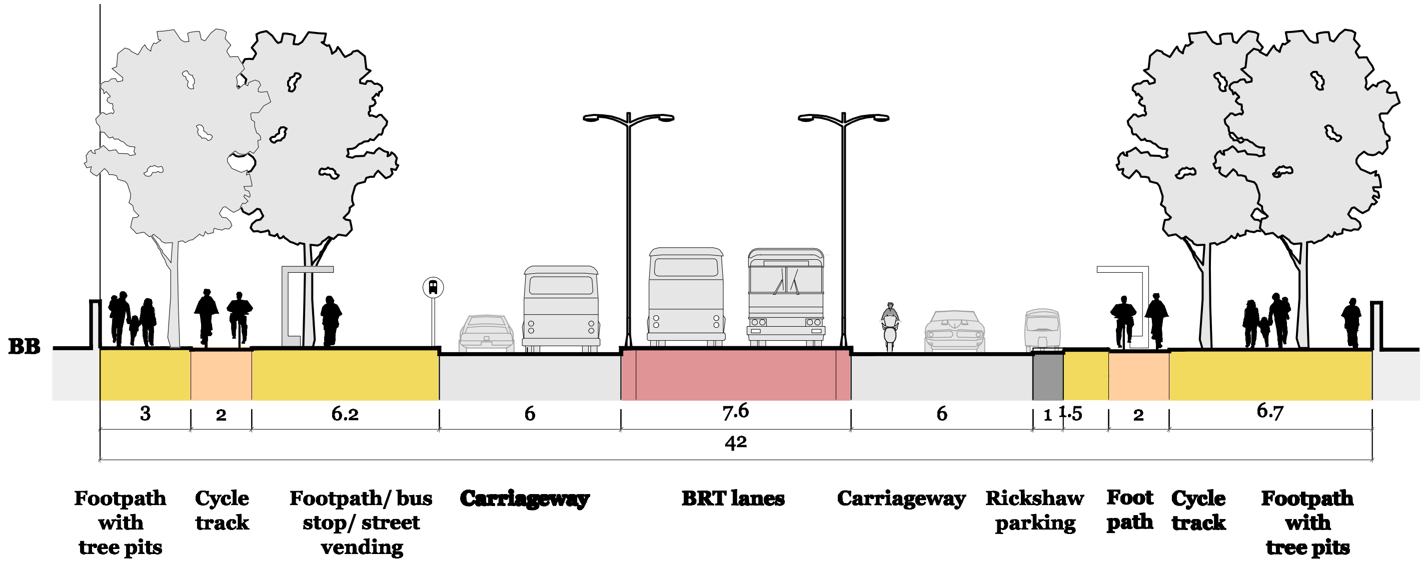


Figure 3.20 -Section through mid-block for a typical BRT alignment for 42m ROW with single lane bus way and overtaking lanes

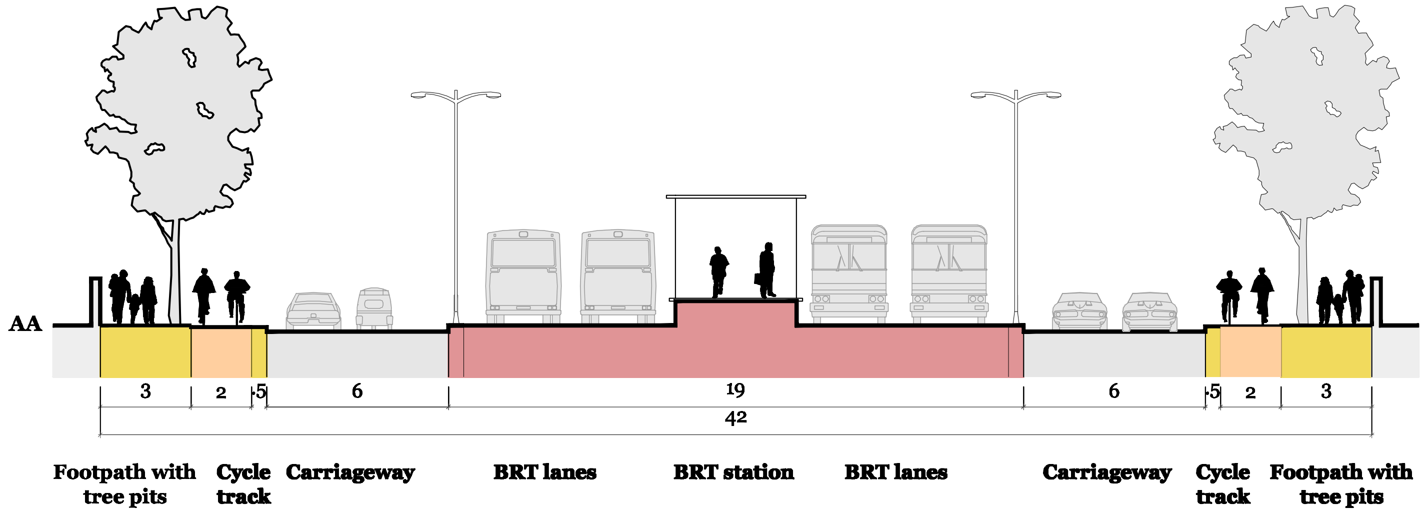


Figure 3.21 -Section through BRT station for a typical BRT alignment for 42m ROW with single lane bus way and overtaking lanes

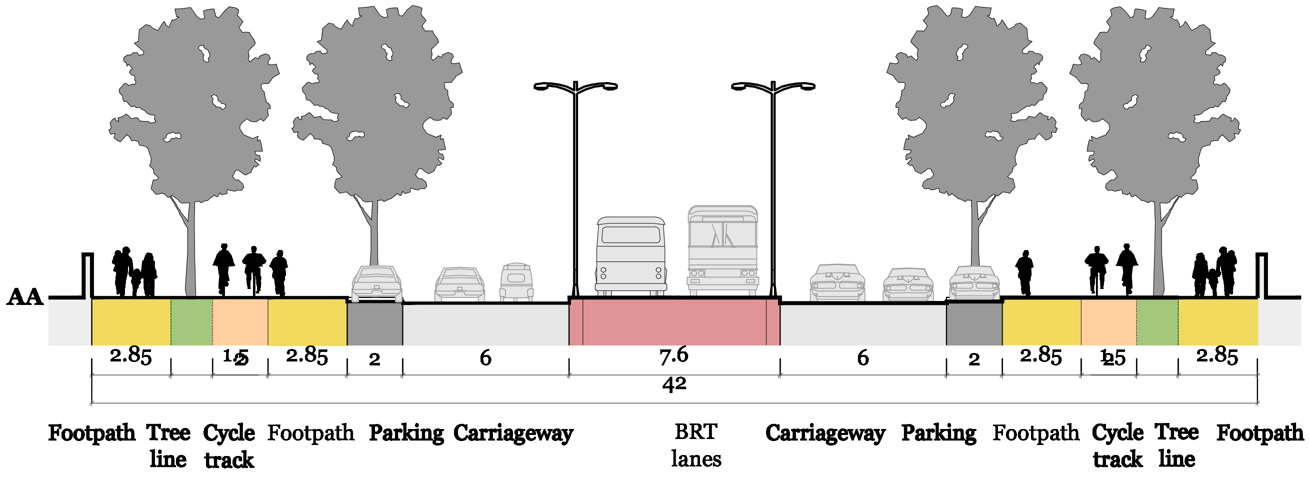


Figure 3.22 -Section through mid-block for a typical BRT alignment for 42m ROW with single lane bus way and staggered station with overtaking lanes

Staggered stations with overtaking lanes

To accommodate passing lanes in a narrow profile— or to provide more space for other uses such as pedestrian and cyclist mobility and informal activities— separate offset platforms can be provided in each direction.

This design is able to fit in a narrower right-of-way or, as shown above, to maintain median tree lines and extra footpath width next to the station in a 42 m right-of-way. However, the design also requires a significantly longer stretch for accommodating the station.

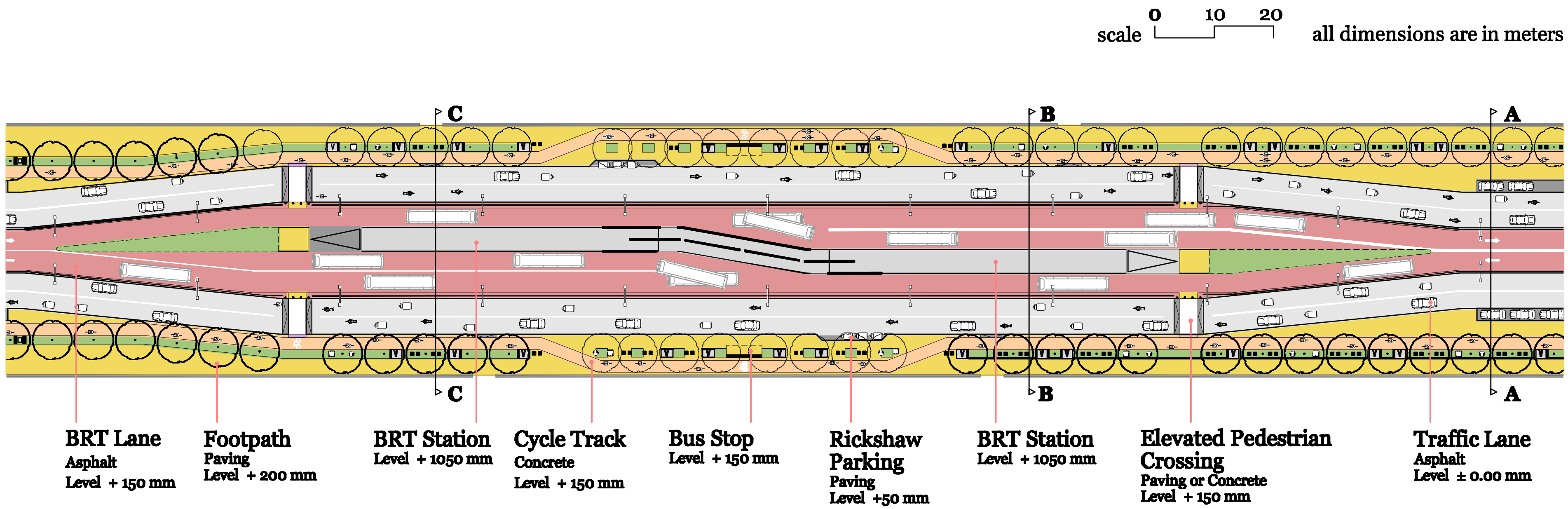
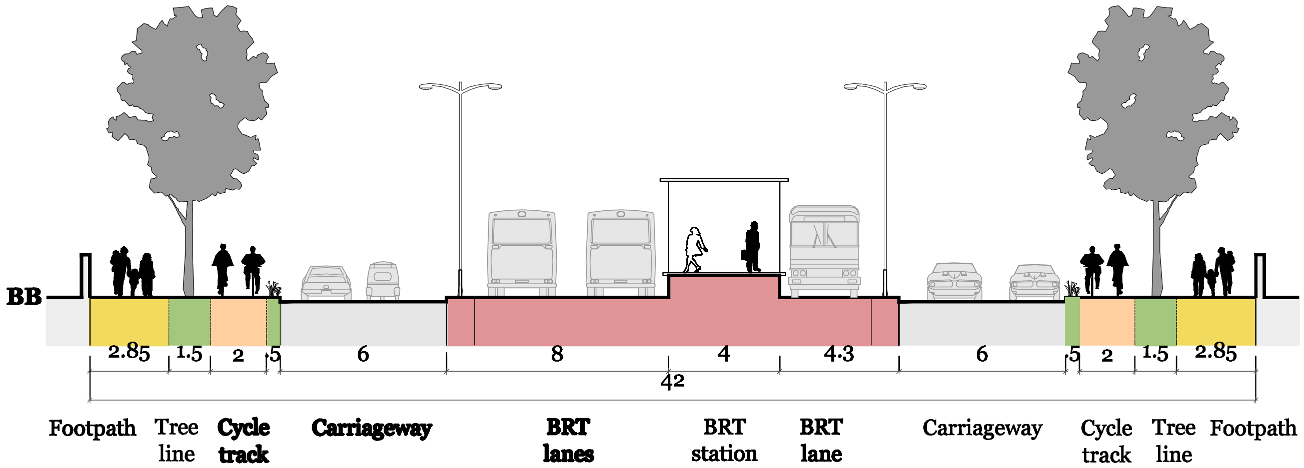


Figure 3.23 - A typical BRT alignment along a 42m ROW with single lane bus way and staggered stations with overtaking lanes



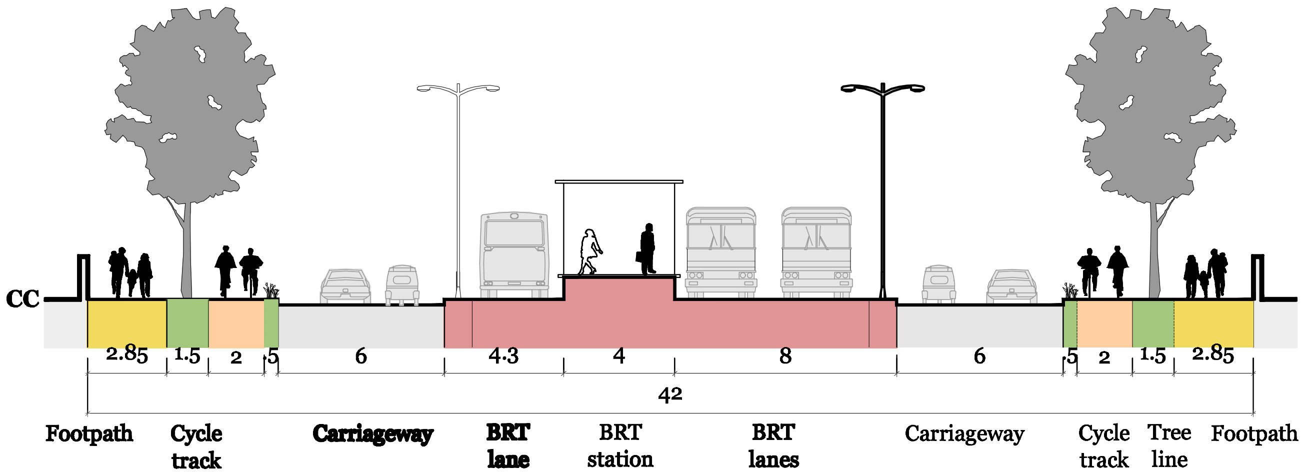


Figure 3.24a and b -Section through BRT station for a typical BRT alignment for 42m ROW with single lane bus way and staggered station with overtaking lanes

Figure 3.25- Transmilenio transit mall near the Gold Museum in Bogota, Colombia

Transit mall corridors

There may be an opportunity in some instances to restrict a segment's access to only public transport vehicles. Private cars, motorcycles and trucks are banned either entirely from the corridor segment or during public transport operating hours. A transit mall is a commercial corridor segment in which only public transit and non-motorized traffic are permitted. More broadly, a transit-only corridor is any such segment whether in a commercial area or a residential area.

Transit malls are frequently an effective solution when a key corridor only has two lanes of road space available. Thus segments with only 7metres of road space could be appropriate for a transit mall.

Transit malls are particularly appropriate when the public transport service enhances the commercial activity and integrates well into the existing land-use patterns. In such cases, the transit mall creates a calmed street environment void of traffic congestion. Transit malls permit a maximum number of customers to access shops and street amenities. Thus transit malls typically reside in locations where shop sales are quite robust.

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3.12 BRT works on narrow streets

Many people believe that BRT requires wide streets. However, BRT systems in Guayaquil and Quito (in Ecuador), Mexico City, and other cities include sections that pass through very narrow streets in historic city centres. These systems have demonstrated that BRT can be implemented in tight settings without disturbing the existing urban context. Streets as narrow as 18 m can accommodate two-way BRT while leaving adequate space for pedestrians as well as a service lane for property access.

If parallel streets are available in close proximity, BRT can also be implemented as a one-way couplet. For example, Ahmedabad's Janmarg BRT travels on a one-way loop through 24 m streets near the Maninagar railway station. The system could also have been designed as two-way BRT with one-way traffic, as has been done on some streets in Johannesburg, Mexico City, Quito, Guayaquil and others.

Appendix 2 provides a range of street design templates to show how it is possible to design BRT corridors on narrow streets starting from18 metres to 24 metres road width.

Road widening

In certain instances, road widening may be used to address the design of BRT corridors in narrow streets. However, land acquisition in core central areas of Chennai may prove to be expensive or politically difficult thereby pushing up the corridor cost considerably.

Alternatively, selective land purchase in bottleneck points away from central areas are a more viable option. Land prices in the fringe areas should be more affordable and there are likely to be fewer conflicts as regards land acquisition. In particular, areas with undeveloped land, parking lots, derelict buildings and illegal encroachments are clearly more cost-effective acquisition options than central areas with soaring real estate prices.

Grade separation

Underground or elevated BRT corridors may make sense for short segments where there is little option for connectivity. This is possible because of the ability of BRT vehicles to negotiate slope changes within relatively short distances in comparison to other modes of mass transit. However, grade separation for longer distances erodes somewhat the cost advantage of BRT in comparison to other technologies. However, it is still cheaper, at approximately Rs30-40cr per km as

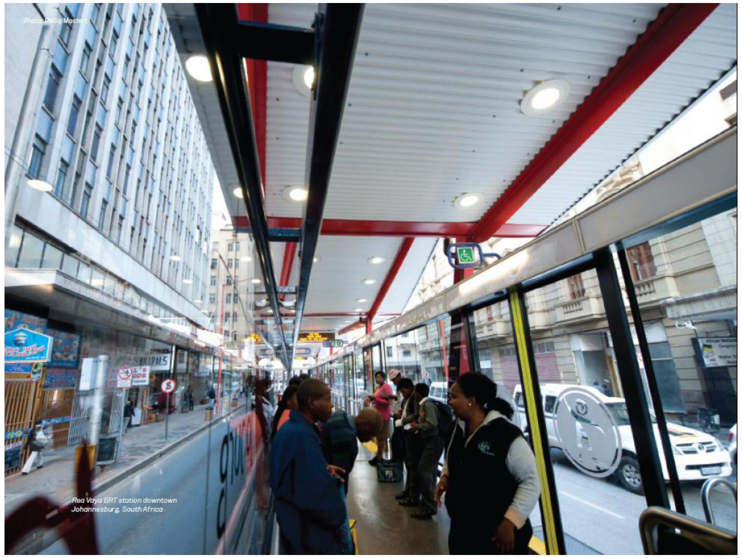

Figure 3.26 -A BRT station on a narrow street in Johannesburg, South Africa

Figure 3.27 - One way BRT in Johannesburg, South Africa

compared to rail based technologies.

Grade separation is a viable option in the following circumstances:
• Roundabouts
• Congested/complex intersections
• Segments of dense, central areas

The main advantages of grade separation are:
• It can significantly improve average commercial speeds and travel times and allows vehicles to maintain speeds through areas that would otherwise require speed reductions for safety
• It marginally improves safety as BRT vehicles will not have to negotiate congested / complex intersections. However, most BRT systems increase safety in general, even without grade separation, because of reduced conflict between buses and pedestrians as well as other vehicles, especially slow moving ones.

Mixed traffic operation
The exclusive priority lane given to BRT vehicles is the principal physical feature that sets it apart as a high quality public transport system. The segregated lane is what enables the customers to develop a mental image of the system in the city. Removing this segregation will make the BRT system indistinguishable from the MTC network and therefore greatly devalues the system from what it is meant to be.

As a last option to narrow road space, a BRT system can operate in mixed traffic for certain segments of a corridor. If the corridor is not congested and future congestion can be controlled or if there is much difficulty/ resistance to restrict mixed traffic, then a temporary mixing of BRT vehicles with traffic may be acceptable. However if the link is congested, it will defeat the purpose of the BRT by affecting its travel times, system control and overall system image. Therefore, short and selected segments of mixed traffic operation are acceptable without undermining the functionality of the larger system.

3.13 BRT Station Design

BRT Stations are planned and designed differently from that of a normal bus stand. Stations are placed at an average spacing of 500 m, relatively close to intersections for easy access, but not at the intersection itself which leads to sub-optimal performance. Stations should be placed at a minimum of 37 m or more off intersection stop lines to allow sufficient space for bus and mixed traffic queues. Centrally located BRT stations which enable ease of transfer from route to route require a width of 4m within the right of way. Larger widths may be required if demand is high.

BRT stations are planned on a modular format. Each module handles the docking of one bus in each direction and also leaves enough room for the next bus to manoeuvre into position. At busy stations, multiple modules can increase capacity.

Bus lanes at BRT stations have a high level of wear and tear because of the frequent bus breaking to slowdown and dock. Further the load of vehicles is on two narrow bands. It is advised that BRT lanes be constructed of reinforced concrete.

Station design is a function of passenger volumes, the route structure, and available right-of-way. Stations need to be sized appropriately to meet projected passenger demand, providing sufficient space for waiting passengers as well as passenger circulation. Details can be found in the 'Bus Rapid Transit Planning Guide'. The entry/exit and queuing space should be sized based on operational parameters such as the number of boardings and alightings per hour.

Beyond basic functionality, BRT stations should provide the following -

- **Safety and security**
Safety and security. Stations need to have good visibility and lighting to ensure the safety of all users, but especially women, children, and senior citizens. If possible, they should be guarded during all hours of operation.

- **Universal design**
Employing universal design standards is needed to ensure accessibility to the physically disabled. Platform extension ledges are essential for close docking of buses to allow for safe passenger entry and exit. Such a ledge typically extends 250 mm from the station wall. Ramps with a slope of 1:15 should be provided at entry points. At least one of the electronic entry/exit gates should be 1 m wide for wheelchair access.

Figure 3.28 -Alternate station configurations in Bogotá's Transmilenio system

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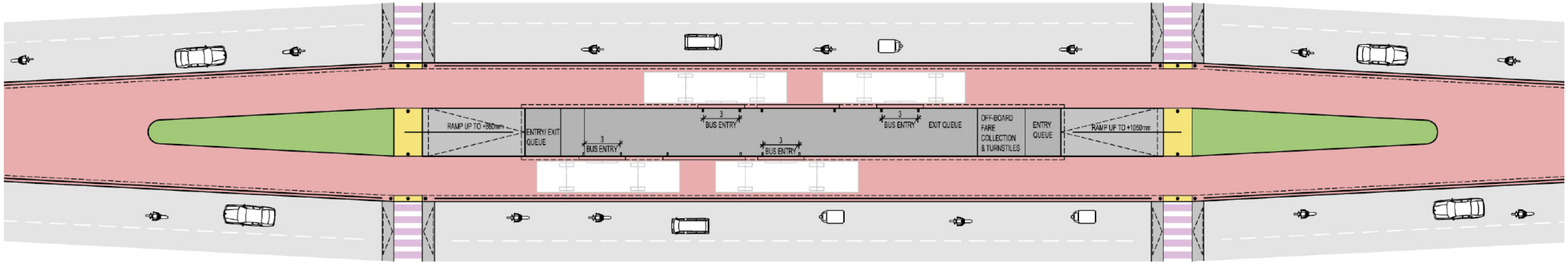

Figure 3.29 -A typical BRT station designed for 12 m buses requires sufficient length for passenger access ramps, ticket vending, turnstiles, boarding/alighting, and internal circulation.

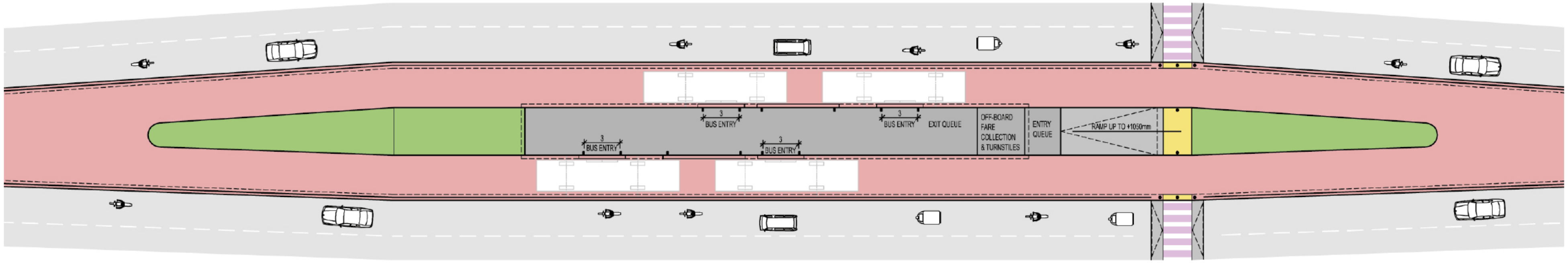

Figure 3.30 -For stations with lower demand, a single entrance may be provided. The design provides two docking bays to increase system capacity. Docking bays should be staggered to reduce friction between passengers boarding and alighting on opposite sides.

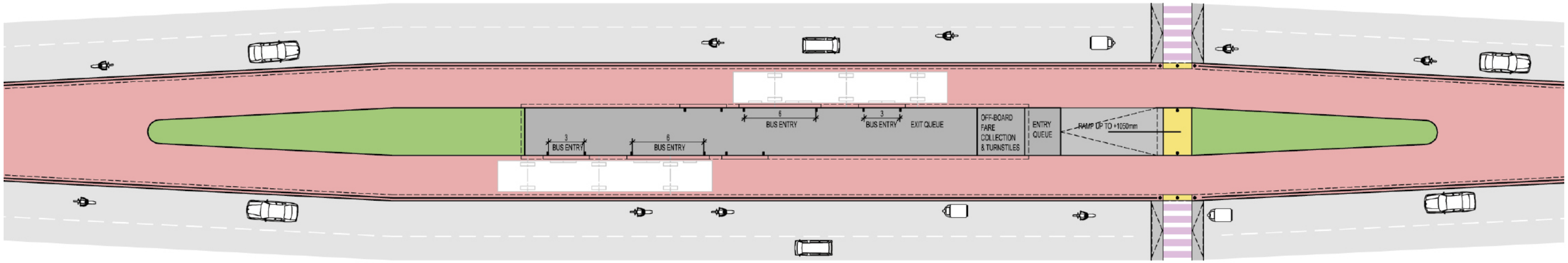

Figure 3.31 -Docking bays for 18m articulated buses consist of two openings: a front opening of 3 m and a rear opening of 6 m.

• **Circulation**
To facilitate fast, uninterrupted boarding and alighting, circulation paths should be clear and intuitive. Areas in and around stations should be maintained free of clutter and encroachments.

• **Aesthetic appeal and identity**
Appealing station designs can help attract riders and make the BRT system distinguishable in the streetscape. An open station design with permeable walls facilitates ventilation and enhances safety. Care should be taken that the gaps in the walls should be small enough to prevent children from falling out.

• **Signage**
Different types of signage, including route maps, schedules, and dynamic arrival time displays can help disseminate information to passengers. Signage should be in at least two languages (local and universal) and be of a size and brightness that everyone can read easily.

Figure 3.32 -Ledge extension at Metrobus BRT station in Mexico City to facilitate seamless boarding

Figure 3.33-Wheelchair access through turnstile at Metrobus BRT station in Mexico City

Figure 3.34 -The attractive design and lighting of janmarg stations helps contribute to the distinctive image of the system.

Figure 3.35 -Unauthorised use of BRT lanes by private vehicles results in slower service and also presents a safety risk.

Figure 3.36 -Improper docking at a BRT station and differences in between the floor level of the bus and station can cause inconvenience for passengers.

3.14 Improved operational efficiency

Since BRT buses travel at higher speeds than regular buses, they can carry more passengers during a given period of time. System speed remains relatively constant and independent of while speeds of private vehicles running parallel to them. BRT speed remains high even if speed of private vehicles deteriorates over time due to increased congestion.

In Ahmedabad, each BRT bus carries over 1,800 passengers per day, whereas each regular bus in the city carries 850 passengers. Improved fleet utilization results in higher farebox revenues for each bus-kilometre operated. The comparison is outlined in table 3.3.

At present, MTC carries 1600 passengers per bus per day. However, buses are dangerously overloaded in the peak hours. Because of improved speed, same number of buses can provided higher frequency, reduce overcrowding and improve passenger travel comfort. BRT buses are likely to carry substantially more passengers.

3.15 Common BRT mistakes to avoid

Bus lanes alone, even in the centre of the roadway, are not sufficient. BRT is a package of features that, when implemented together, create an efficient transport system that attracts new ridership while retain existing public transport users. There are many examples of poorly partially implemented BRT systems that do not achieve their intended goals. Common pitfalls include the following:

Poor enforcement of bus lane.
Effective enforcement on the part of the Traffic Police is needed to ensure that private vehicles do not enter the bus lane. Allowing private vehicles to enter the lane reduces bus speeds and creates a safety hazard.

	REGULAR BUSES (AMTS)	JANMARG BRT
SPEED (KM/HR)	18	24
KILOMETRES PER BUS PER DAY	190	240
PASSENGERS PER BUS PER DAY	850	1800
REVENUE PER BUS PER DAY (RS)	4500	11000

Table 3.3- Performance comparison between regular buses and Janmarg BRT in Ahmedabad

Lack of level boarding.
BRT systems whose buses have steps at the door lose out on the travel time savings offered by level boarding. Step-less boarding is not only a matter of matching the station floor height with that of the bus floor. It also requires driver training to ensure that drivers dock near the platform.

Multiple types of buses permitted to travel in BRT lane.
Deploying modern rolling stock is central to ensuring that a BRT system can meet a high standard of service quality. Allowing old buses—particularly those with stepped boarding—to operate in a BRT lane reduces system speed and ease of use. It also detracts from the image of the system. Delays can also be expected if multiple types of buses, such as luxury tour buses, state transport buses, and private company vans, are permitted to enter the BRT lanes.

Operations planning.
Detailed operational planning is necessary to match services and infrastructure to passenger travel patterns. Several BRT systems have encountered difficulties where bus frequencies or station sizes are inadequate to meet passenger demand.

Avoiding these pitfalls requires a systematic approach to the planning of a BRT system. Adequate data collection is essential to ensure that system planners have a clear idea of expected passenger loads. Cooperation amongst governmental authorities is necessary to ensure that the complete package of system components can be implemented.

Figure 3.37 -Allowing multiple types of buses to ply in a BRT lane results in slower commercial speeds.

Figure 3.38 -Route networks that do not take into account passenger travel patterns can lead to unnecessary transfers and serious crowding at major transfer stations.

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PLANNING FOR CHENNAI BRT

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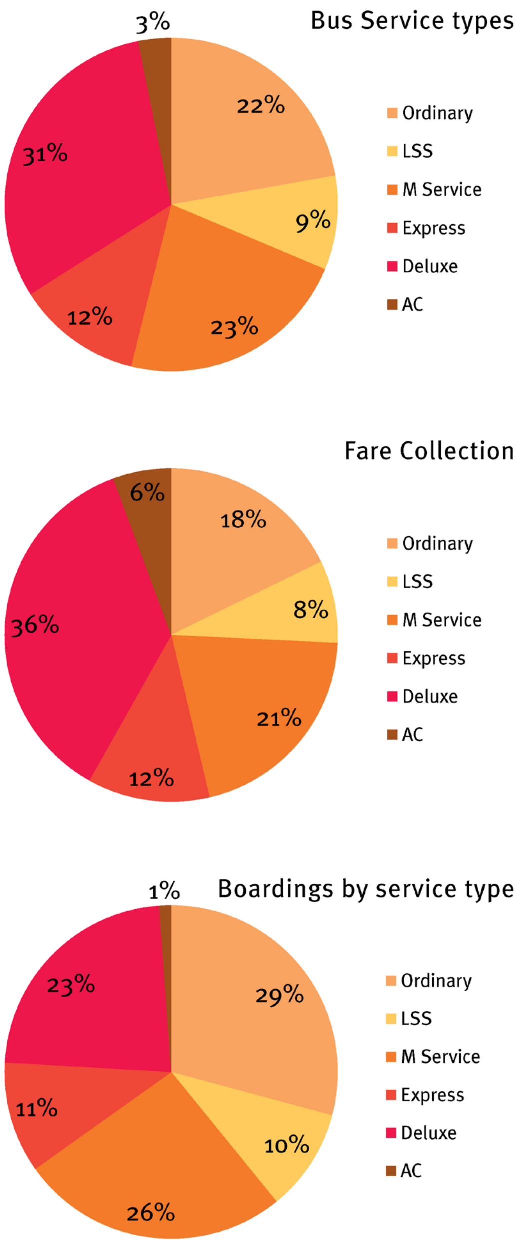

Figure 4.1 -Division of MTC bus service types, fare collection and boardings

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4.0 Planning for Chennai BRT

4.1 Public Transport in Chennai

Public transport has existed for well over a century in Chennai, starting with electric trams in 1895. The service was spread over 24 km at its peak and served thousands of passengers daily. The system went bankrupt and shut down in 1953. But by this time, bus services were already common in the city and were run by private operators. As in many other cities, tram services went out of business due to heavy costs and lack of flexibility, both of which were addressed by the cheaper and flexible bus services.

The Chennai suburban rail services started in the year 1931. In 1947, government-run bus services were started. Eventually, all private operations were closed. Chennai is presently served by only one public bus transport operator, the Metropolitan Transport Corporation (MTC), which was formed through the amalgamation of other publicly owned bus corporations.

4.2 MTC Operations

Metropolitan Transport Corporation (MTC) is considered to be one of the better run city bus transport systems in the country, alongside BMTC (Bangalore), APSRTC (Hyderabad), and BEST (Mumbai). As of 2011, the city is served by 3,420 buses, carrying as many as 5.5 million passengers daily (including pass holders) [1]. This translates into 1,600 passengers per day per bus, highest by any bus operator in India. However, such a high ridership results from fact that most buses are overcrowded, carrying nearly 50 percent more passengers than their rated capacity (i.e. 100-110 passengers in a bus rated for 72 passengers). Such crowding dissuades many potential passengers from using buses. There is an urgent need to increase the bus fleet even to serve existing passengers at an acceptable level of service.

MTC services are operated from 25 depots. These depots vary in size. The Tambaram and Anna Nagar depots, with 206 buses each, are the largest, and Basin Bridge, with only 43 buses, is the smallest. Nineteen of these depots have more than 100 buses with an average of 137 buses per depot.

1 Data provided by MTC, May2011

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MTC service types and fares

MTC fares are among the lowest in the country. The fares start at two rupees and go up progressively in a tapering fashion. However, the low fares are applicable only to the ordinary service, which accounts for 22 percent of the total fleet. There are many other types of services including limited-stop, express, deluxe, and AC. Sevent five percent of the fleet provides these premium services. The average earning per ticket on non-ordinary services is 80 percent higher than the earning per ticket on ordinary service. This calculation does not include the newly added AC bus service, which accounts for 3 percent of MTC fleet. AC bus fares start at ten rupees and are on average 6 times higher than ordinary fares. The average fare for each type of service corresponds to 5 bus stages. A stage ranges from 1.5-2 km.

The 'ordinary service', though perceived to be for the poor, has a fifth of the frequency of all services put together. Given that other services are running successfully, even at higher fares, fare does not appear to be the principle factor in the choice of service. There is scope to improve the overall quality of service—especially the frequency during peak hours—by increasing the fare up to 30 percent, without much adverse effect.

Success of high quality AC service

AC bus service has been very successful in Chennai compared to many other cities. The fare, even at six times that of ordinary service, does not seem to deter people. It has attracted a new class of passengers who are willing to pay for the comfort that AC buses provide. On an average, each AC bus serves 470 passenger trips every weekday—less than a third of the overall average in Chennai. However, due to a higher fare, each AC bus earns nearly twice as much as what the remaining buses earn: Rs. 12,900 per bus per day, compared to Rs 6,500 per bus per day for the remaining fleet.

The AC buses that are presently employed are of high quality low-floor type. Actual operating costs are not available for different bus types in Chennai. However, experience from other cities suggests the following cost of operation.

Bus travel patterns in Chennai

As part of this study, all of Chennai's bus services were mapped using a GIS platform. Bus route schedules were imported into transport modelling software (EMME) and an in-depth analysis was performed. The results of this exercise can be seen in the map on opposite page. The principle corridors that have medium to high

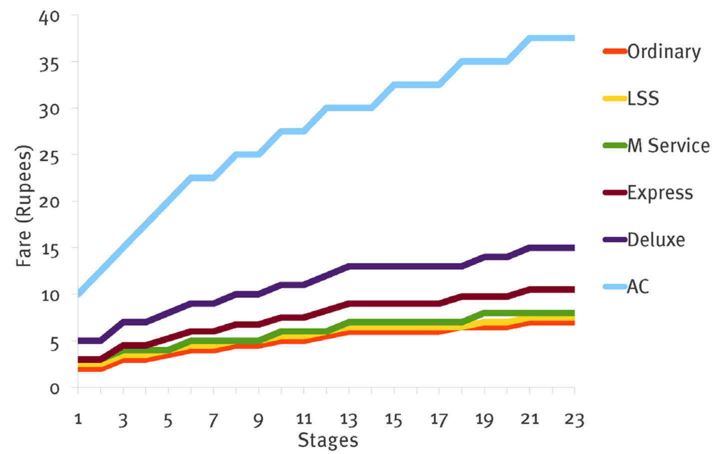

Table 4.1 -MTC fares by service type

BUS TYPE	BUS PURCHASE PRICE (MILLION RS.)	BUS OPERATING COST INCLUDING AMORTIZATION (RS. PER KM OPERATED)
ORDINARY BUS	1.8-2.0	30
SEMI-LOW-FLOOR DELUXE	2.4-2.7	35
SEMI-LOW-FLOOR DELUXE AC	3.0-3.2	40
LOW-FLOOR AC	7.0-8.5	60-65

Table 4.2 - Price and cost of operations of different types of buses

demand, as can be seen in figure 4.2 as well as listed in table 4.3.

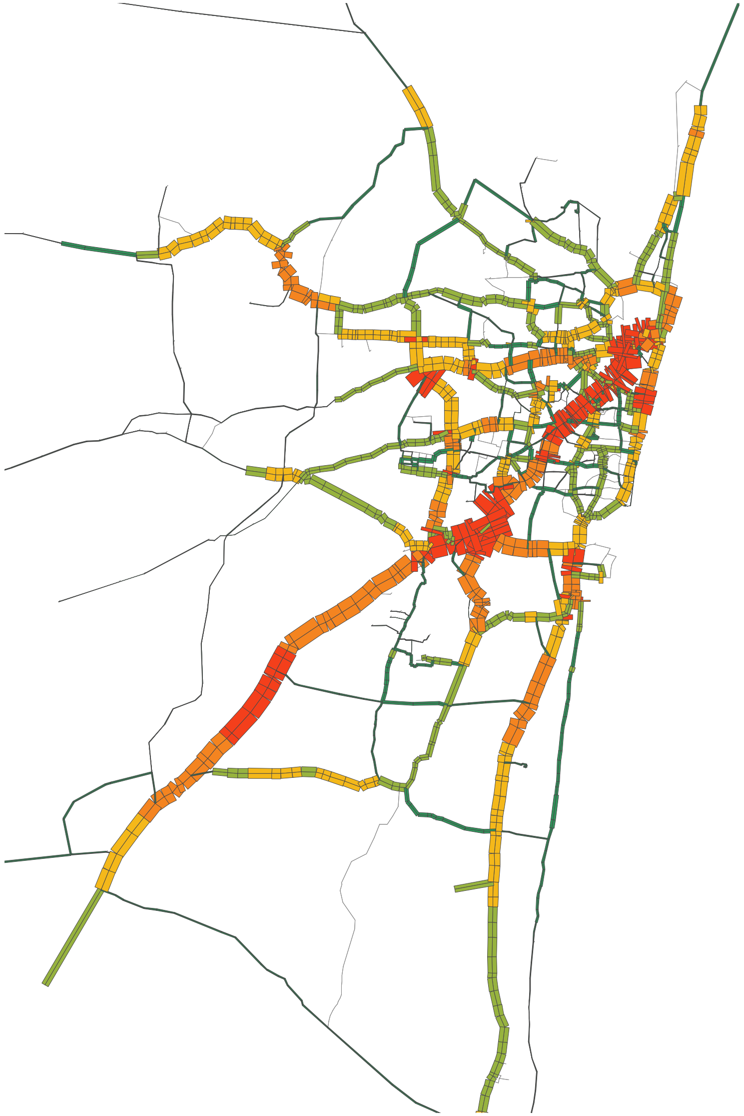

Figure 4.2 -Graphical illustration of demand volumes on MTC network

CORRIDOR	FREQUENCY (BUSES PER HOUR PER DIRECTION)	MTC PASSENGER LOAD (PER HOUR IN PEAK DIRECTION)
ADYAR-PARRYS	70	5600
ADYAR-SAIDAPET	108	8600
AMBATTUR-THIRUMANGALAM	97	8100
ANNA SATHYA NAGAR-EXPRESS ESTATE	76	6100
ANNA SATHYA NAGAR-MYLAPORE	56	4500
CATHEDRAL RD	39	3100
CMBT-MADHAVARAM	27	2300
FORT-GUINDY (ANNA SALAI)	180	14400
FORT-KOYAMBEDU	94	7500
FORT-TIRUVOTTIYUR	83	6600
GST ROAD JUNCTION-THORAIPAKKAM	20	1600
KOYAMBEDU-GUINDY	90	7200
MADHAVARAM-PARRYS	56	4500
MADURAVOYAL-CMBT	38	3000
PORUR-SAIDAPET	61	4900
PORUR-VADAPALANI	44	3500
SIRUSERI-ADYAR	90	7600
TAMBARAM-SAIDAPET	122	10200
TAMBARAM-VELACHERY-SAIDAPET	60	4800
TRIPLICANE-EGMORE STATION	45	3600
VADAPALANI-NUNGAMBAKAM	80	6400

Table 4.3 -Principle MTC bus corridors that have medium to high demand

4.3 Rail services in city

Chennai has three suburban rail lines and one elevated rail line in operation. A 45 km metro system is under construction. The three principle suburban lines - North, West and South- have 286 km of dedicated tracks and carry nearly 1 million passengers each day [2]. The elevated rail line, called the MRTS, is 25 km in length and connects Chennai Beach Junction with Velachery. This line sees 85,000 boardings each day [3]. On the whole, the rail serves far fewer passengers than the bus system, which carries 5.5 million passengers daily.

The busiest suburban rail line is the Beach-Tambaram line, which runs 9-12 coach rakes at peak hour headways of 4-5 min. This line has a peak demand of around 24,000 passengers per hour per direction. In the Saidapet-Tambaram section, nearly parallel to the rail service, there are bus services with high demand of around 10,500 passengers per hour in the peak direction. A single public transport system is insufficient to meet public transport demand on major corridors in Chennai. In many places, bus and rail system need to co-exist, each carrying large numbers of passengers, to serve the needs of Chennai residents.

Phase-1 of metro system that is under development right now has two lines. Line-1 is from Tiruvottiyur-Washermanpet to Airport, running primarily along Anna Salai and GST road. Line 2 is L-shaped. It starts at Chennai Central and terminates at St. Thomas Mount. Lines 1 & 2 have two interchange points - Chennai Central and Alandur. When completed in 2016, the metro system is expected to carry 0.7million trips daily.

4.4 Paratransit services in Chennai

Public transport demand in Chennai is higher than the capacity of all of the city's formal public transport systems put together. This gap between demand and supply is reflected in the presence of paratransit services across the city. These include improvised auto rickshaws as well as the more comfortable Tata Magic vans, which typically carry 7-10 passengers. Accurate fleet sizes and ridership estimates for these modes are not available. However, it is estimated that there are 14,000 paratransit vehicles in operation across the Chennai metro area, carrying as many as 2.5 million passengers each day. It is interesting to note that paratransit services carry

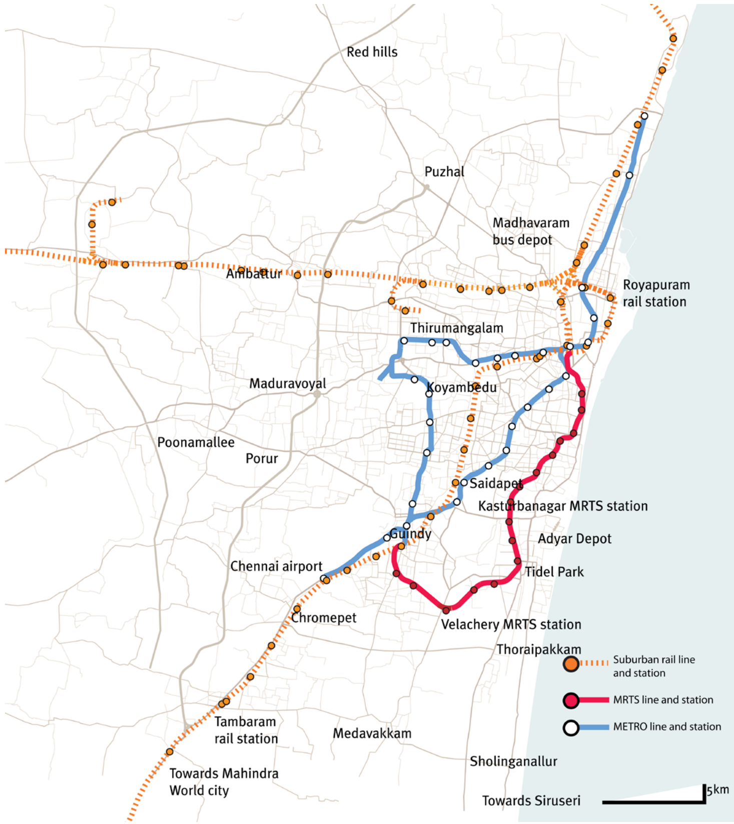

Figure 4.3 -Mass transit networks (existing and proposed)

2 http://www.thehindu.com/news/cities/Chennai/article1515259.ece

3 Estimated based on September 2009 monthly ridership of 23,27,000

more than twice as many passengers as all of the rail system in the city.

Paratransit services typically charge a flat fare that is at par or above fares charged for MTC's deluxe service for the same distance travelled. In spite of their higher fares, paratransit services have a few key advantages that contribute to their popularity:

- Frequency
  They are more frequent than MTC services.
- Clarity of information
  They clearly announce their destination. Passengers are not confused about routes and destinations as they are with cryptic bus route numbers. Passengers get the information they need.
- Speed
  They typically provide point-to-point service with very few stops. In effect, they work like express services.
- Comfort
  They provide the passenger with a seat, in contrast to overcrowded buses.

Bus services in general and BRT in specific can learn a few important lessons from the above. BRT service needs to be frequent, have a simple route structure with clear passenger information, provide fast service and offer a high degree of comfort without overcrowding.

4.5 Integration among public transport modes

Chennai has a fairly good public transport network, including MTC buses, suburban rail, and the MRTS. The Metro, currently under construction, will further enhance this network of services. However, despite all these systems with high carrying capacity and dedicated corridors, the network is limited in terms of achieving connectivity to all parts of the city. Integration between various rail systems and bus services is relatively weak at present.

The suburban rail and MRTS network are not well integrated systems at present. On the one hand, ticketing is integrated to the extent that a single ticket can be purchased that allows transfer between Suburban and MRTS (for example, a ticket can be bought from Mambalam Station to Tiruvanmiyur Station. In this trip, a passenger will have to transfer from Suburban rail line to MRTS near Chennai Central Station). However, the physical interchange from one line to the other is of a poor quality. It requires a long walk through an ill maintained pedestrian underpass. The connection between these rail lines and buses at Central Station is still worse. There is no clear signage that guides passengers.

A very narrow footpath at the edge of a flyover and an unsafe intersection connects the MRTS Park Station to Bus Station at Central Station. There is no protection from the sun and rain.

The elevated MRTS line, which presently ends at Velachery, is slated for extension up to St Thomas Mount, where it will connect with the Beach-Tambaram suburban line as well as Line 2 of the upcoming Metro system. The Metro fares better in this respect, with two interchange points at Chennai Central and Alandur. This intermodal integration is a welcome step. Upon Chennai Metro Rail's request, ITDP provided detailed integration designs that connect the three rail lines and bus services.

It is important to integrate the proposed BRT system with the remaining bus services as well as the rail systems. The next chapter, Critical Elements for Success of BRT, deals with this topic in detail.

4.6 BRT corridor selection

The planning of BRT corridors not only impacts existing travel demand management but also the future development of the city. While corridors might be selected based on various criteria, the following broad considerations were taken into account in the process:

- There is medium to high demand as of today
- Substantial increase in demand for transport is projected due to new growth
- Present mass transit lines (or those under construction) do not serve these areas
- Adequate right of way is available (30 m or more)

Basing corridor selections on these criteria will help to:

- Maximize the number of beneficiaries of the proposed BRT system
- Reduce implementation and operational costs
- Mitigate adverse environmental impacts like vehicle emissions
- Minimise negative impacts on general traffic
- Ensure that implementation is politically easy

The starting point for corridor decisions is the study of daily commuting patterns in Chennai. Demand profiles are assumed to be roughly proportional to the MTC bus volumes presented earlier in this chapter. Several corridors across Chennai have high public transport demand and can support a high-performance BRT system. MTC buses already carry 4000-14,500

Figure 4.4 -Drawing/visualization showing intermodal integration of St. Thomas Mount Metro Station by Oren Thatcher, Consultant to ITDP

Figure 4.5 -Pattern of bus routes connecting OMR to other parts of the city

passengers per hour per direction on many corridors and a high-quality BRT system can be expected to generate even higher demand. In some fast growing areas of Chennai, transport corridors with moderate demand today may become crucial links in the near future. The proposed BRT network includes some such corridors with an eye toward influencing land use decisions to favour high-density development.

Gaps in the existing mass transit system network

Next, the network of existing and upcoming mass transit corridors was examined. Some parts of the city will remain unconnected to the city's rail network, even after phase 1 of metro rail starts operations.

- South-Southeast Chennai.
- North-Northwest Chennai
- West Chennai
- East-West Connection in Central Chennai

While these areas have bus connectivity, with growing traffic congestion buses will no longer be rapid. Therefore a high quality, high-capacity, bus-rapid-transit system should be implemented to form a comprehensive integrated mass-rapid-transit network spread across the city.

South & Southeast Chennai

IT parks located on the fringe areas of the city along Old Mahabalipuram Road (OMR) generate a substantial number of commuter trips. While there is sizable number of public transit riders on this corridor, most employees of IT firms travel by company run bus or private motor vehicle. It is estimated that only a third of the potential IT services facilities are operational as of today. Two thirds is yet to come and the existing road infrastructure will be choked with private vehicles unless a high quality public transit system is put in place. Existing MTC services indicate that most of the trips to OMR come from Tiruvanmiyur, Adyar, Velachary, Saidapet and Broadway (via Beach Road). A study done on company run buses by one of the prominent IT firms also shows a similar pattern.

Figure 4.5 shows the pattern of bus routes that connect OMR to other parts of the city. It can be seen that OMR routes extend up to Saidapet and Parrys. Thickness indicates frequency of service and demand.

Velachery has rapidly urbanized in the last one decade. While it is connected to some of the IT facilities in Tidel Park and Taramani, its connectivity by public transport to facilities on OMR further south is poor. There is large movement of people from Velachery northwards, to Guindy, Saidapet and T Nagar. Velachery, as well as the rapidly urbanizing suburban catchment areas such as Medavakkam, and Pallikaranai will benefit from a reliable BRT system that allows residents to commute to central areas without getting caught in peak hour traffic congestion. Pallikaranai 100ft road (State Highway 109), that has been developed recently, connects Chromepet (GST Road) and Thoraipakam (OMR). Area along this stretch will see substantial growth in the coming days. It is a great opportunity to create a BRT system on this road before it gets choked with private vehicles due to lack of good public transport. The road between Tambaram and Sholinganallur (via Medavakkam) is slated for clearance and widening. Again, this provides an opportunity to implement BRT.

GST road (airport road) is an interesting study. While areas on this road are well connected to the rail line, there is a substantial ridership on bus on this section (~10000 passengers/hr/dir). A prime reason for this large bus patronage is big spacing between rail stations, on an average 2km. Bus stops on the other hand are around 600m apart, providing better access to people. The upcoming metro line will stop at airport and will not connect to the large catchment of Pallavaram, Chromepet and Tambaram. Therefore, it is essential that a BRT corridor be developed on this road even though it runs parallel to the suburban line. This BRT line should be integrated with MRTS and Metro Line 2 at St Thomas Mount to facilitate transfers to these rail lines. Without BRT integration with MRTS, someone wishing to go from Velachery to airport has to transfer to Metro Line-2 at St. Thomas Mount and then again transfer to Metro Line-1 at Alandur to reach Airport. With BRT integration at St. Thomas Mount, MRTS passengers can access airport and areas beyond like Pallavaram, Chromepet and Tambaram with just one transfer to BRT. Tambaram BRT line should be integrated with South Suburban Line and Metro Line-1 at Guindy and Saidapet as well as with city bus services to non-BRT locations.

Figure 4.6 shows the pattern of bus routes that connect Tambaram to other parts of the city. It can be seen that Tambaram routes extend split up into two axis – one towards Parrys along Anna Salai and other to CMBT along Jawaharlal Nehru Road. Thickness indicates frequency of service and demand.

The South Chennai BRT Network will connect Siruseri, Sholinganallur,

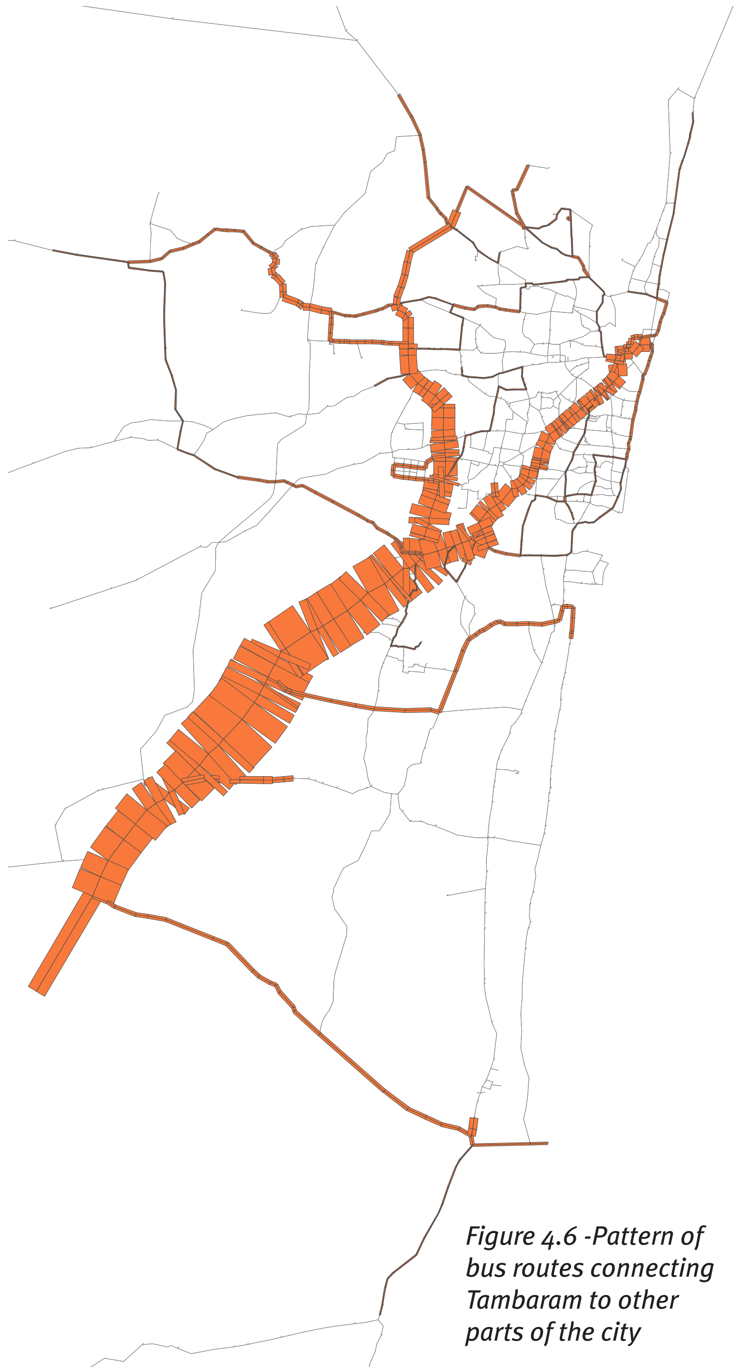

Figure 4.6 -Pattern of bus routes connecting Tambaram to other parts of the city

Perungudi, Taramani, Velachery, Saidapet, Guindy, Chromepet, Tambaram, Medavakkam, and Pallikaranai. Saidapet will become a big point of integration between BRT corridors coming up north from Tambaram, OMR and Velachery. Two east-west lines, connecting Thoraipakam and Sholinganallur on OMR to Chromepet and Tambaram on the GST road, complete the South Chennai BRT Network.

An important point to note is that BRT routes and buses are not restricted to one corridor. For example, a BRT route from Tambaram can go all the way up to Adyar via Saidapet. Another BRT route from Tambaram can reach Adyar via Chromepet, Pallikaranai, and Thoraipakam. Further, BRT routes are not restricted to segregated corridors alone. A BRT route from Medavakkam to Saidapet can be extended all the way up to T-Nagar bus terminal. While small extensions are possible, and advised, to provide direct service outside BRT corridor network, it is not advisable to extend BRT services way outside corridor network. Long extension outside BRT corridor network will reduce the effectiveness and reliability of BRT system.

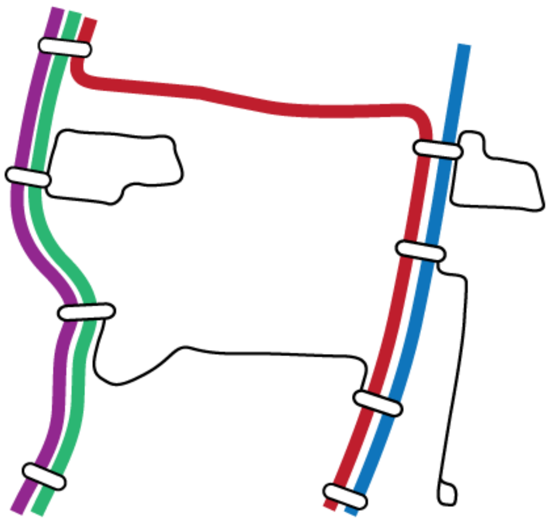

Figure 4.7 - BRT routes are flexible and not restricted to a single corridor

Northwest & North Chennai

Neighbourhoods in the northwest and northern part of Chennai, including Moggapair, Ambattur, Madhavaram, Red Hills, and Vyasarpadi, are primarily serviced by a few arterial roads. Two suburban rail lines run along the periphery without penetrating into neighbourhoods. Suburban railway stations between Ambattur and Perambur are spaced far apart and 3km away from the Moggapair main road making it difficult for area residents to access the system. BRT corridors in this part of Chennai will ensure better connectivity to the rest of the city and will provide a reliable way of reaching the suburban rail and Metro corridors.

To the northwest, the Ambattur Industrial estate and surrounding areas are undergoing a transition from industrial land uses to mixed use development with residential, commercial and IT development. Good public transport will be essential to ensure that these areas accommodate new higher-density uses without suffering from crippling traffic congestion.

Figure 4.6 shows the pattern of bus routes that connect Ambattur to other parts of the city. Thickness indicates frequency of service and demand.

BRT will have a big impact in north Chennai as this area historically has suffered from a lack of public infrastructure. BRT can serve as an extension of the metro rail service from Tirumangalam up to Madhavaram. Another line that should be explored, possibly in the second phase, is the connection from Madhavaram to Parry's, via Vyasarpadi and Basin Bridge. This road is presently constrained in parts, especially near Basin Bridge and will require special treatment to give bus priority.

West Chennai

Rapid residential development is happening in Porur, Madhuravoyal, and Poonamalee in the last 5-6 years. Porur, in addition to OMR and Ambattur, is coming up as a third centre of IT services industry in the city. New growth is expected in this area. Not only do these areas need connectivity to city centre, in the form of radial lines, they should be interconnected with a north-south axis. The by-pass road, which was designed with the thought of having mass transit corridor in the centre, fits the bill.

The BRT corridor network in the west will connect Poonamalee with Guindy via Porur, and to Tirumangalam via Madhuravoyal. Another important radial corridor for a future phase would be from Porur to Marina Beach via Arcot Road, Vadapalani, Kodambakam, Gemini, and Royapettah. Further, the bypass road will connect Tambaram to Porur, Ambattur and Puzhal.

Comprehensive integrated network of mass transit

Considering the corridors of high public transport demand as well as areas underserved by existing mass transit networks, a comprehensive network of BRT corridors was selected. A phased implementation sequence for the BRT network is presented in the next section.

Integrating the BRT with existing modes will multiply the efficiency of the combined public transportation network to address travel demand effectively. Effective integration can help prevent redundancy among Chennai's public transport modes. Figure 4.7 superimposes the BRT and rail networks, showing important interchange locations.

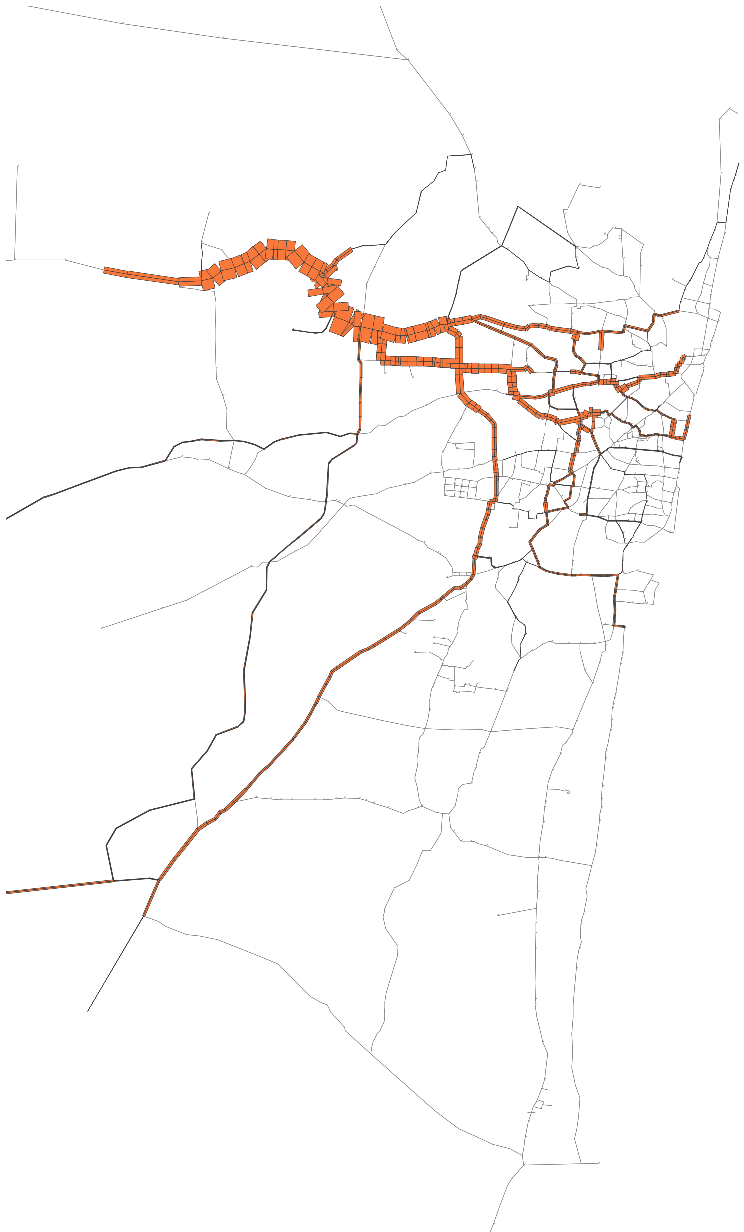

Figure 4.8 -Pattern of bus routes connecting Ambattur to other parts of the city

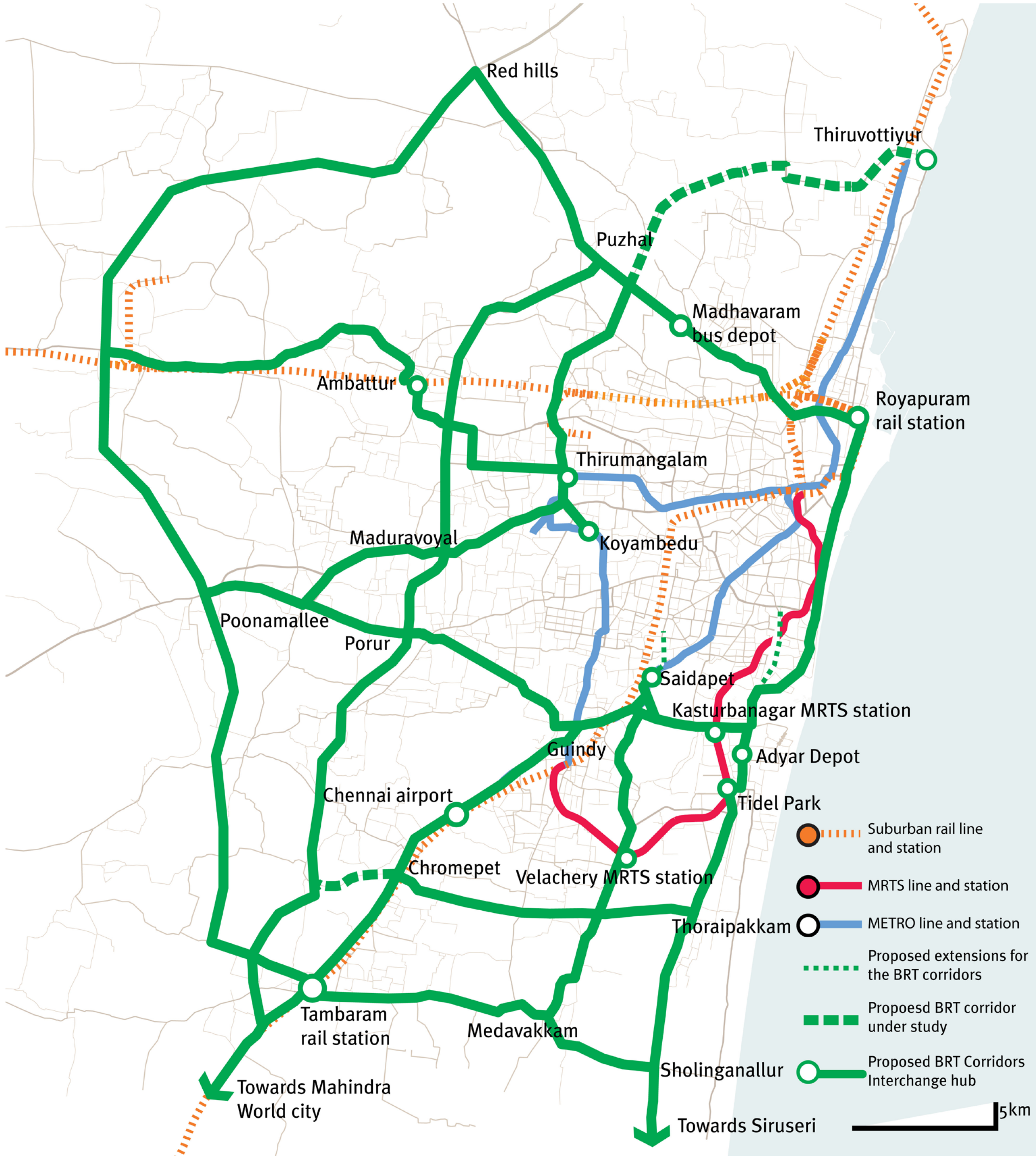

Figure 4.9 -Proposed BRT network with the suburban rail network, MRTS, and Metro (under construction)

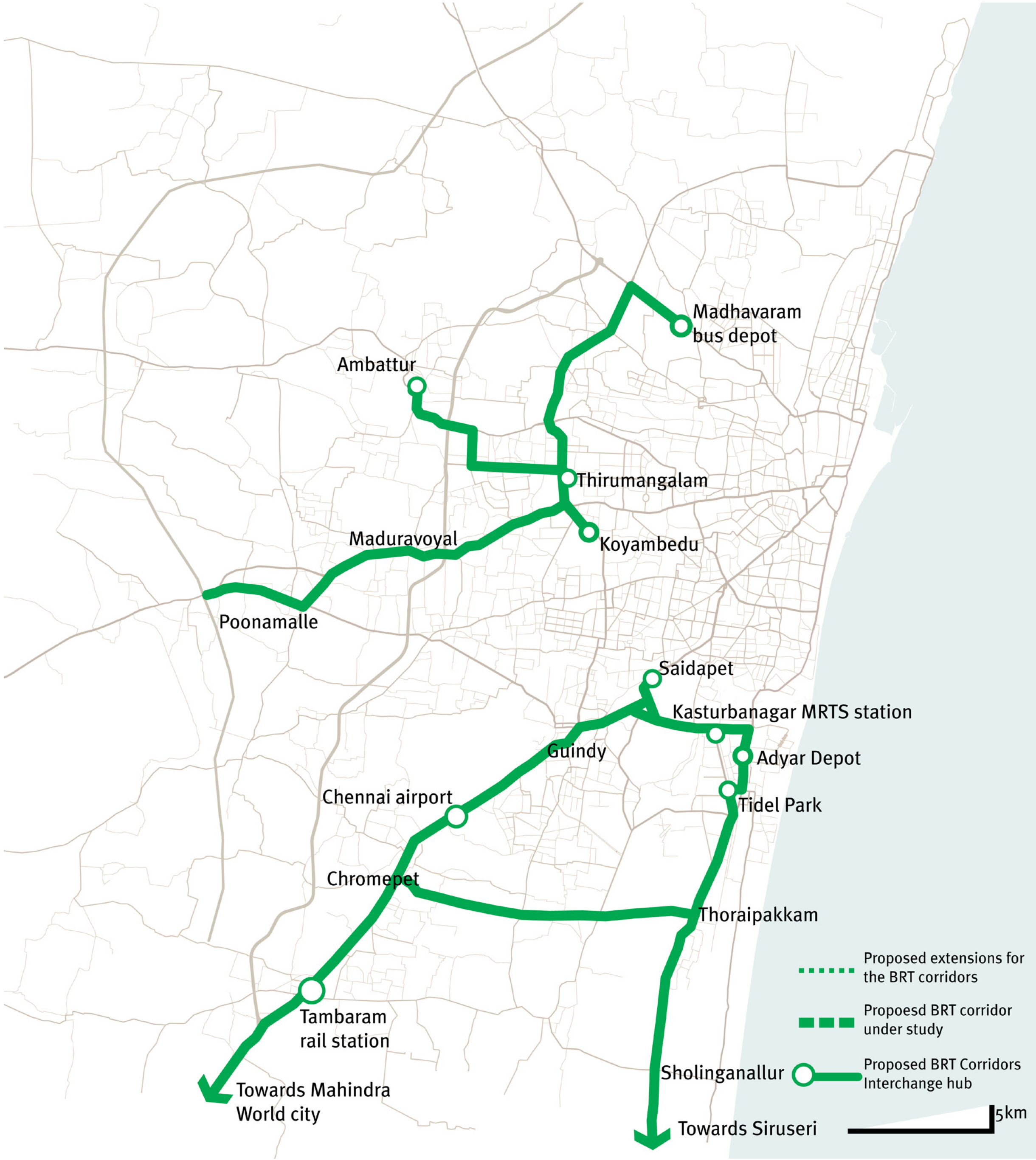

Figure 4.10 - Phase 1 BRT corridors

CORRIDOR	LENGTH (KM)	BRT PASSENGER LOAD (PER HOUR)	BRT FLEET REQUIREMENT	
			12 m	18 m
MADURAVOYAL-CMBT	14	3300	56	
AMBATTUR-THIRUMANGALAM	7.7	9200		53
CMBT-MADHAVARAM	12.4	3100	47	
SIRUSERI-SAIDAPET	24.8	8200		131
TAMBARAM-SAIDAPET	18.5	7900		96
GST ROAD JUNCTION-THORAIPAKKAM	10.6	1800	23	
TOTAL	88			

Table 4.4 - BRT passenger load and fleet requirement for phase 1

CORRIDOR/NETWORK	PASSENGER TRIPS/DAY
OMR-SAIDAPET	220,000
TAMBARAM-SAIDAPET	540,000
NORTHWEST (AMBATTUR-TIRUMANGALAM MADHAVARAM-TIRUMANGALAM POONAMALEE-TIRUMANGALAM)	370,000
TOTAL	1,130,000

Table 4.5 -Estimated ridership on the Phase-1 network

4.7 BRT corridor phasing plan

Phase 1

Phasing of implementation is important for many reasons. For starters, it is not possible to implement a mammoth network of few hundred kilometres at one go. So, some corridors will have to be prioritized based on demand and ease of implementation. After the first phase demonstrates a well functioning system to the citizens, it becomes easy to implement the system in more complex physical conditions.

This study suggests that the first phase of the BRT project include two networks with high travel demand - one in the northwest and the other in south. These two networks of BRT corridors provide greater accessibility in rapidly developing areas and IT parks on the urban fringe that are not presently connected by high quality public transport. The corridors chosen to be part of these networks have adequate width (30m or more) which makes it easy to implement BRT. It is possible to implement BRT on narrow streets, as many cities across the world have demonstrated. However, creating a BRT where there is high demand as well as adequate street width will help demonstrate the viability of BRT system. It will have sufficient ridership to make it successful. It can achieve financial sustainability from the outset.

As part of this study, BRT passenger load on each of the corridors and approximate fleet sizes were calculated. These calculations are based on data provided by MTC of its routes and frequencies and observed traffic volumes. They give a good indication of the size of the system proposed and are sufficient to determine physical design parameters for different corridors. They also give a ballpark idea of the fleet that will have to be procured. The routes, as suggested earlier, will not be limited to the BRT corridor alone but will extend, where essential, to provide direct connectivity to key destinations. In the South Network, some BRT routes will extend from Saidapet up to T-Nagar and other BRT routes will extend from Adyar up to Mylapore. These extensions are typically 2km beyond the dedicated corridor network. Around half of the buses are estimated to provide direct services beyond the dedicated corridor of Phase-1. The other half will remain within the exclusive corridor network. Fleet estimates take these service extensions into account.

The ridership forecast based on existing ridership on MTC buses on these corridors and expected mode shift from private motor vehicles and shared autos is given in the next table.

Figure 4.11 - Streets with 30m ROW or more in Chennai

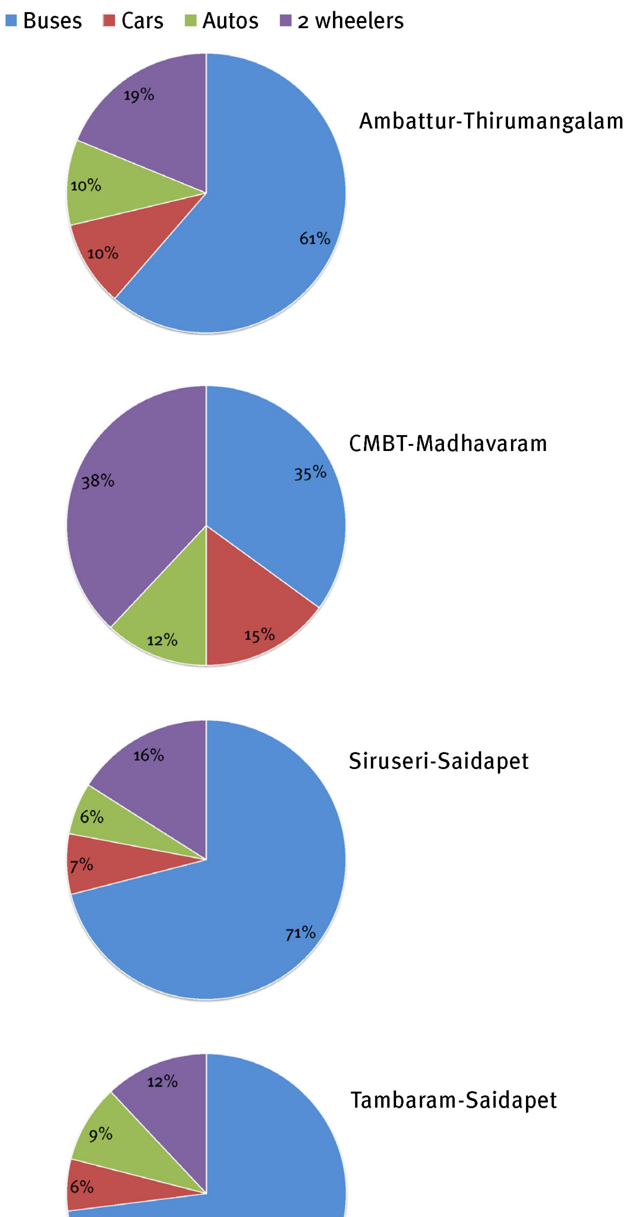

Figure 4.12 -Modal share split along various corridors of phase 1

Studies in other cities where BRT has been implemented, like Ahmedabad and Bogota, have shown that a shift of 20% from private modes to BRT is not beyond reason. The total ridership on the Phase-1 network shall be 1.13million trips daily.

An in-depth route rationalization and operations plan is beyond the scope of this study. Such a study should be undertaken as the next step for further refinement of route-wise passenger demand estimates and fleet size calculations. A detailed Terms of Reference (ToR) can be provided by ITDP. ITDP can provide necessary support to consultants who are hired by the nodal government agency in-charge of the BRT project to develop detailed BRT operations plan and MTC route restructuring and rationalization plan.

Implementing BRT in both north and south Chennai will make the system available to a broad cross-section of the population right from the first phase, helping to build widespread support for subsequent expansion.

In many cases, buses already carry a large fraction of the total passenger volume on the Phase 1 corridors. (see figure 4.11)

However, private vehicles occupy most of the road space. Cars are the least efficient users of road space. In most places in Chennai, they occupy half of the road space but account for 10% of people being transported. If the entire street is occupied by cars, then just about 20% all people using roads as of today will be able to travel. However, with the implementation of a high-capacity BRT system, commuter carrying capacity of the road will go up manifold. A 3-lane carriageway in one direction will get saturated at 3600 cars per hour. This translates into roughly 4300 people/hr/dir (at existing average occupancy of 1.2people per car). BRT system, by occupying a third of a 3-lane carriageway/dir, can enhance the people carrying capacity of the same carriageway by 300% (10000pphpd on BRT + 2900pphpd by cars). With an additional overtaking lane for BRT, the capacity can go up to 1000%. The only solution for rapid mobility of all people in Chennai is to provide dedicated space to a high-quality bus rapid transit system.

BRT lanes will ensure that bus passengers—who represent the majority of passengers on most corridors—can travel without being obstructed by mixed vehicle congestion.

The chosen corridors for first phase implementation are arterial roads with constant road widths that can accommodate two-way BRT plus two lanes for mixed traffic in each direction. Assuming that 20 percent of private vehicle users switch to BRT, the remaining two lanes per direction will be sufficient to accommodate the remaining peak hour private vehicle traffic. Studies in other cities where BRT has been implemented, like Ahmedabad and Bogota, have shown that a shift of 20% from private modes to BRT is not beyond reason.

CORRIDOR	MIXED TRAFFIC CAPACITY BASED ON IRC (PCUS PER DIRECTION)	PRIVATE VEHICLE VOLUME, POST-BRT (PCUS)
AMBATTUR-THIRUMANGALAM	1,500	1,475
CMBT-MADHAVARAM	1,500	1,160
SIRUSERI-SAIDAPET	2,400	900
TAMBARAM-SAIDAPET	2,400	1,100

Table 4. 6- Volume versus capacity on various BRT corridors

Integration with existing modes of transport is also a key consideration for the selection of phase 1 corridors. Saidapet, Adyar Depot, and Tirumangalam/Anna Nagar West Depot can work as terminals or interchange stations for transfer to the metro or MTC. In BRT systems, terminals are the most important transfer point. They are normally located at the end of each corridor and provide important transfers between BRT and MTC bus lines serving surrounding areas. The design of the interchange facility should minimize both customer and vehicle movements to the extent possible. For BRT-MTC transfers, the ideal terminal layout is to have BRT buses arrive on one side of a platform area while MTC buses stop on the other side.

Terminals can be combined with depots for the BRT system where space is available. In doing so, the cost of acquiring separate parcels for terminals and depots can be avoided and dead kilometres of operation reduced.

Appendix 1 gives station locations along the proposed corridors for phase 1 and BRT street cross section for each corridor.

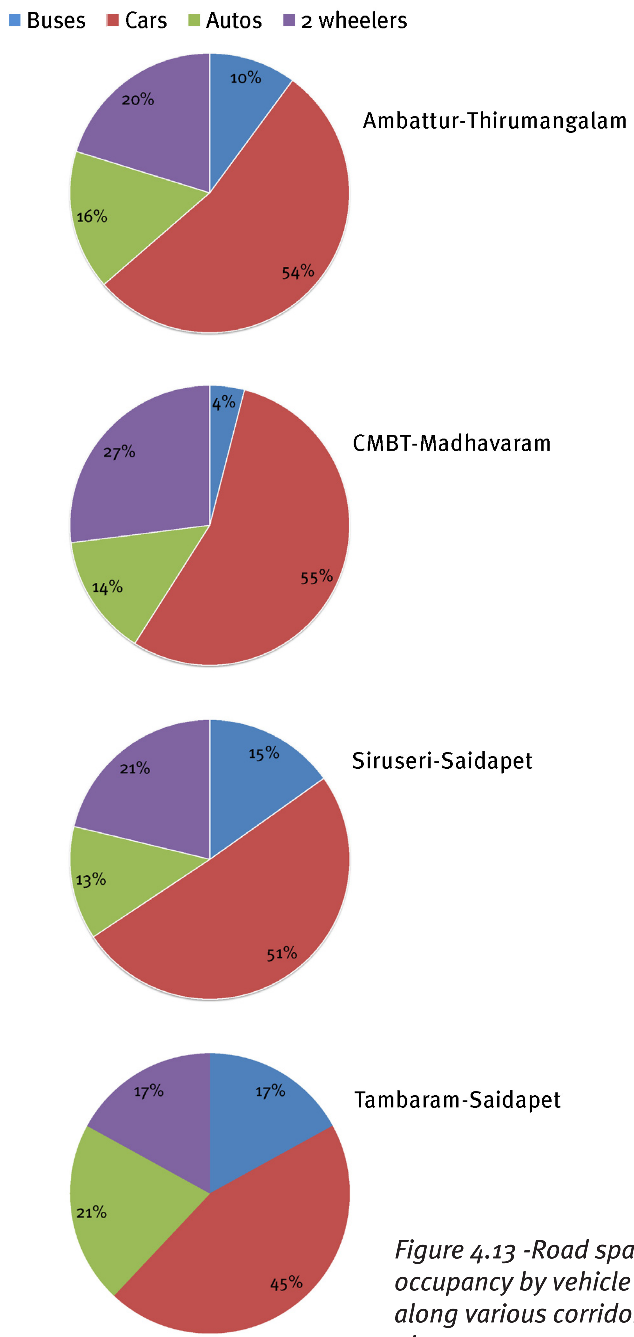

Figure 4.13 -Road space occupancy by vehicle type along various corridors of phase 1

CORRIDOR	LENGTH	BRT PASSENGER LOAD (PER HOUR)	BRT FLEET REQUIREMENT	
			12 m	18 m
MADHAVARAM-PARRYS	9.9	4928	61	
ADYAR-PARRYS	12.9	6100		54
TAMBARAM-VELACHERY-SAIDAPET	21.5	5438	133	
PORUR-SAIDAPET	11.5	6035		48

Table 4.7- BRT passenger load and fleet requirement for phase2

Phase 2

Phase 2 incorporates additional high-demand bus corridors that extend the reach of the BRT system. Rights-of-way vary along the Phase 2 corridors, with adequate width in some sections but not in others. This poses an implementation challenge that was not present in the Phase 1 corridors. However, given sufficient public goodwill generated by a successful Phase 1, it will be easier to implement BRT on these challenging corridors.

Phase 2 fills in the BRT network, enhancing corridor integration whereby a single corridor is used by many different bus routes. With a variety of services available within the network of dedicated BRT lanes, a larger customer base will be able to complete their entire journey on the BRT without having to switch to an alternate mode of transport. Therefore, it is to be understood that in order to further the successes of the implementation of phase 1, a determined effort with phase 2 will be important and lend to the long-term viability and robustness of the BRT as mass transit system for Chennai.

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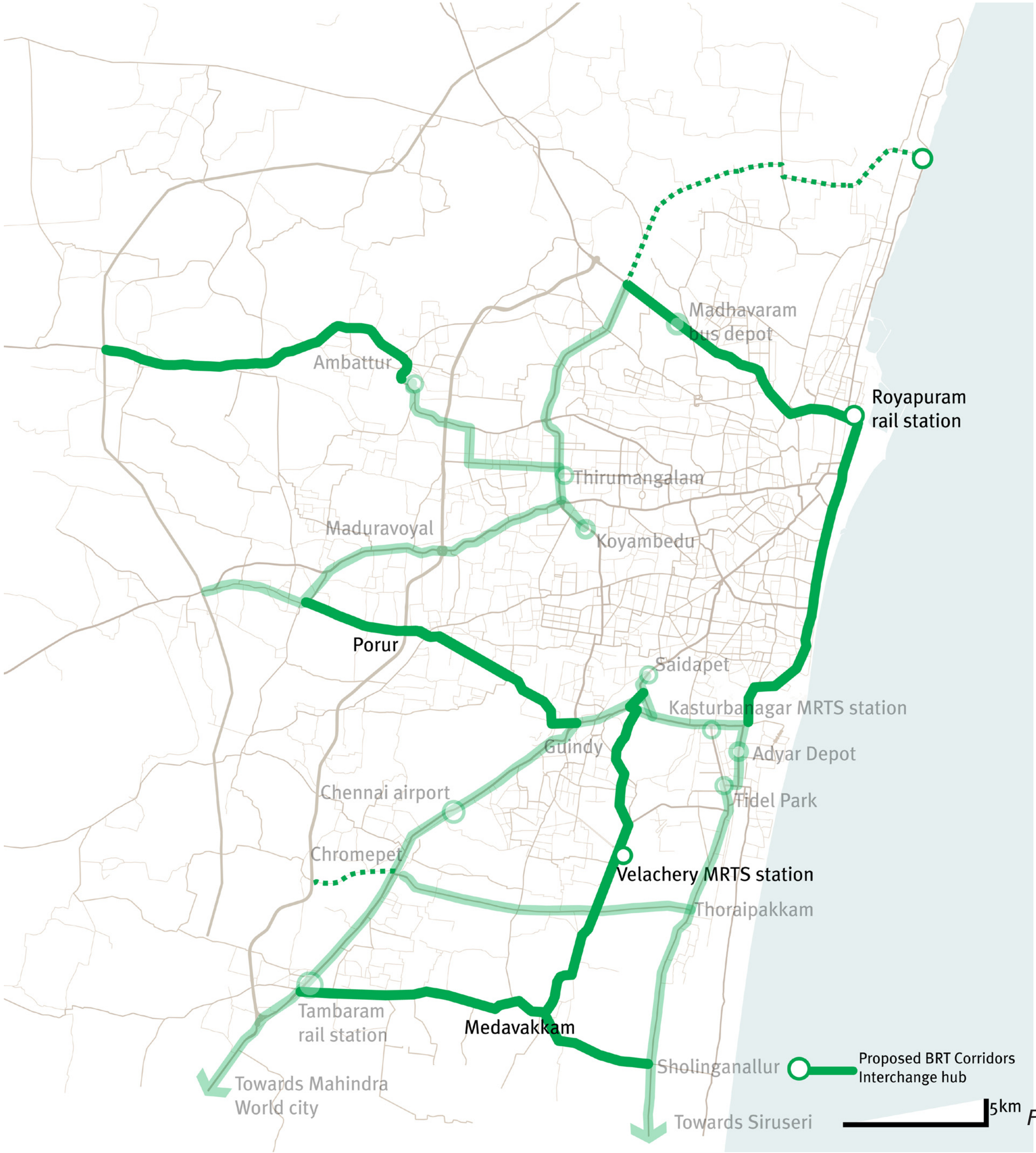

Figure 4.14 -Corridors planned for phase 2 of the BRT system

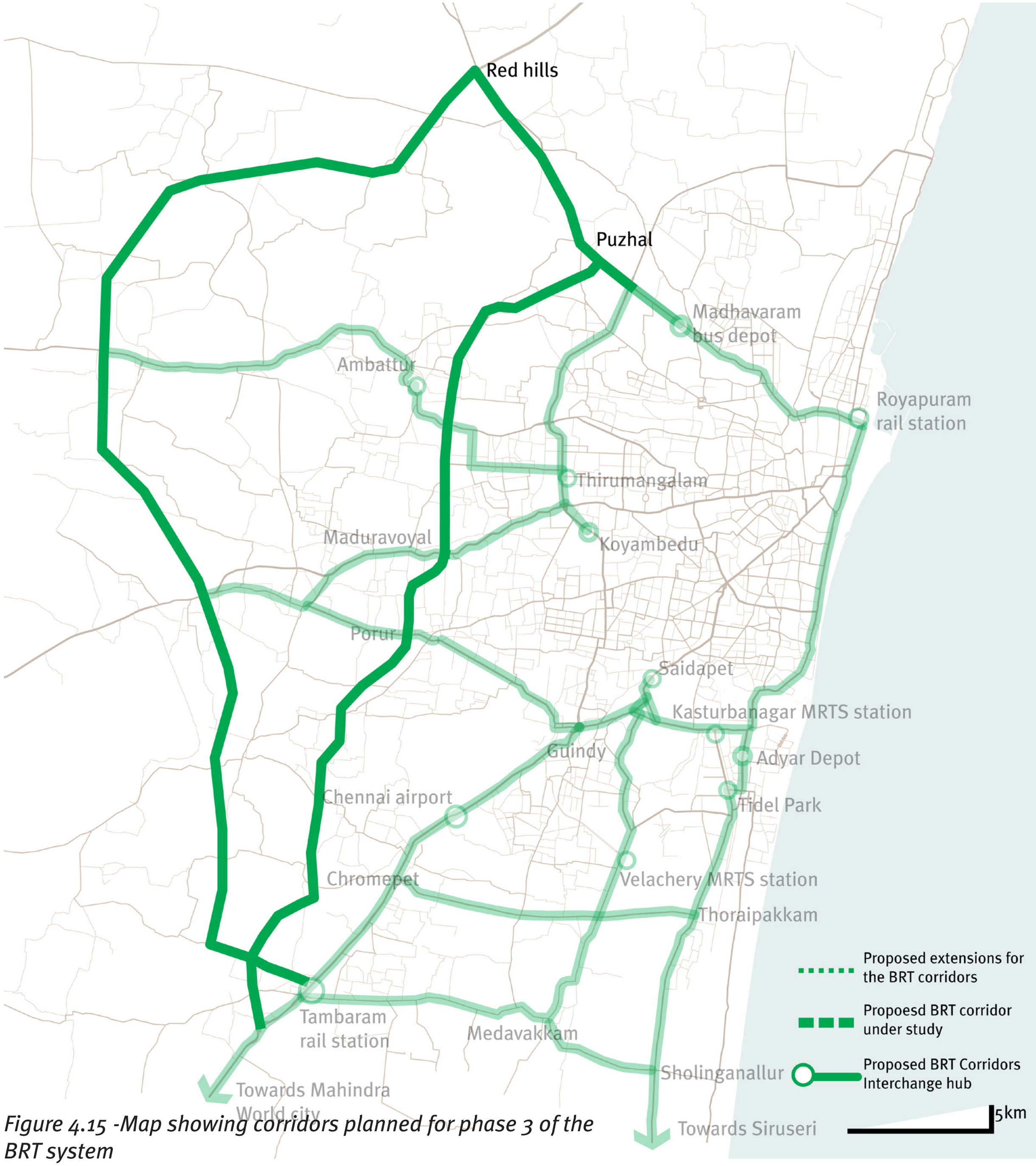

Figure 4.15 -Map showing corridors planned for phase 3 of the BRT system

Draft- Not to be circulated

Phase 3

Phase 3 corridors cover future growth areas along the Chennai Bypass and upcoming road infrastructure, namely the Outer Ring Road (ORR).

In Chennai and other Indian cities, the provision of new road infrastructure catalyzes the development of nearby land parcels. When new development zones are opened without provisions for public transport, residents are forced to use private vehicles. Public transport authorities may try to catch up and expand service into the new areas, but with the built environment already oriented around vehicle use, luring residents to use public transport is difficult. In the end, such developments add more vehicles to already crowded streets when residents travel to central areas of the city for employment or recreation.

Phase 3 of the BRT is an effort to pre-empt automobile-oriented development by facilitating a better model of compact development served by high quality public transport. BRT stations can anchor dense, mixed-use nodes that provide a high quality walking environment and promote the use of public transport.

4.8 BRT Corridor integration

Prior to integrating a public transport system with other modes of transport, a basic first step is to ensure that the proposed system is integrated with itself. This means physical and fare integration exists between the different corridors, routes and feeder services. Unfortunately there have been cases such as Quito, Kumming, Porto Alegre, Recife and Taipei where there is no transfer between different bus lines sharing a BRT corridor.

Systems operating as individual corridors lose out on the many advantages of a fully integrated network because customer mobility needs will include destinations on several corridors. As a result, a non-integrated system loses out on a potential customer base as customers will switch to alternate modes of transport instead of performing many different transfers each involving additional payment.

It has been commonly observed from studying cities that have executed a BRT system that non-integrated systems are chosen for political convenience and usually for not upsetting the specific interests of a small set of people. It needs to be stressed here, that basing public transport system around the customer almost always guarantees success whereas basing it around a few special interests almost always results in a compromised system. Therefore integration begins with a focus on the system's internal routes and corridors. An internally integrated system can then expand its reach and customer base considerably by permitting other modes to form a seamless interconnection with the BRT system.

4.9 Corridor designs

The basics of corridor design were discussed in the third chapter on key elements of BRT design. Here, designs appropriate for various street widths and BRT demand are given for different corridors in the city that would be implemented as part of Phase 1. These streets vary in width from 30-40m.

At40m, OMR and GST road are the widest of the corridors. These corridors also have high passenger demand of all the corridors identified for BRT implementation in the city. With increase in ridership forecast for the future, these corridors must be designed with high capacity in mind. Overtaking lanes and express services will be required on these corridors. The suggested cross sections are given below. These include one lane per direction for BRT and two lanes per direction for other vehicular traffic. At every station location, there will be a bulge to accommodate a BRT station as well as an overtaking lane. Given the limited right-of-way, it is suggested that the stations be staggered, i.e. the boarding bays for each direction of BRT will not be in front of each other but staggered. By doing so, the overtaking lanes for either direction are also staggered thereby reducing the width requirement for BRT at station locations by 3.5m. Pedestrian access is key element for the success any public transport system. Good pedestrian infrastructure on either side of the BRT corridors is essential. At the very least, a clear pedestrian path of 2m and an additional space of 1-1.5m for trees.

1. Koyambedu – Thirumangalam- Padi- Kolathur- Madhavaram junction- Madhavaram bus depot

2. Along Pallikaranai 100ft road- GST road intersection

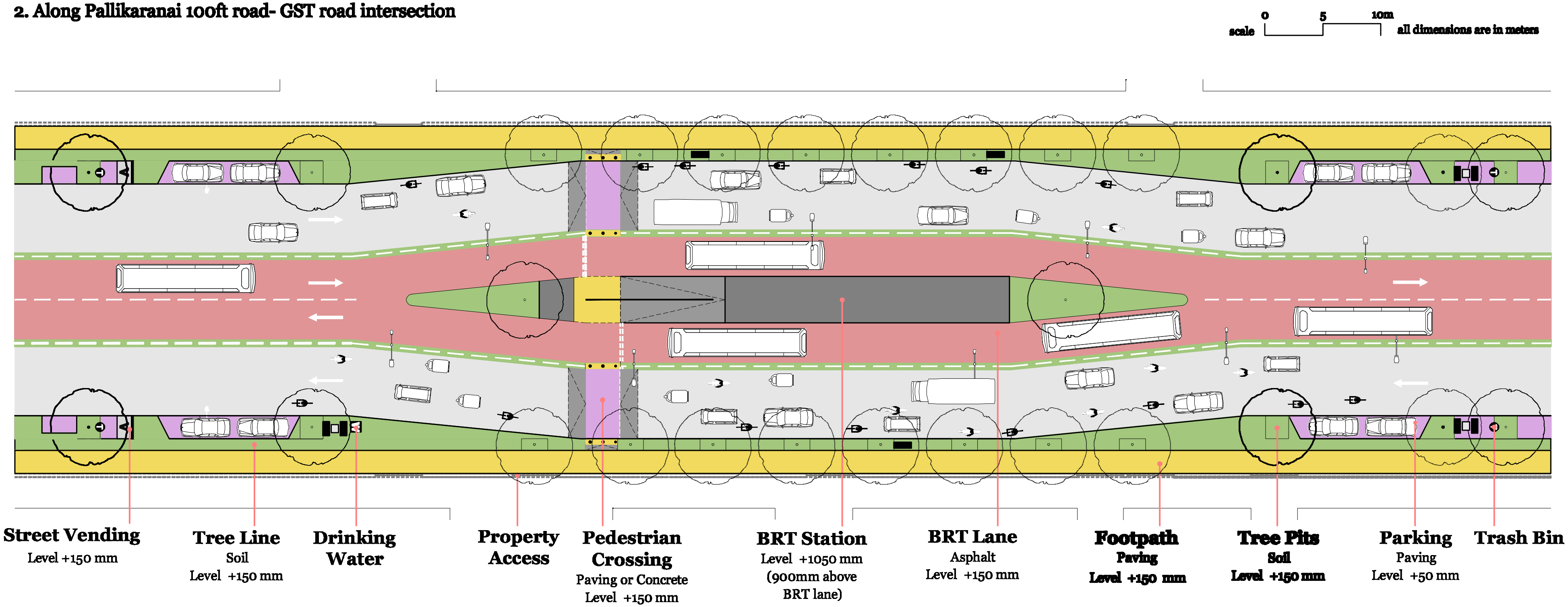

Figure 4.16 -Plan showing typical design for BRT corridors with 30 M ROW

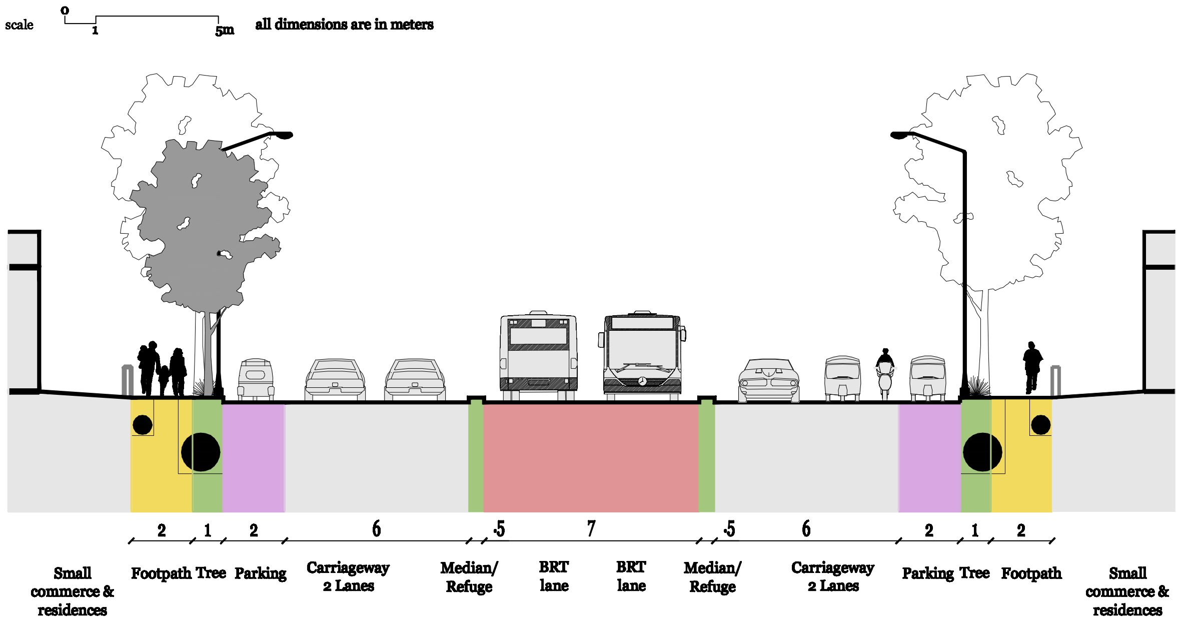

Figure 4.17 -Section through mid-block for typical design for BRT corridors with 30 M ROW

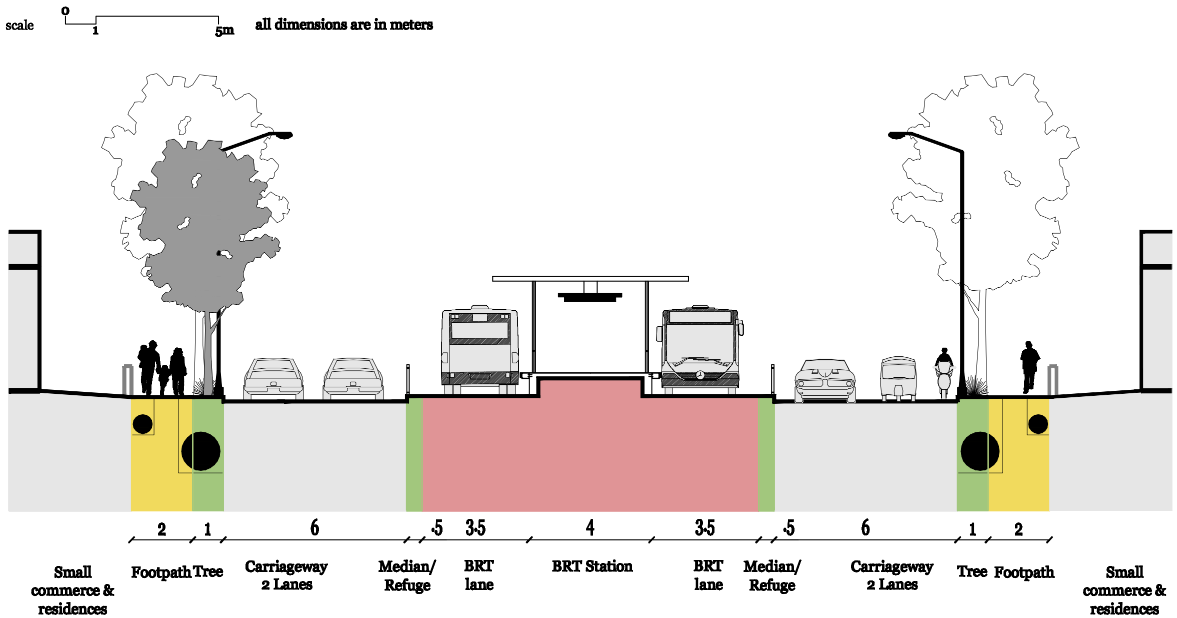

Figure 4.18 -Section through BRT station for typical design for BRT corridors with 30 M ROW

1. Thirumangalam- Ambattur Industrial estate- Ambattur Rail station

2. Koyambedu - Maduravoyal

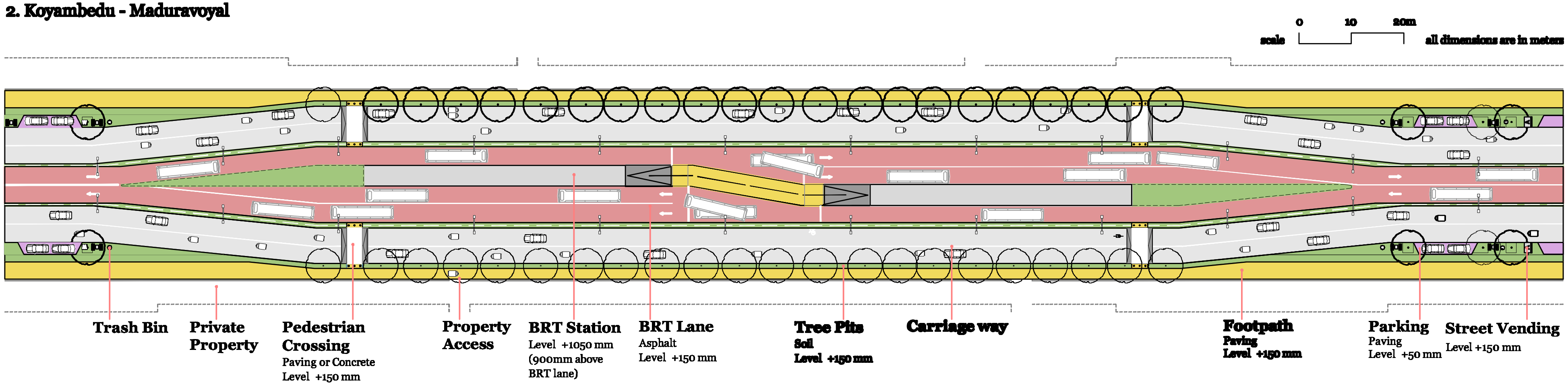

Figure 4.19 -Plan showing typical design for BRT corridors with 36 M ROW

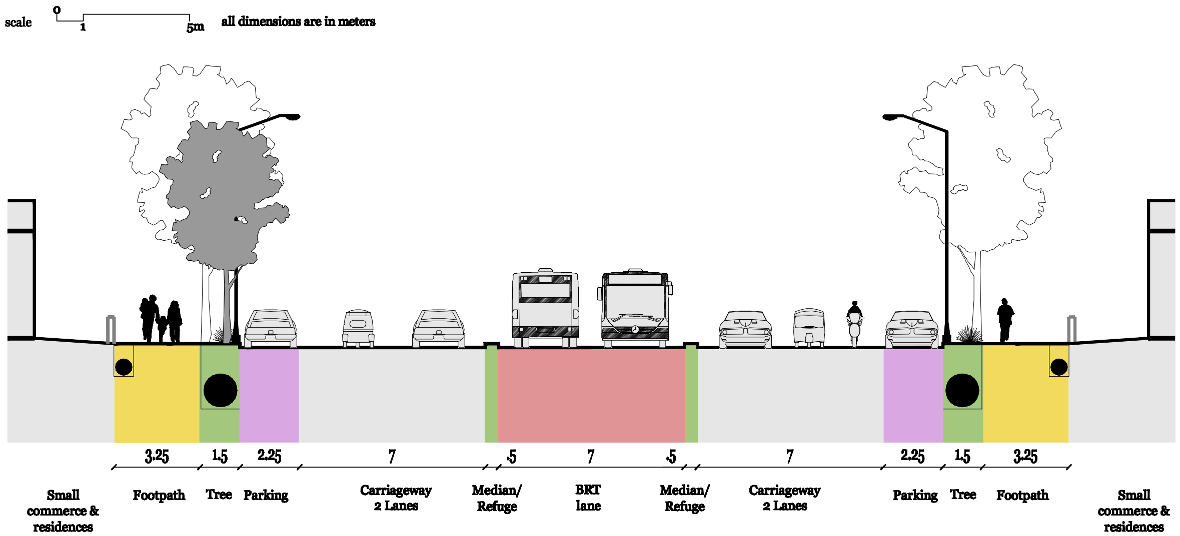

Figure 4.20 -Section through mid-block for typical design for BRT corridors with 36 M ROW

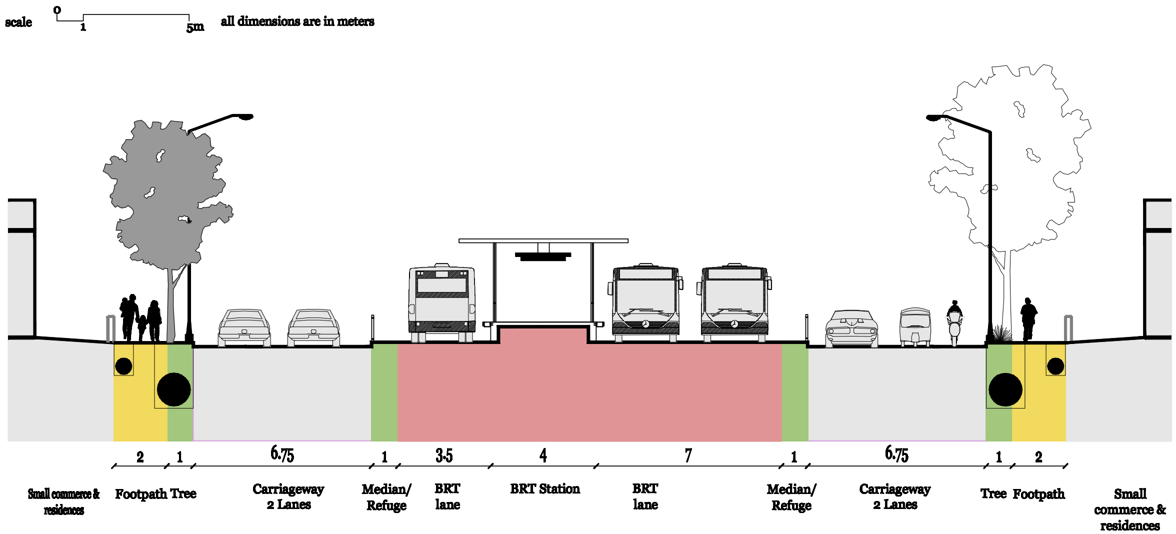

Figure 4.21 -Section through BRT station for typical design for BRT corridors with 36 M ROW

1. Saidapet - Adyar - Tidel Park -Perungudi - Thoraipakkam - Sholinganallur - Naavalur - Siruseri

2. Saidapet - Airport - Chromepet - Tambaram - Vandalur - Estancia IT SEZ - SRM Engineering College - Maraimalainagar - Singaperumalkoil - Mahindra World City

scale 0 10 20m all dimensions are in met

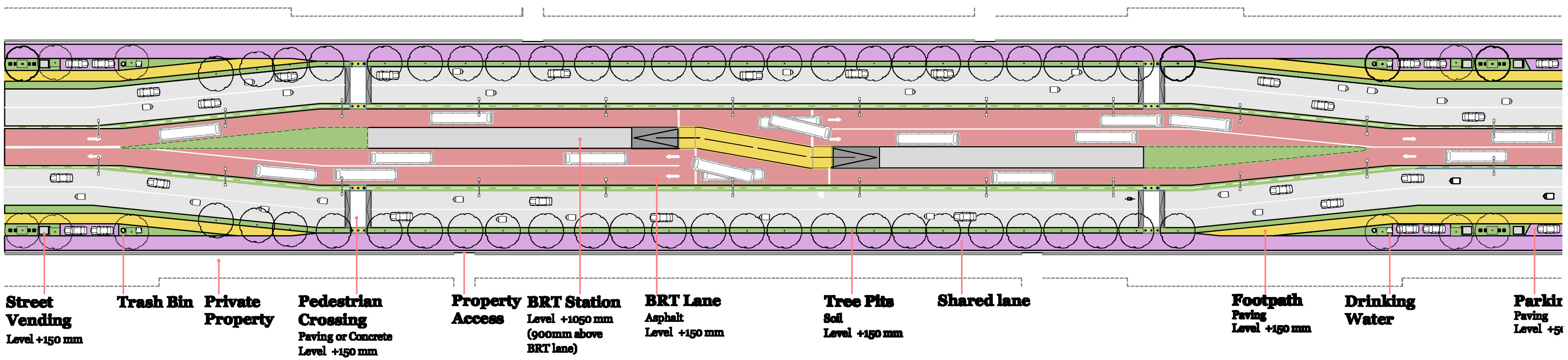

Figure 4.22 -Plan showing typical design for BRT corridors with 40 M ROW

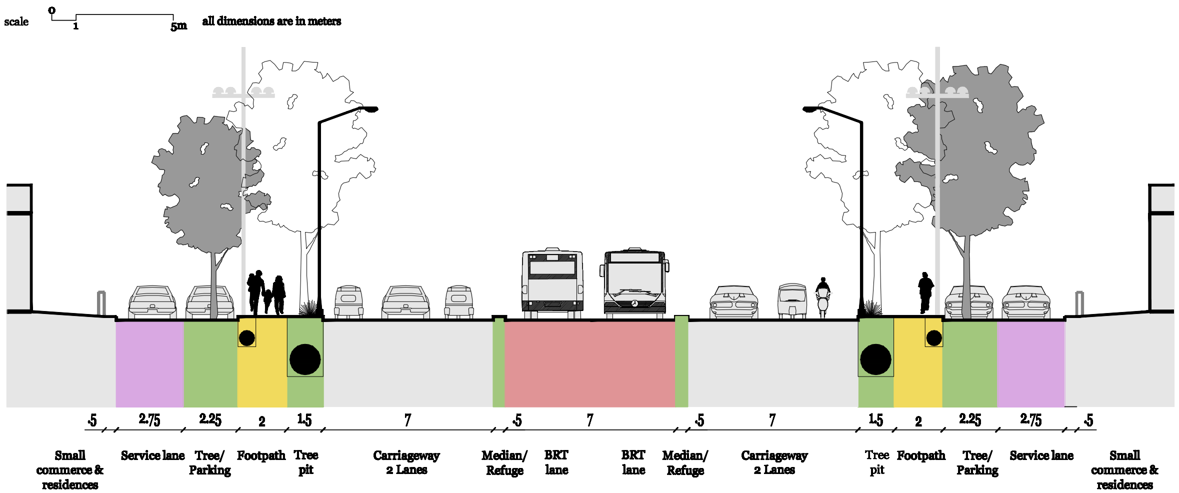

Figure 4.23 -Section through mid-block for typical design for BRT corridors with 40 M ROW

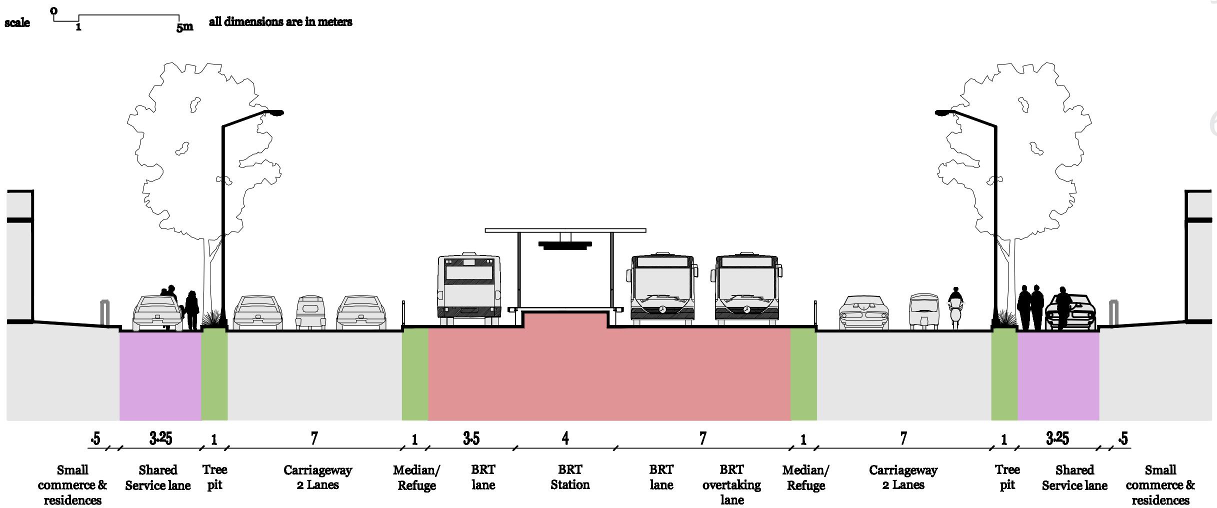

Figure 4.24 -Section through BRT station for typical design for BRT corridors with 40 M ROW

Summary of proposed BRT corridors

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CORRIDOR	LENGTH (KM)	RIGHT-OF-WAY (M)	NUMBER OF STATIONS
PHASE 1			
Koyambedu – Thirumangalam- Padi- Kolathur- Madhavaram junction- Madhavaram bus depot	12.4	30	23
Thirumangalam- Ambattur Industrial estate- Ambattur Rail station	7.7	36	15
Koyambedu- Poonamallee	14	36	9
Saidapet- Adyar- Tidel Park-Perungudi- Thoraipakkam- Sholinganallur- Naavalur- Siruseri	24.8	40*	13
Saidapet- Airport- Chromepet- Tambaram	18.5	40	23
Along Pallikaranai 100ft road- GST road intersection	10.6	30	14
Sub-total for phase 1	88		97
PHASE 2			
Adyar- Durgabhai Deshmukh road-Kamarajar salai-Rajaji salai- Royapuram rail Station	12.3		
Royapuram rail station- Stanley hospital- Mint rail station- Basin bridge road- Erukancheri high road, Vyasarpadi market- Ambedkar arts college- Moolakadai- Madhavaram bus depot	7.8		
Saidapet- Guindy- Mount Poonamallee road- Nandambakkam- DLF IT park- Ramachandra Medical College	8.0		
Saidapet- Velachery- Medavakkam	11.7		
Tambaram- Selayur- Medavakkam- Sholinganallur	13.3		
Tambaram- Vandalur-Estancia IT SEZ-SRM Engineering College-Maraimalainagar- Singaperumalkoil-Mahindra World City	25.5		
Subtotal for phase 2	78.6		
PHASE 3			
Tambaram- Porur- Maduravoyal- Ambattur- Madhavaram junction (along Chennai byepass and NH-5)	37.6		
Tambaram- Redhills- Puzhal- Madhavaram junction(along Outer ring road and NH-5)	60.7		
Subtotal for phase 3	98.3		
TOTAL FOR ALL PHASES	265		

** - 40m ROW applicable from Madhya Kailash junction until Siruseri*

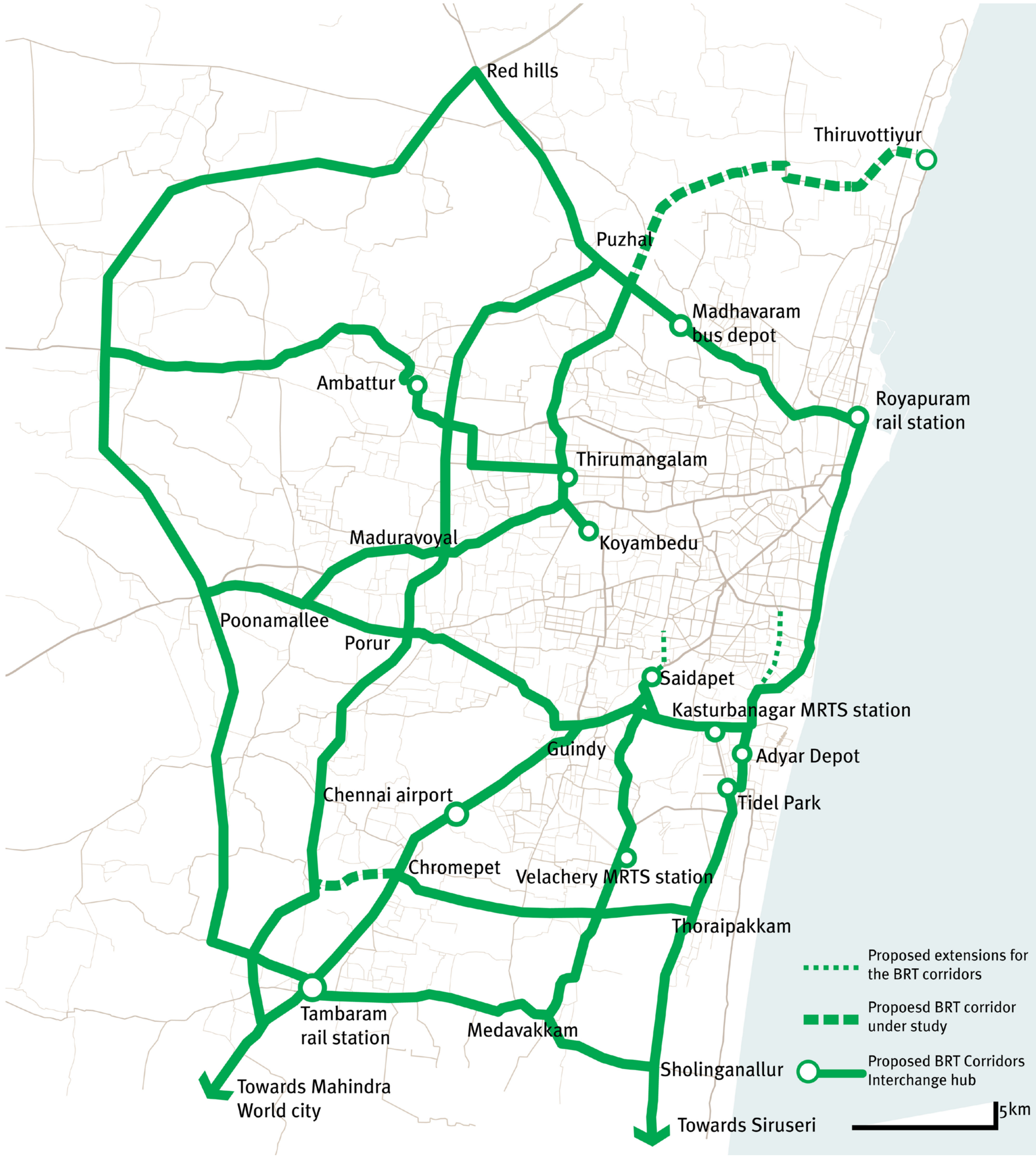

Figure 4.25 -Map showing all corridors of the proposed BRT network

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CRITICAL ELEMENTS FOR SUCCESS OF BRT

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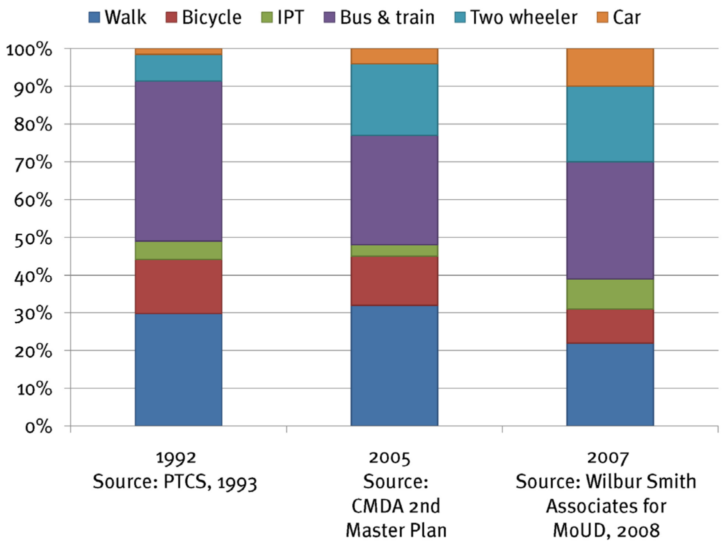

Table 5.1- Comparative modal share split for Chennai

5.0 Critical elements for success of BRT

Public transport in Chennai bears a stigma of being an inconvenient and unreliable mode of transport. Due to this poor reputation, public transport ridership is limited largely to those who have no choice but to use it for their everyday commute. Public transport is losing out to cars and two-wheelers, as indicated in table 5.1.

Simply building standalone mass rapid transit lines will not suffice to increase the user base—and thus the financial viability—of public transport. Instead, public transport needs to be designed and planned as a cohesive system. Elements such as pedestrian access, intermodal integration, and passenger information are critical to the overall success of public transport in Chennai. A holistic planning approach will help make BRT a more appealing mode of commuting for everyone, not just those who do not have an alternative. Effective communication will inform and attract the support of the entire populace.

5.1 Pedestrian access

Every public transport trip begins and ends with a walking component. The success of public transport and its ability to reduce dependence on private vehicles is governed largely by the ease and comfort of pedestrian access to transit stops. A user who is forced to compete with traffic and navigate through cluttered footpaths in the sun before he reaches the public transport system is less likely to use public transport than a user who gets to walk on a shaded walkway that is active, well-lit, clutter-free, and continuous. Therefore, providing high quality footpaths is essential to the long-term viability of all of Chennai's public transport systems, including BRT.

All pedestrian footpaths need to have:

- **Continuous, unobstructed space for pedestrian movement**

The size of this space is planned in accordance with observed pedestrian volumes and should be a minimum clear width of 2 metres. Separate additional space is required for trees, utilities, planting, shop frontages, and vendors so that they do not encroach into the clear space. While 2 metres is the minimum width, it is adequate for movement of only 800 pedestrians per hour. . Width should be increased by an additional half metre for every subsequent 800 pedestrians per hour on the footpath. Pedestrian facilities become desirable when they are wider than the technical minimum so that people do not have to walk in a crowded condition. Wherever possible, they should be made wider than the technical minimum as stated above.

- **Continuous tree cover to provide shade**

Shade is particularly important in Chennai's hot, humid climate. Trees can reduce the perceived temperature by up to 8°C and make walking comfortable. The location and design of pedestrian paths should take advantage of existing trees. Wherever possible, existing trees should be retained on BRT corridors and additional trees may be planted where there is a gap in shade.

- **Minimum level differences at property entrances and intersections**

Abrupt and frequent kerb cuts require pedestrians to constantly step up and down and therefore discourage them from using footpaths. Negotiating level differences at property entrances and intersection with suitably aligned ramps is essential to ensure a comfortable walking experience. Otherwise, pedestrians are forced to walk on the carriageway, thus reducing the total effective width for vehicles.

High quality pedestrian facilities should be developed within a 500 metre radius of each BRT station. This will significantly improve accessibility and increase ridership of the BRT system. Shifting a greater share of travel to walking, and combining walking with public transport trips is an effective way of reducing congestion and pollution. ITDP has developed a manual for street design for Indian cities[1]. This manual can be used as a guide for developing pedestrian facilities and other elements of street design.

Increasing walking access to public transport can give people with limited transport options access to more opportunities and services and reduce demand for parking facilities around stations. Providing better pedestrian access also increases public health benefits because the average public transport user is much more likely to achieve the recommended 30 minutes of moderate intensity physical activity a day.

A coordinated approach between the transit authorities and the Corporation of Chennai (CoC) and other civic organizations is needed to develop and maintain safe footpaths and shaded walkways that link with public transport. Chennai Metro Rail Ltd. (CMRL) and Corporation of Chennai

1 'Better streets Better cities - A manual for street design in urban India' by The Institute for Transportation and Development Policy (ITDP) and Environmental Planning Collaborative (EPC)

Figure 5.1 -High quality footpaths make it easy for passengers to access BRT stations.

(CoC) have already begun a program to improve station area access near Metro stations. Lessons from this program can inform the station planning process for BRT station precincts.

5.2 Intermodal integration

For Chennai's public transport system to function as a coherent network, passengers need to be able to transfer easily from one mode to another. Integration does not merely mean placing stations for multiple public transport modes close together. Instead, it involves the detailed design of stations incorporating the following features:
• Short, direct walking paths for transferring passengers
• Minimal level differences
• Adequate clear space to prevent bottlenecks
• Protection from sun and rain
• Public information

Integration can also be enhanced through the use of a uniform electronic ticketing system. These features are described in more detail below.

Physical integration
An important function of BRT is to function as a complementary system to the Chennai Metro, suburban rail and MRTS thereby greatly extending the catchment area of each system. Integrated stations that allow for convenient transfers between all these modes are necessary to achieve a combined maximum ridership and meet travel demand requirements for Chennai.

ITDP and its advisors have developed a plan for the Ashok Nagar Metro station showing how the Metro rail station can be expanded to provide direct access to the adjacent BRT station. This design minimizes level difference by providing a shared concourse that spans both the BRT and Metro stations. Staircases and escalators are adequately sized and the overall layout is structured so as to minimize bottlenecks.

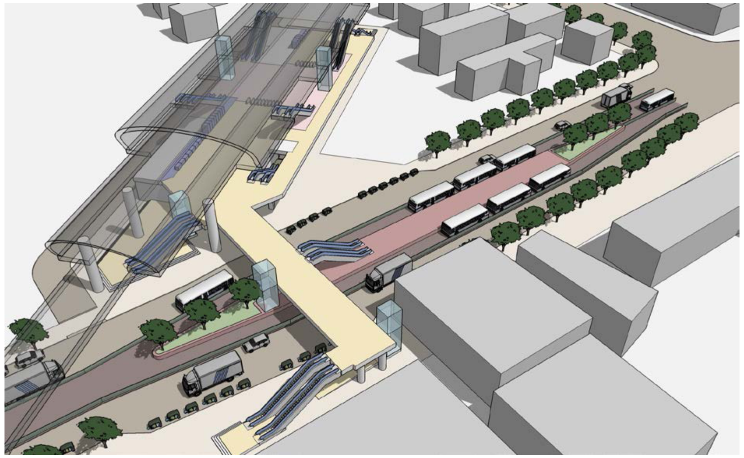

Figure 5.2 -Design proposal for integrated metro and BRT station, Ashok Nagar.

The regular MTC bus fleet should also be integrated with BRT. Well-designed terminals can brings multiple services to the same platform, allowing passengers to transfer without crossing a street or climbing steps. Similarly, designated stopping bays for rickshaws and para-transit can be provided near each station to provide connectivity to passengers whose final destination is too far to walk. Auto-rickshaws and informal para-transit van services already operate over a widespread network in Chennai. They can become a cost effective means of providing last-mile connectivity from BRT stations.

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Existing transport interchanges in Chennai demonstrate varying levels of success at intermodal integration. For example, the bus terminal in front of Central Station makes bus-train transfers easy. However, the connection between the central station and suburban rail Park station and MRTS station is weak. CMBT integrates city bus services and auto rickshaws with intercity services with a fair degree of success.

The suburban rail station at Guindy works well in its current proximity to the Guindy MTC bus terminus. Share autos too have a terminus point near the MTC bus terminus. With an upgrade to the station street interface design, pedestrian facilities and parking facilities, Guindy could become one such intermodal mobility hub. The existing proposal to upgrade the MTC bus depot in T. Nagar to accommodate parking facilities is a step in the same direction. Upgrading the pedestrian environment between the bus depot and the Mambalam suburban rail station and providing shuttle services emanating from the MTC bus depot will complete the picture.

Similarly, the Madhya Kailash Junction at Adyar where the Kasturbai Nagar MRTS station is located presents an opportunity for intermodal connection if the Adyar-Madhya Kailash Bus stop is moved closer to the MRTS Station and other shuttle services also start operating from the hub. In summary, integrating all BRT stops with other modes in a manner that allows a seamless and effortless transfer is highly critical to the success of the system.

Information and signage integration

Keeping the passenger informed at all times is crucial to making public transportation user friendly and desirable. Bilingual information is particularly useful in reaching out to a larger populace. At present, the lack of information on existing public transit routes and their timings discourages the use of public transport in Chennai. Such information is usually only gathered from fellow passengers waiting at transit stops or from commuting on a daily basis along the same route.

For the BRT to work to achieve its full potential, it is essential to do the following:

• Display onboard schematic maps of the BRT network that indicate interchange points with other public transport systems
• Keep passengers informed through on-board automated announcements
• Display arrival times of the next bus

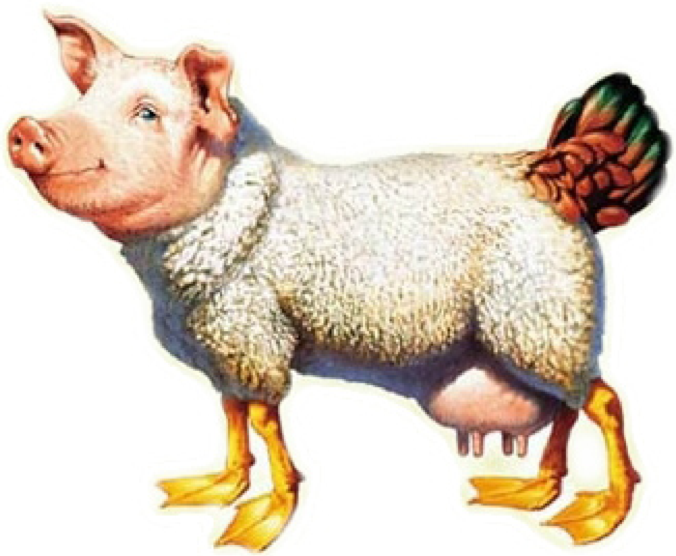

Figure 5.3 & 5.4 -Bremen's SMART card is known as the as 'egg laying-wool-milk-sow' (eierlegendewollmilchsau), a German term that means bringing unexpected things together in a positive way.

to reduce the anxiety of waiting

• Provide information and maps for smart travel, highlighting walking, cycling, and public transport routes

Before boarding, passengers need to be able to determine the routes that are available for travelling to the desired destination, transfer points, and departure times. Once on board, passengers need to be informed about upcoming bus stops and transfer opportunities.

Public transport systems need to be simple and easy to understand. All information should be up to date because unreliable and out-of-date information pushes existing and potential passengers to distrust the system and look for alternatives.

Integrated ticketing

Electronic fare collection through a common pre-paid ticket or smartcards usable on all modes of transport saves time and can be used to reduce the monetary penalty for switching from one mode of transport to another. Having such a system in place is critical to the success of BRT as well as other public transport systems because:

• It enables passengers to easily switch modes at interchange stations without queuing to buy another ticket.

• Typically, two tickets for separate segments cost more than a single direct trip. Use of smart cards provides a way to pay for a multi-segment trip as if its a single trip. Customers do not get penalized for making transfers.

• It reduces the risk of revenue leakage by reducing the number of cash collection points.

Since access to mobiles is widespread, mobile technology should be leveraged to set up systems of payment and recharge. Mobile phone operators have a wide network of recharge centres, often run as a side business by general goods shops. With an appropriate tie up, this wide network can be used for recharge rather than setting up independent infrastructure for cash collection.

Further, it should be made possible to buy these tickets at vending machines located at major public transport stations. Additionally, incentives for prepayment should be made by providing discounts for multi-trip tickets.

Chennai Metro Rail Ltd plans to implement automatic fare collection, and it is recommended that the system be designed with enough flexibility to be able to function on the BRT system as well as other modes and among multiple operators.

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5.3 Parking management

Along with creating high quality accessible and integrated public transport system that serves the needs of city residents, it is equally important to discourage people from using private modes of transport. This means that parking should be restricted in areas well-served by the integrated public transport system so that people are encouraged to use public transport. Parking is not an inevitable need at the end of a trip. By contrast, the availability of parking at the destination results in a trip by personal vehicle.

Presently, parking occupies up to half the street width on many commercial streets. Effective on-street parking management will be needed to ensure that parking does not conflict with other activities along BRT corridors. If implemented on a citywide basis, parking fees can become a major source of revenue that can help fund public transport operations and streetscape improvements. Parked vehicles encroach on pedestrian space, making it harder for passengers to access public transport.

Several dimensions of parking management will need to be addressed:

• **Clear designation of parking and no-parking areas**

Demarcation of parking areas is a prerequisite for enforcement.

• **Introduction of appropriate parking fees**

In areas with high parking demand, parking fees can help reduce the pressure on on-street parking facilities. Parking fees create an incentive for the use of off-street lots, and they also encourage people use alternate modes, including public transport. Parking fees need to be calibrated to the size of the vehicle (e.g. cars should be charged 4–5 times as much as two-wheelers).

• **Enforcement of no-parking zones**

A robust system for parking enforcement is needed to ensure that parked vehicles do not compromise pedestrian footpaths and vehicle movement in the carriageway.

At present, parking occupies a great deal of the right-of-way on many of the proposed BRT corridors. Where space is limited, priority should go toward public transport, pedestrian access, cycling, and mixed traffic. Parking can be limited through appropriate management and pricing.

Corporation of Chennai has already started Pay-n-Park facilities in different areas of the city. This is a good start. Going forwards, a clear policy on

Figure 5.5 -Transmilenio's distinctive red buses contribute to the system's brand value.

parking that takes an integrated city-wide approach will be pivotal to the success of the integrated public transport system. On-street parking should be discouraged near public transport stations, where people have the option of using sustainable modes of transport. If absolutely required, such parking should be priced at premium rates to discourage the use of private vehicle use.

Park-and-ride facilities should be considered only at terminal stations in city outskirts. In other locations, intensification of land use through mixed-use residential and commercial development is a more effective long-term means of generating public transport ridership.

The design and management of all parking facilities must also reflect the new mobility as well as 'safe design.' Priority should be given to non-motorized vehicles, para-transit, energy-efficient vehicles, and car-share companies—all in advance of single-occupancy cars.

5.4 Communications & marketing

In this day and age, people are acutely concerned about lifestyle and image. Being efficient and utilitarian is not sufficient. Attractive branding and constant outreach is essential for the successful adoption and patronage of a new public transport system, especially by the growing middle class. As prosperity rises, public aspires to be associated with products and services that exude style and class. The marketing team needs to create a buzz that BRT is more than just another bus.

Several fundamental components of effective branding are covered in the handbook, 'From Here to There'[2] :

- **"Building a strong brand"**
The brand communicates the system's values. A modern BRT system needs a modern-looking logo, colour scheme, and graphic style. The brand should reference local values and sensibilities. In systems such as Ahmedabad's Janmarg, a local-language name helps people connect.

- **"Sell your values"**
Agency employees are all brand ambassadors, so it is critical that they understand and internalize what the system stands for. In Ahmedabad, drivers underwent a two-month training upon them that they would

2 Embarq, From Here to There: A creative guide to making public transport the way to go, <http://www.embarq.org/sites/default/files/EMB2011_From%20Here%20to%20There_web.pdf>, 2011

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need to adopt more courteous driving style than they might have practiced in previous posts in the city's Municipal Transport Service or as private freight transporters.

- **"Get started early"**
Outreach can begin well before the official launch of the system. In Bogotá, representatives of Transmilenio distributed rider information door-to-door in neighbourhoods along the BRT corridor. Ahmedabad's Janmarg offered free rides for the first three months to entice new users to try out the system. This trial period was followed up with active outreach to introduce various communities to the BRT.

- **"Systematise your information"**
Present customer information in an easy-to-use format. Signage and information graphics need to be straightforward and concise.

- **"Know what riders want"**
Advertising and outreach campaigns should be tailored to the specific needs and interests of different user groups.

- **"Control the narrative"**
While officials are often leery of divulging too much information to the media, it is better to have a pro-active approach to media outreach. The Ahmedabad Municipal Corporation fed information about the Janmarg BRT to the press on a regular basis, resulting in extensive coverage of the project before its opening.

- **"Be responsive to riders"**
Periodic user surveys can gather information on passenger perceptions of service quality, and this feedback can inform operational plans and the design of subsequent corridors.

IMPLEMENTING BRT IN CHENNAI

6.0

6.0 Implementing BRT in Chennai

6.1 Introduction

The ultimate sustainability of any BRT system depends as much on the system "software"—the business and regulatory structure—as it is on the "hardware"—buses, stations, busways, and other infrastructure. A lot of emphasis is typically placed on the physical aspects of BRT, such as corridor design, bus stations, and vehicles. These are very important elements that determine the quality of any BRT system. However, the success of BRT is also a function of effective cooperation among multiple government authorities and contracting structures that facilitate efficient involvement of the private sector.

Organizations that will be involved in the implementation of BRT in Chennai include the Transport Department, the Corporation of Chennai, the municipalities of Ambattur and Tambaram, the Chennai Metropolitan Development Authority, the Highways Department, and the Traffic Police. Support from other agencies such as Tamil Nadu Road Development Corporation, the Public Works Department, Chennai Metro Water, the Electricity Board, telecom firms, and others is essential. Planinng and implementation of BRT should be carried out by a new entity, expressly created to oversee the BRT project.

6.2 Setting up a special implementation unit

For any public transport system to function well, it needs to have a solid foundation. This foundation is provided in the form of a dedicated core organization whose purpose it is to manage the system and coordinate with all associates. A dedicated special purpose unit (SPU) should be set up to implement and manage the BRT system. After implementation the SPU takes on the role of the BRT management and monitoring. It also continues to oversee the planning and implementation of future phases. The SPU can eventually become the nodal agency for all transport related projects and programs in Chennai Metropolitan Region, including city bus service, bicycle sharing program and parking management.

One option is for BRT to be taken up as the first major program by the newly formed Chennai Unified Metropolitan Transport Authority (CUMTA).

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The SPU will carry out the following functions:

- **Planning and design**
The SPU will retain consultants to conduct demand assessments, conduct financial analysis and to design stations and other infrastructure. The SPU will need the internal capacity to review these designs.

- **Operations**
The SPU is responsible for service planning, scheduling, and monitoring. The operations team will not operate the buses directly—this can be contracted out to a private operator, as described below.

- **Communications**
The SPU needs to develop and execute an effective branding strategy for the system and disseminate information to the public.

While it can be argued that MTC itself is a special purpose corporation set up to manage city transport service, its present scope and role do not match what is being proposed. MTC is essentially a city bus operator. It knows how to procure and operate buses. It has a basic level of planning expertise to run bus service. However, it does not have the wherewithal to plan a BRT system and eventually facilitate the overall planning and integration of public transport in Chennai. Its management is bogged down by day-to-day fire fighting and does not have the bandwidth to take up larger responsibilities. Therefore, for the success of the BRT system, it is essential to create an SPU that has the bandwidth to innovate and establish best practices in the city.

The SPU needs qualified, professional staff and the independence to make swift decisions during the process of implementation. This is similar in structure to Chennai Metro Rail Limited. It should be headed by a senior IAS officer supported by a team with backgrounds in the following areas-

- **Financial management and economics**
This person will be the principal advisor to the project head and will provide advice on project financing, contracting, and fiscal control.

- **Transport planning**
This person brings an understanding of transport operations. With advice from experts and consultants, this person will oversee system planning and design.

- **Infrastructure development**
This person will be an engineer

who manages all construction-related activities. Infrastructure forms a substantial part of BRT development. With support from a project management consultant, this person will manage all infrastructure development in coordination with various civic authorities such as municipal corporations, Highways and PWD.

- **Public relations and communications**
As discussed in Section 5.4, public outreach will need to start early to garner support from various stakeholders. Advertising firms and public relations agencies should be contracted to develop an outreach plan. This position oversees all outreach and communications activities.

- **Legal affairs**
This person may be part of the team or may be contracted for specific input on legal affairs and to draft contracts and regulations as and when required.

- **Internal administration**
Manages the office, its staff, and accounts.

- **Operations management**
An operations management team has to be inducted before the start of operations. This team should be put together well before the start-up operations preferably during the planning process so that they can understand the system and manage its operations well.

6.3 Role of the private sector in bus operations

In many cities, BRT systems have taken advantage of private sector expertise and financial resources to operate buses, collect fares, and perform other important functions. While the SPU handles overall regulation, planning, management, and service monitoring, the private is responsible for day-to-day operational activities. Contracting these activities to third parties allows the BRT system to take advantage of private sector investment and efficiency to maximize quality and minimize cost over the long term. However, contracting structures need to be designed to create the right incentives for private operators and a clear set of guidelines and contracting arrangements needs to exist.

There are two principal forms of contracting:

- Route/zone operations licensing
- Bus operating service contracts

Zone licensing
Cities across the world almost always explore the first form of contracting,

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route or zone licensing. In business terms, it seems to make sense that private operators will aim for profitability and therefore would make good choice in route selection. Operators will compete with each other to bring out the best. From the government's point of view, route contracting means one less headache—the government does not need to worry about planning nor spend its own money since operators are expected to earn directly from operations.

However, route contracting entails serious drawbacks. In the crudest form of route contracting, route permit fees are fixed irrespective of the route. Since some routes are more profitable than others, all bidders are interested in the most lucrative routes and there is a high risk of corruption within the agency responsible for issuing operating permits worth much more than the official price. Often, a black market exists where permits are resold at a much higher price by winning bidders. Low demand routes find few takers. In the absence of monitoring, license holders for low demand routes ply illegally on high demand routes.

The eventual license holder under a route licensing system further subcontracts the business to a bus driver/fare collector team at a fixed payment per day. The driver chooses how to earn money and the incentive to provide good quality service is low. The driver and fare collector's survival depends on what they earn each day. They try their best to snatch that extra passenger from their competitor on the street, even to the point of causing accidents and fatalities. If this form of contracting is employed in a BRT system, the quality of service is only marginally better than it would be in the absence of bus lanes. This form of competition is called "competition in the market." A better alternative is to facilitate "competition for the market," described in more detail below.

Often, to avoid issues of competition among operators, the regulator is tempted to design routes such that any given corridor has only one route. But this creates a monopolistic situation. Further, a large proportion of passengers are forced to make transfers that could have been avoided otherwise. This only adds to passenger discomfort and pushes them towards private modes.

Another disadvantage of a route licensing is that operations are fixed for the period of contract. Routes cannot be changed based on demand. A good public transit system, especially a BRT system, is one where the routes are optimized so that the profitability per bus goes up and fewer buses can satisfy the same demand.

In case of off-board fare collection, payments cannot be directly related to the passengers carried in each bus. Fare collection is done by a single agency or by the regulator directly. Thus, the only basis for distributing payments is the number of kilometers each operator plies. Payment should be proportional to the number of buses that each operator deploys and the number of kilometers operated. Multiple operators may operate on the same route but they do not compete on the street because fare revenues are distributed in proportion to the number of kilometers they operate. This is the second form of contracting, a kilometer-based contract.

Service contract based on per-kilometer payments
When a kilometer-based contract is awarded, the bidding criterion is the rate per kilometer, with the lowest eligible bidder winning the contract. The regulator as well as each of the operators needs to have trustworthy and untampered data indicating the number of kilometers plied by each operators. Also, each operator should be offered kilometers proportional to the number of buses they have on the system. Further, since the payment is made from fare revenues, the operators as well as the regulator need to know this amount. In other words, passenger ridership data should be available and be transparent.
Fare collection services are offered to a third party so that neither the regulator nor the operator can tamper with data. The other reason why fare collection services are given to third party is to bring in electronic fare collection. Implementing such systems, including procurement and integration of technology, and their management, is a complex job and must be given to a capable agency.

If ridership falls, the regulator should reduce the number of kilometers operated such that all operators are equally affected. If the regulator does not reduce the kilometers, then the operators cannot be paid at the bid rate per kilometer. The only other option left to the regulator is to increase the passenger fare to increase the revenue. However, a fare increase can result in a drop in ridership, again bringing revenue down.

As one can see, this form of contracting puts substantial risk on the operator. It is possible that no operator may be willing to operate on such terms. To put a limit to the risk for the operator, the regulator can guarantee a minimum

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number of kilometers per bus. (Such a guarantee should be as an average over the fleet and should be on a yearly basis, not daily.)

Maintaining customer service

To improve profitability, the operator seeks to reduce the cost of operations. This can mean smarter choices in maintenance to enhance the life of components (tires and spares), training of drivers to improve fuel efficiency, and better scheduling of staff and maintenance to reduce input costs. However, the operator may also resort to reducing the quality of service—poor maintenance, poor quality of staff, missing stops to reduce passenger intake, and so on. Therefore, it is essential for the regulator to monitor the service quality on an ongoing basis and penalize the operator in case the minimum benchmarks are not met. Conversely, those operators who excel in service quality should be rewarded. The assessment of whether an operator meets service levels or not should be objective. Evaluation and inspection criteria should be included in the contract to avoid subjectivity and favoritism. As in contracting, access to information is the key to success. This gives the operator an incentive to excel. Better performers may be given the option to increase the fleet size and an opportunity to earn more than others.

The more empowered the regulatory agency, the better it is able to steer the interests of the private operators toward achieving the public good. Further, the regulator should be independent to take decision and not suffer from political interference. It should have the right to increase the passenger fares if needed to make sure that the business is in good health.

Role of subsidies

Fare setting is often a political issue. It is the prerogative of the state to define what levels of fare should be charged from citizens. In a developed system, formal subsidies recognizes the social and economic importance of public transport. Many developing cities have a publicly owned bus company incurring deficits which are met “by default” from public funds. The debt payments are not officially regarded as a formal subsidy. [1] Subsidy is meant to offset the cost of travel for economically weaker sections and promote public transit…not to cover the inefficiency of the regulator and operator.

1 . Meakin R., Sustainable Urban Transport: A Sourcebook for Policy-makers in South Asian Cities

Salient points of BRT institutional structure
The following are key players for successful BRT systems across the world:
• A lean SPU serving as a regulator, with high level of planning and monitoring capacity
• Private bus owner-operations firms paid by the kilometer for bus servces operated
• An independent fare collection contractor
The SPU needs to have:
•Access to untampered information on passenger ridership and bus operations (km & quality)

• The freedom to modify operations as required, based on demand or business opportunity

• The authority to set fares after all means of optimization are exhausted

• Formal subsidies that are passed directly to passengers to provide better service rather than pay for the inefficiency of the regulator or operator.

All operating contracts should be awarded based on fair competitive bidding. Operating contracts should stipulate rewards and fines based on clear service quality indicators to ensure high quality bus service, and more than one private bus company should operate on any given route.

The construction of dedicated bus lanes, which creates a low risk, high profit public transport market, should be used to leverage investment in new buses and a high quality of service from private operators. Ensuring that this leverage can be applied on a regular basis rather than only when a contract expires requires having more than one bus company operating each route, and building a system of immediate rewards and fees for quality of service indicators into the contract.

This model was fine tuned and adopted by Bogotá when it created the Transmilenio BRT system. Ahmedabad and other cities have emulated the Bogotá model in place of the traditional government run and operated bus company model. The ensuing efficiency helps keep costs low while providing high quality service.

6.4 Timeline of implementation

Worldwide experience shows that a BRT system can be implemented from start of idea to operations in under 3 years. They are easy to finance since total cost of infrastructure is low compared to other public transport systems. In

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most cities, BRT systems are financed through local funding, with or without support from national government grants.

Implementation can be broadly divided into three categories:

1) Planning & Design
This is the first phase of implementation. It is important that careful planning precede any construction activity. Planning includes operations planning, determining the location of facilities like terminals and depots, and detailed physical design of corridors, stations, terminals, and depots. A core team should be set up to contract consultants, monitor planning and design activities, and oversee implementation. Typically, this phase takes between 6-9 months. Some cities have attempted to implement a BRT system in under one year based on inadequate planning, but the result is delay, substandard quality, and considerable expense to fix mistakes.

2) Construction and outreach
Based on the detailed planning and design by consultants, capable construction firms should be contracted to create high quality infrastructure. Infrastructure includes the BRT corridor (with exclusive bus lanes, footpaths, pedestrian access, stations and public amenities), interchange terminals, and depots for bus maintenance and parking. Construction activities can result in public inconvenience, so outreach activities should be started at this stage to keep people engaged and supportive of the process. Construction, from hiring of a contractor to completion of work, can take up to two years. It is important to have a good project management consultant to keep track of the timeline and ensure quality of construction.

3) Contracting and trials
BRT is not just about constructing infrastructure. It is a complete system that includes procurement of services for BRT operations. This includes bus procurement and operations contracts, installation and operation of fare collection equipment, fleet monitoring, system branding, security, and many other services. The core team will have to develop, with support from experts, detailed terms of reference for each of these contracted activities. This period will take up to a year. It has to be synchronized with construction of infrastructure so that both can be ready for testing and trials at the same time. The outreach activity will have to be heightened towards the end of this period and during trials to get public feedback and make last minute adjustments.

CORRIDOR	LENGTH (KM)	COST/KM	COST
POONAMALLEE- CMBT	14	14	196
AMBATTUR-THIRUMANGALAM	7.7	14	108
CMBT- MADHAVARAM	12.4	12	149
SIRUSERI- SAIDAPET	24.8	15	372
TAMBARAM- SAIDAPET	18.5	15	278
GST ROAD JUNCTION-THORAIPAKKAM	10.6	12	127
	88		1229

Table 6.1 - Cost of implementation for phase 1

6.5 Cost of implementing BRT in Chennai

BRT systems are relatively low cost compared to other forms of mass rapid transit. In the Indian context, the capital expenditure is of the order of Rs 12-16 crores per kilometer of BRT system. The cost of just constructing cement concrete bus lanes and BRT stations is much lower (approximately 3-5 crores/km). The above suggested cost includes all associated costs like depots and terminals, improvement of facilities for pedestrians and cyclists, repairing of motor vehicle carriageway and utilities along BRT corridors, and IT systems for fare collection, fleet management and traffic signaling.

BRT lanes should be constructed from high strength cement concrete since the load on these lanes is concentrated. BRT buses trace the same track and do not have much sideways movement. Flexible pavement, even special bituminous pavement like mastic asphalt, tends to wear out quickly, resulting in potholes. This is especially evident at BRT stations where buses have to start and stop, resulting in heavy friction and wear of the pavement surface. Cement concrete pavement, if laid well, has a longer lifetime of a decade or more. If poor quality pavement is constructed, then it will have to be repaired frequently, resulting in disruption of service and increase in overall cost over its life-cycle. This is better avoided.

BRT stations in Chennai BRT Phase-1are spaced approximately 1km apart on average. However, in denser areas of habitation, the spacing is approximately 600 m. BRT stations can cost anywhere between Rs 50 lakhs to 2 crores, depending on their size and capacity. A basic module with two docking bays per direction (50 m in length and 4-5 m wide) can cater to a corridor demand of up to 9,000 pphpd. Overtaking lanes and additional modules will be required for larger demand. The cost of BRT stations is included in the cost per km of BRT network stated above.

Terminals allow for interchange between BRT lines as well as intermodal transfers. They are a very important component of BRT and should be created simultaneously. Good maintenance of BRT fleet is a critical component in effective operations. Therefore, developing good maintenance depots where buses can be cleaned and repaired is essential to the success of the system. (Each depot costs between Rs 8-15 crores to develop, depending on the size of the facility. Terminals, depending on size, cost between Rs 5-15 crores. not including cost of land.)

As per this study, it is suggested that phase-1 of BRT will serve a network of 88 km. Of this, 65 km will have overtaking lane configuration while 23 km will be of the simple type with no overtaking lane. The total cost of developing infrastructure will 1229 crores for Phase-1. These figures are given in table 6.1. It should be noted that these costs are indicative. They are based on information available on cost of construction from other Indian cities. The design and engineering consultants hired by government shall have to perform detailed physical surveys, make an inventory of existing conditions and calculate exact infrastructure cost.

The cost of bus fleet is not included. Buses are not part of the capital infrastructure and are better placed under operating expense. The government is encouraged to invite private players into BRT operations. Private operators can provide service for a fee per km of operations that includes the cost of procurement of bus fleet. In case of AC Semi-Low-Floor buses, cost of bus is about a third of the total cost of operations over its life-cycle. Two-thirds of the cost goes towards operating expenses such as fuel, repairs & maintenance, and staff salaries.

Since buses are much cheaper to procure and operate than trains, their full cost can be paid through fare box revenue. This encourages private investment in BRT operations as compared to rail operations. The cost of bus fleet procurement for Phase-1, not including cost of operations over its life, will be ~260 crores rupees.

There are other ongoing operating expenses as well. This includes
- Fare collection system operations cost
- System security cost
- Traffic management cost
- SPU management team cost.

In addition, cost of maintaining infrastructure (BRT corridor, Stations, Terminals etc), including cleaning and repair of BRT lanes and stations, should be considered when preparing a financial model. ITDP has developed a financial modeling tool which can be used to assess various costs depending on system parameters. The cost of bus operations, including the cost of amortizing the fleet, is Rs200crores/ year. The approximate annual cost of operations, excluding the cost of bus operations, will be 50 Crores.[2]

A point worth noting is that all the

2 For Phase-1 network. Cost is in 2011 rupee value. Does not include inflation

OPERATING EXPENDITURE COMPONENT	CRORE RS/ YEAR
BUS OPERATIONS (INCL FLEET COST AMORTIZATION)	200
FARE COLLECTION SYSTEM	20
SYSTEM MANAGEMENT AND SECURITY	10
SYSTEM MAINTENANCE (CLEANING & REPAIR OF INFRASTRUCTURE)	20
TOTAL	250

Table 6.2 - Summary of operating expenditure per annum

above operating expenses except for bus operating cost are fixed for a given network size. Therefore, with increase in ridership on the system, the cost per passenger for fare collection comes down. This is unlike traditional bus operations where cost of fare collection increases in a linear fashion with increase in number of buses in operation.

6.6 Funding sources

Given the quantum of expenditure which is much lower than any other form of mass rapid transit, it is possible that the entire capital expenditure is borne by the Tamil Nadu government. However, other funding opportunities exist. The Union Ministry of Urban Development (MOUD) has been a big proponent of BRT systems across the country and have funded the development of 9 systems till date. While the first phase of National Urban Renewal Mission (NURM) is coming to an end, a second phase is expected to start in 2012. It is conceivable that MOUD would continue partial grant funding of BRT systems across the country as part of NURM-2. For Chennai, given its population and size, the funding from NURM would be limited to 35% of the total cost of project. This includes infrastructure as well as soft side of the project. 15% of the funding is expected from State Government and 50% from the local urban body.

Development Banks such as Asian Development Bank (ADB) and The World Bank also actively support implementation of BRT through soft loans for capital expenditure and grants for system planning and outreach.

ITDP can help Tamil Nadu government in reaching out to the appropriate divisions at these organizations to explore funding options. ITDP played a key role in case of Pimpri-Chinchwad BRT for the city to procure funding from The World Bank under the World Bank-MOUD Sustainable Urban Transport Program (SUTP).

6.7 Appointment of consultants for detailed planning

To proceed with the planning and design of the Chennai BRT system, ITDP recommends that the Tamil Nadu government appoint the following consultants:

Operations planning consultant. This consultant will conduct a detailed demand assessment for BRT. Outcomes of the contract include recommendations on route structuring, fleet size, bus specifications, and station configuration for each location.

Design and engineering consultant.
This contract covers the detailed physical designs of the BRT stations and corridors as well as other associated infrastructure including depots and terminals based on operations parameters set by the Operations planning consultant.

Public outreach.
To get the active support of citizens of Chennai, it is urged that public outreach be started as early as possible.

6.8 Closing remarks

BRTS as proposed in this report has the capacity to transform Chennai's public transportation into a truly world class system. With such a comprehensive system Chennai has the opportunity to be counted among some of the great cities of the world that provide its citizens with high quality, environmentally and economically sustainable public transportation system. By seamlessly integrating with other current and future modes, BRTS can rapidly unfold a high quality system to Chennai's rapidly growing suburbs. This would require strong, dedicated political will that has been amply displayed in the state throughout its history. The idea of a BRTS forces citizens and their government to choose as to what kind of a city they want Chennai to be. With sustained communication of a positive vision from political leadership, Chennai can have its own world class BRTS that is highly beneficial to all its citizens – both rich and poor.

APPENDICES

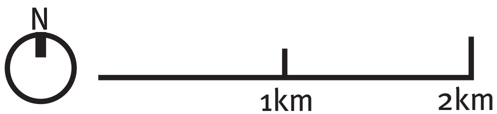
Appendix 1- Proposed Corridors and Station locations

Corridor 1- CMBT to Maduravoyal

Right of way- 36m
Length- 4.5 km
Number of stations- 9
Key BRT stations- Koyembedu Interchange; Nerkundram; Maduravoyal

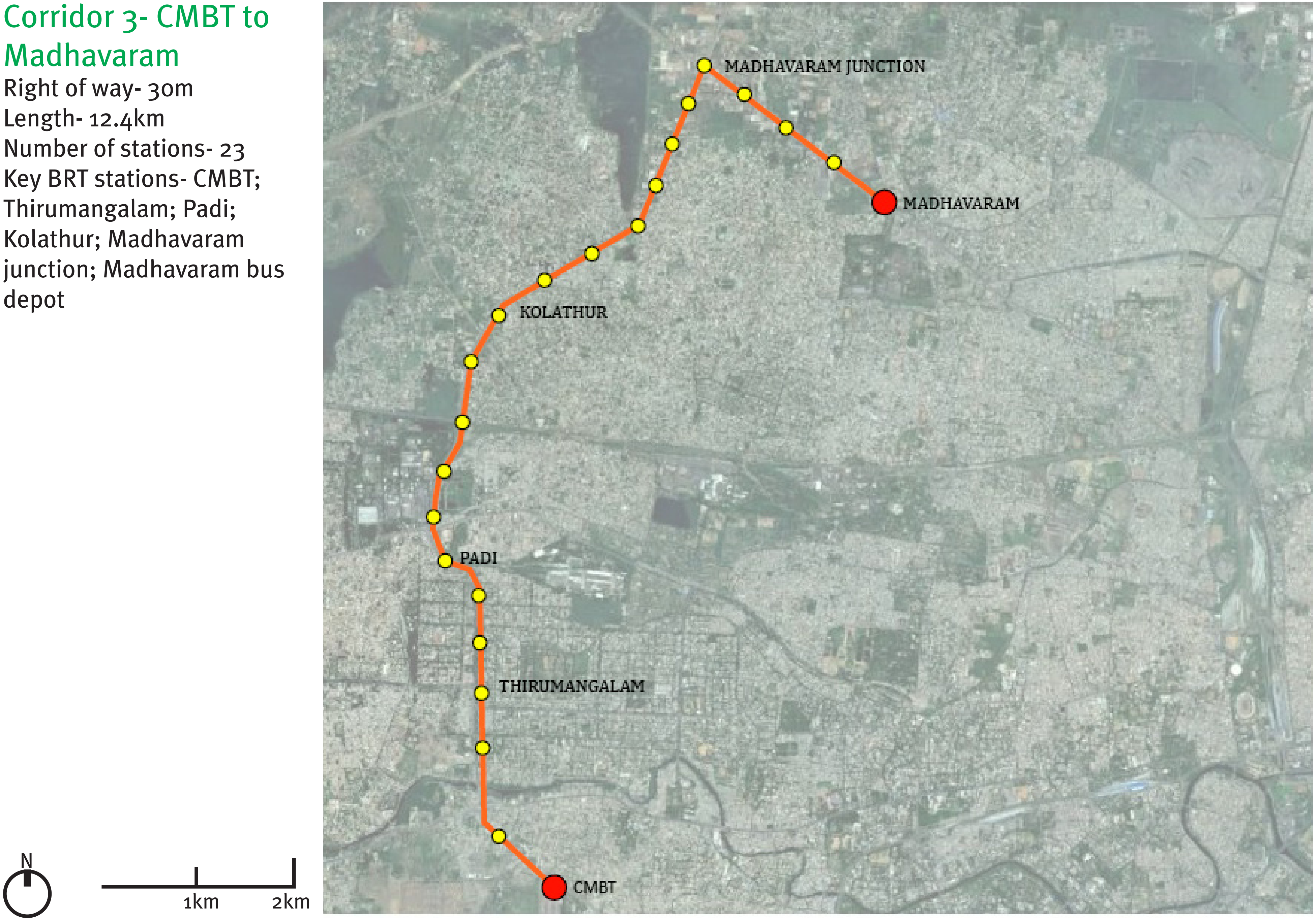
Corridor 2- Thirumangalam to Ambattur Railway Station

Right of way- 36m
Length- 7.7km
Number of stations- 15
Key BRT stations- Thirumangalam; Ambattur I.E.; Ambattur Railway Station



Corridor 3- CMBT to Madhavaram

Right of way- 30m
Length- 12.4km
Number of stations- 23
Key BRT stations- CMBT; Thirumangalam; Padi; Kolathur; Madhavaram junction; Madhavaram bus depot



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2.0
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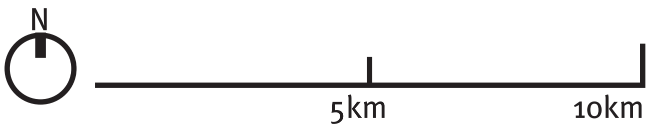
Corridor 4- Saidapet to Siruseri

Right of way- 40m
Length- 24.8km
Number of stations- 13
Key BRT stations- Saidapet; Little Mount; Anna University; Madhya Kailash; Adyar; Adyar Depot; Tidel Park; Perungudi; Thoraipakkam; Sholinganallur; Naavalur; Siruseri



Corridor 5- Saidapet to Mahindra World City

Right of way- 40m
Length- 44.8km
Number of stations- 23
Key BRT stations- Saidapet; Guindy; Airport; Chromepet; Tambaram; Vandalur; Estancia IT SEZ; SRM Engineering College; Maraimalainagar; Singaperumalkoil; Mahindra World City

Corridor 6- Thuraipakkam to GST Road

Right of way- 30m
Length- 10.6km
Number of stations- 14
Key BRT stations- Thuraipakkam; Pallikaranai; GST road intersection

2.5km 5km
N

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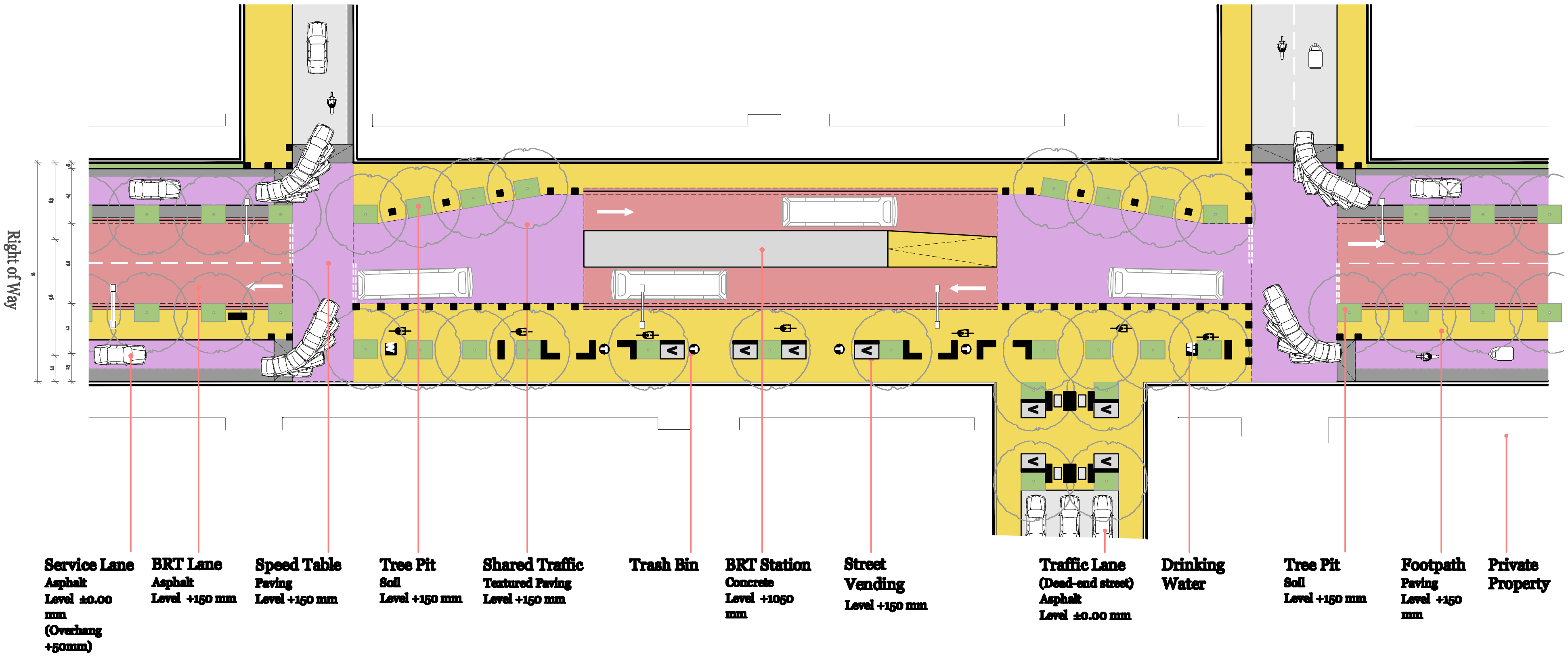
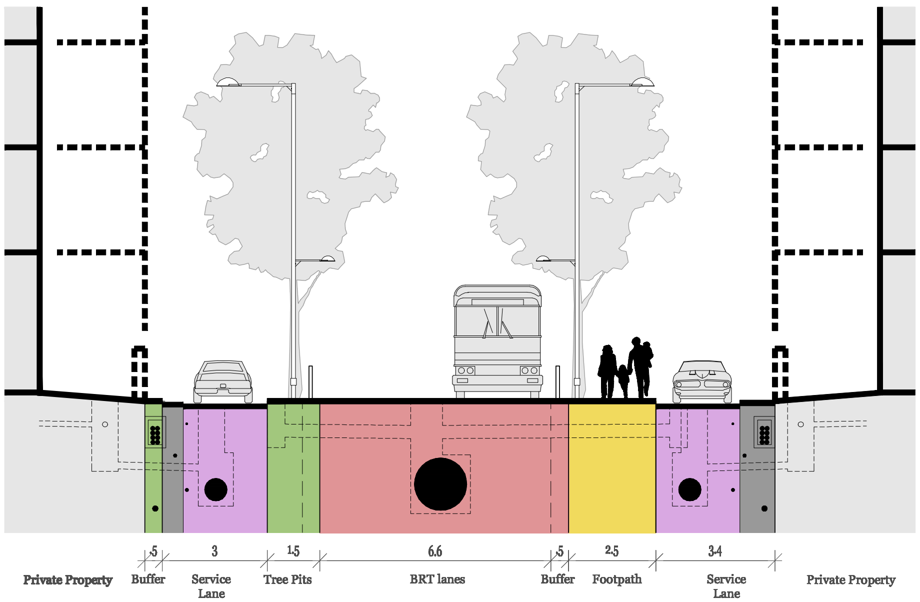
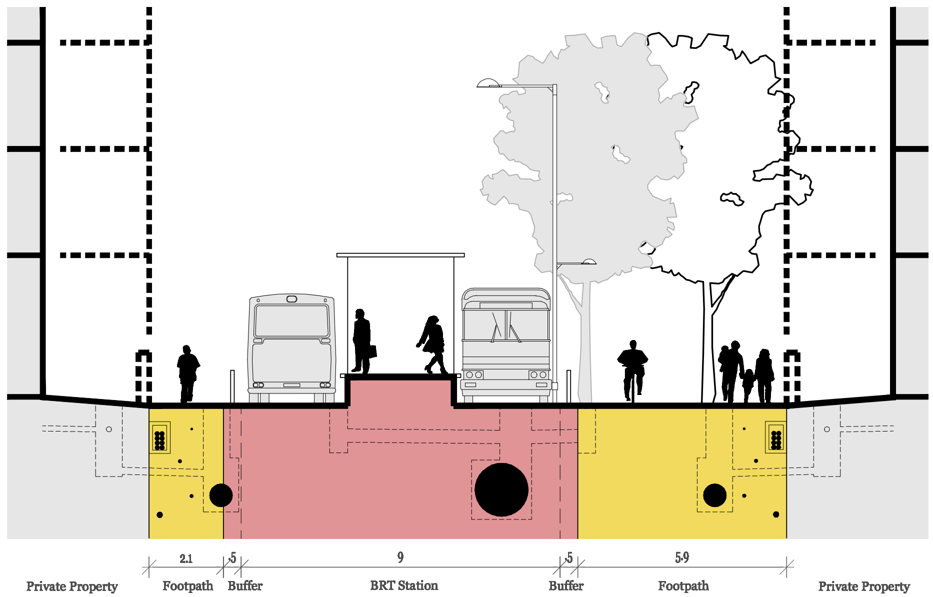
Appendix 2- BRT Street design templates for narrow roads

18 m right of way
with sidewalk, 2 service lanes and
BRT lane

5m 10m



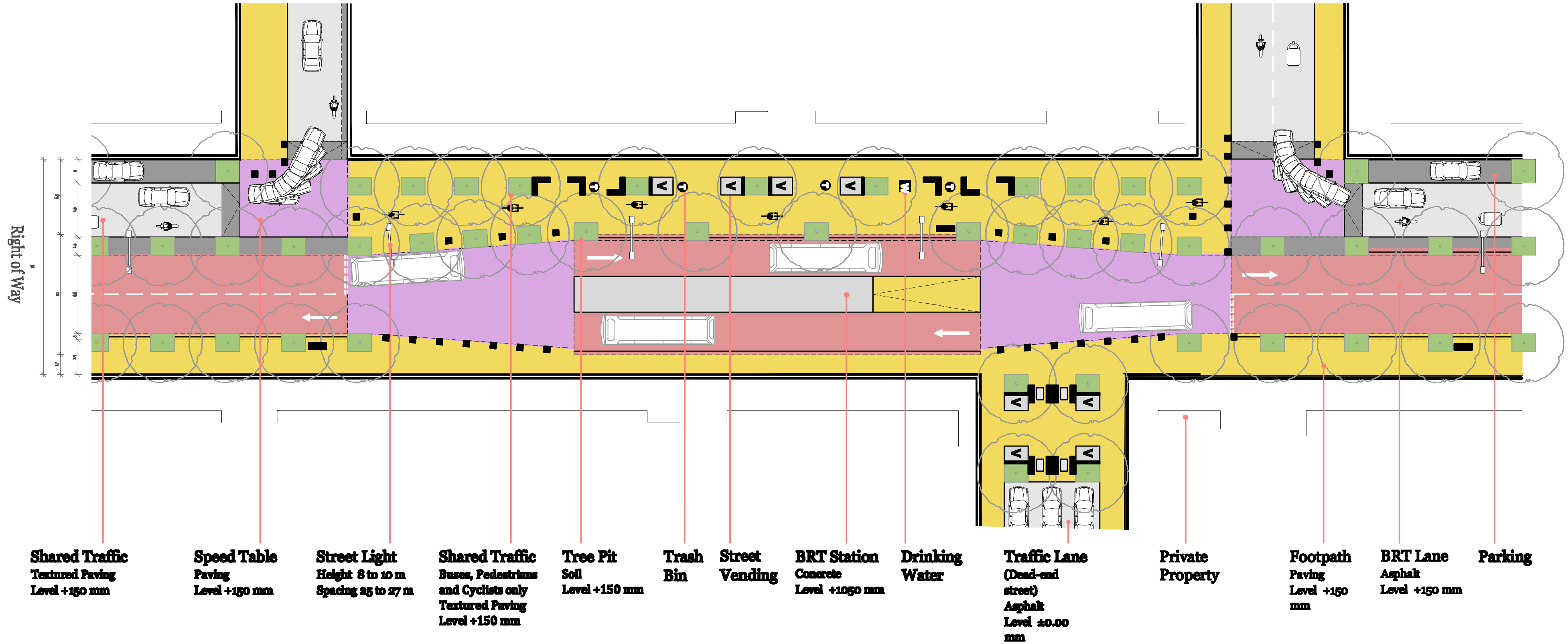

.5
3
1.5
6.6
.5
2.5
3.4
Private Property
Buffer
Service Lane
Tree Pits
BRT lanes
Buffer
Footpath
Service Lane
Private Property


2.1
.5
9
.5
5.9
Private Property
Footpath
Buffer
BRT Station
Buffer
Footpath
Private Property

18 m right of way with sidewalk, local road on one side and BRT lane

5m 10m

1.0
2.0
3.0
4.0
5.0
6.0



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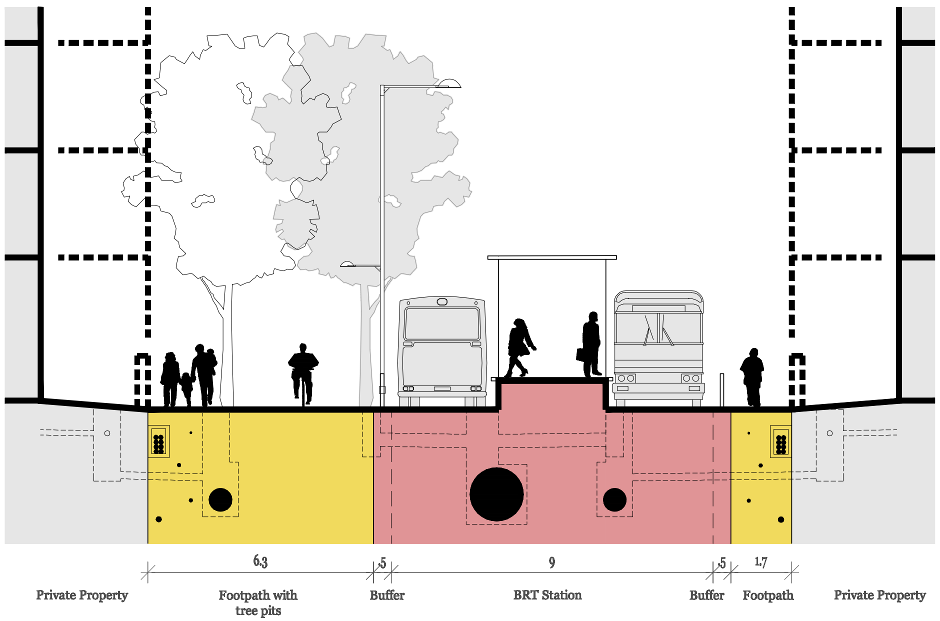

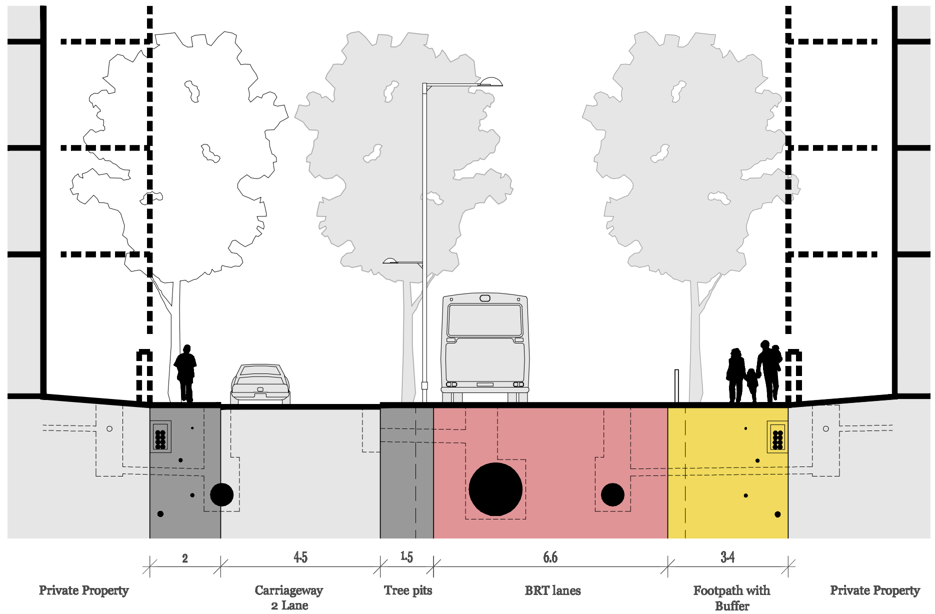

24 m right of way with sidewalk, 2 service lanes and BRT lane

5m 10m

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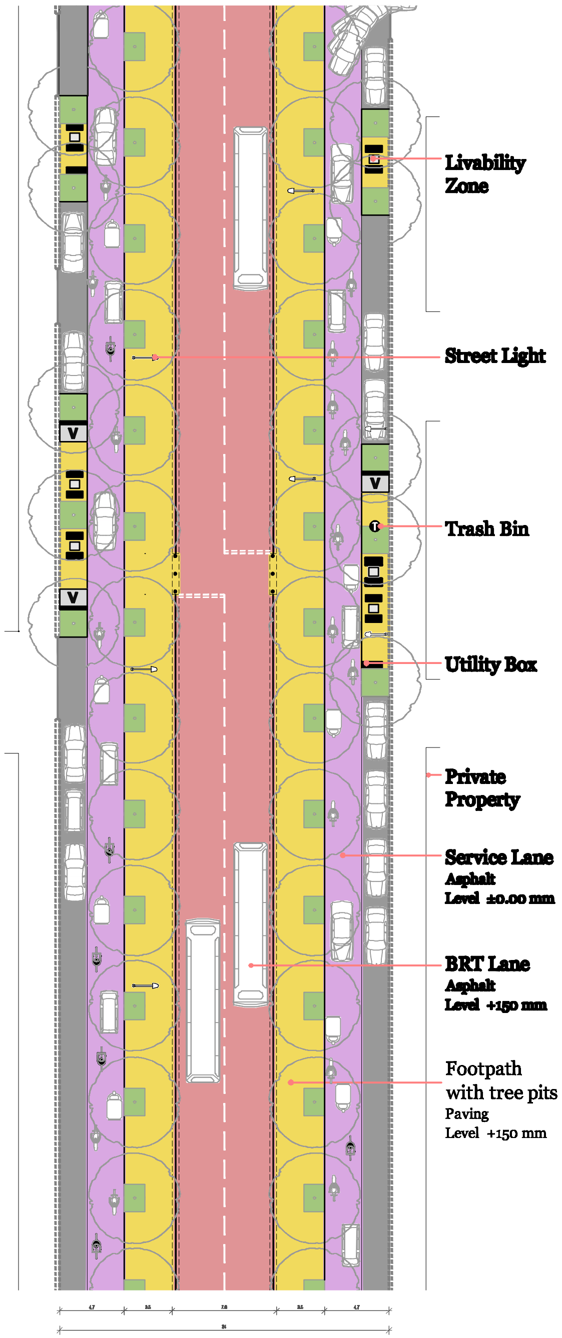
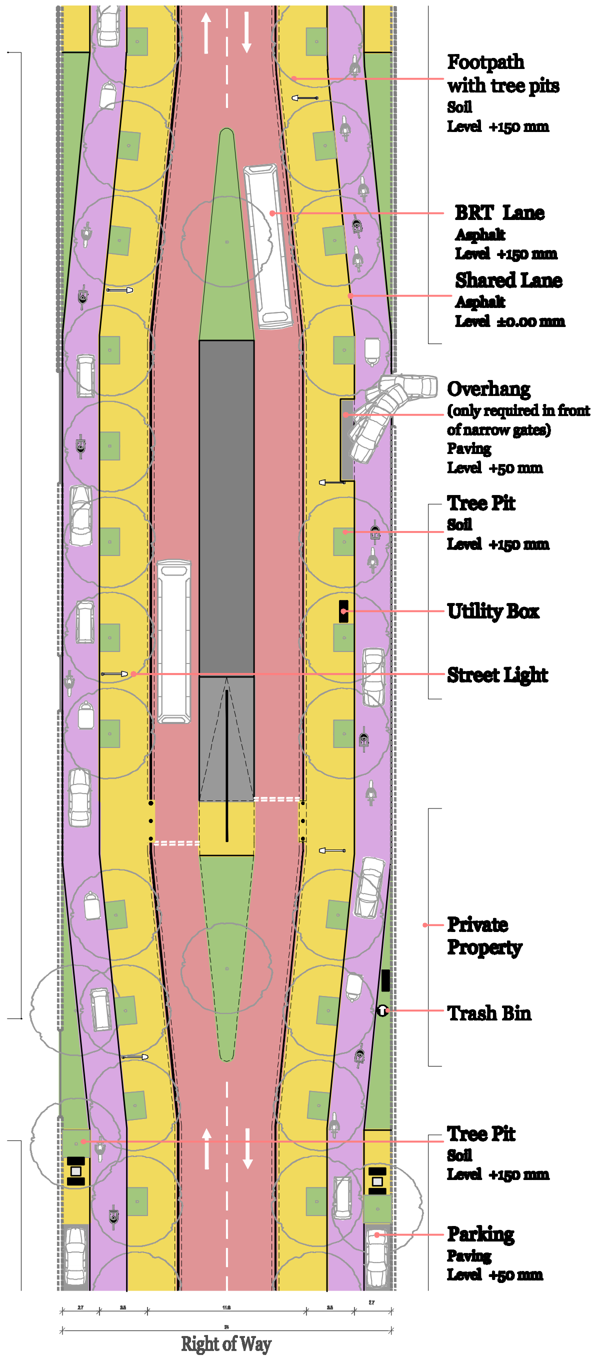
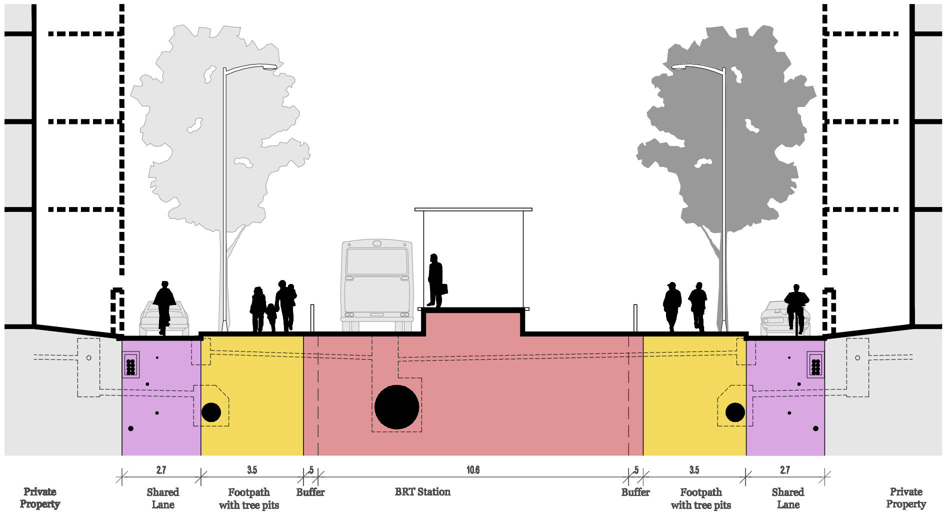
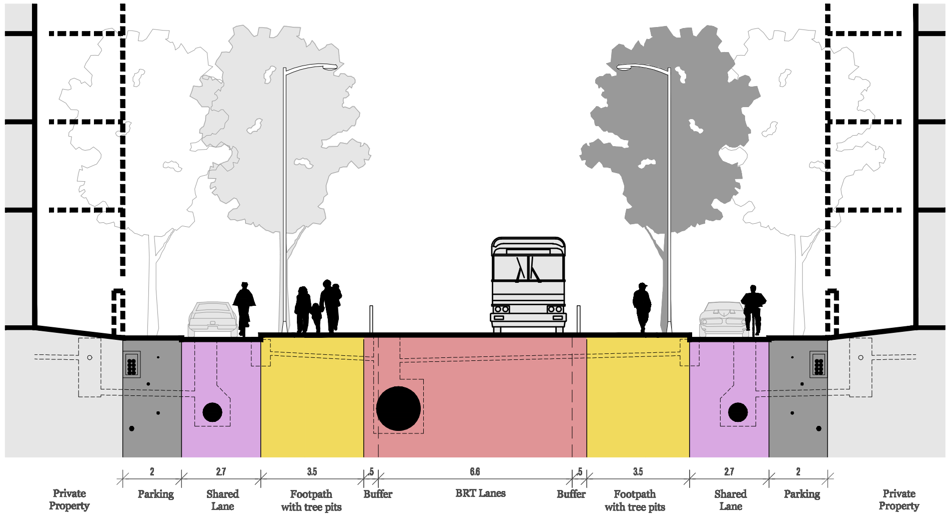
5.0
6.0






2.7
3.5
.5
10.6
.5
3.5
2.7
Private Property
Shared Lane
Footpath with tree pits
Buffer
BRT Station
Buffer
Footpath with tree pits
Shared Lane
Private Property


2
2.7
3.5
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6.6
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3.5
2.7
2
Private Property
Parking
Shared Lane
Footpath with tree pits
Buffer
BRT Lanes
Buffer
Footpath with tree pits
Shared Lane
Parking
Private Property

24 m right of way with sidewalk, bicycle lane, 2 traffic lanes and BRT lane

5m 10m

1.0

2.0

3.0

4.0

5.0

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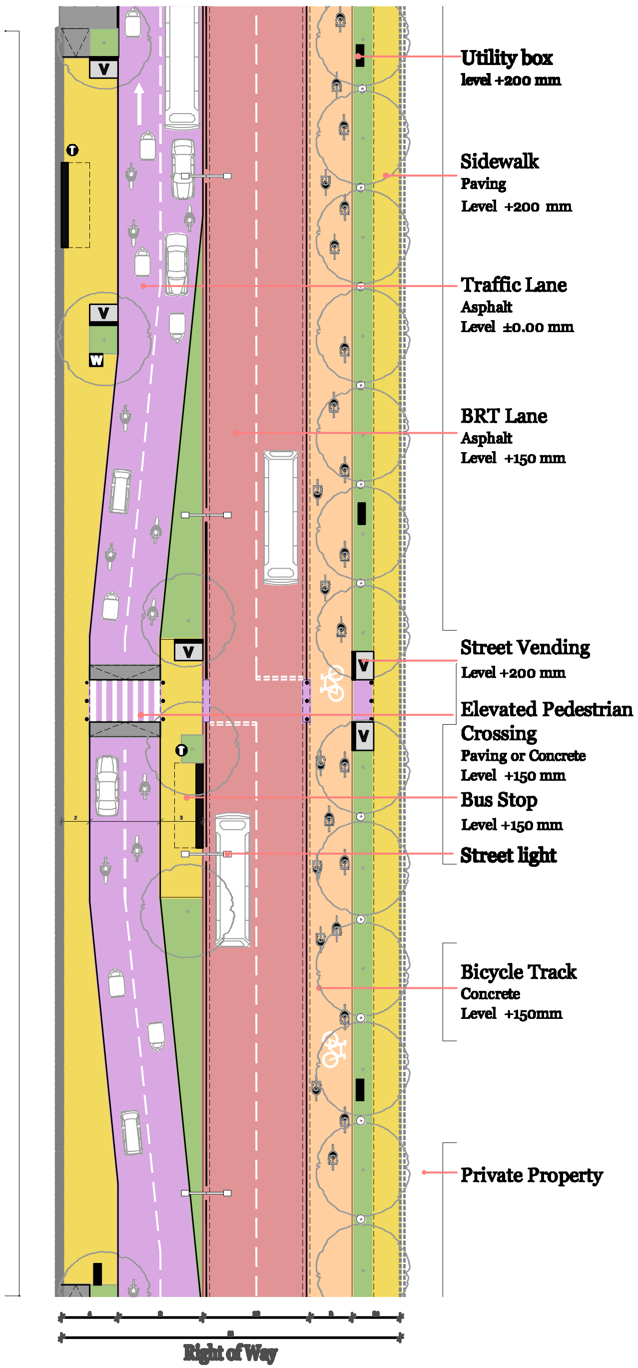
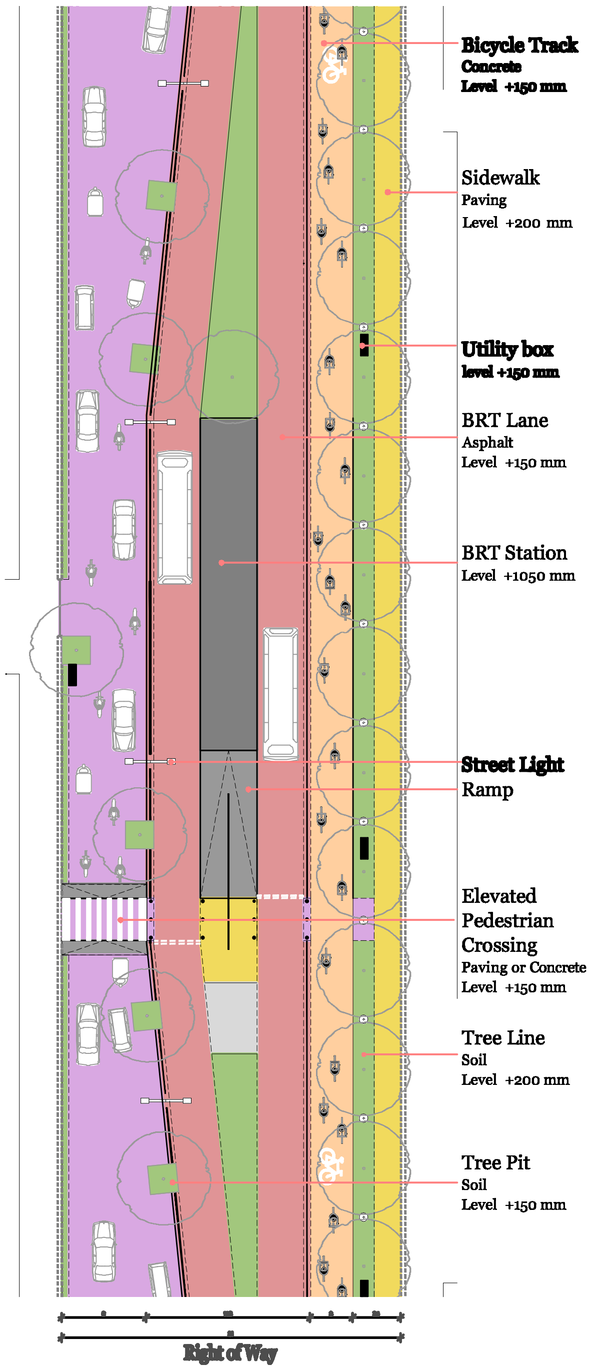
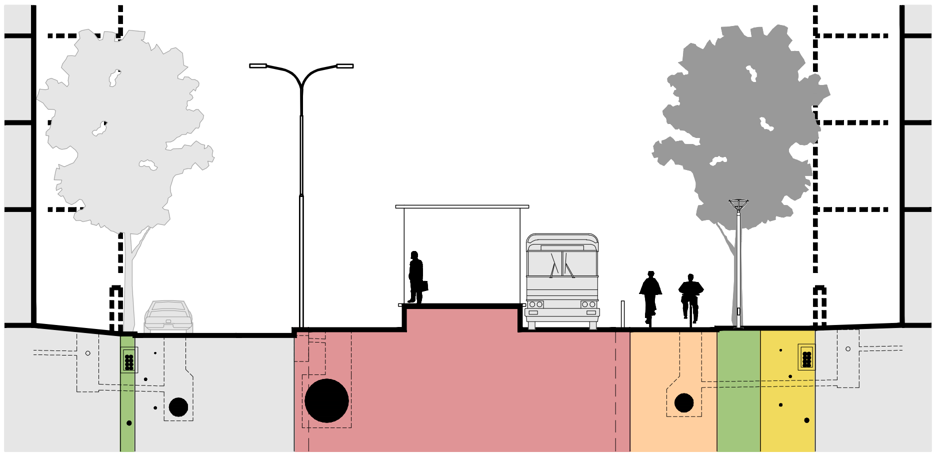
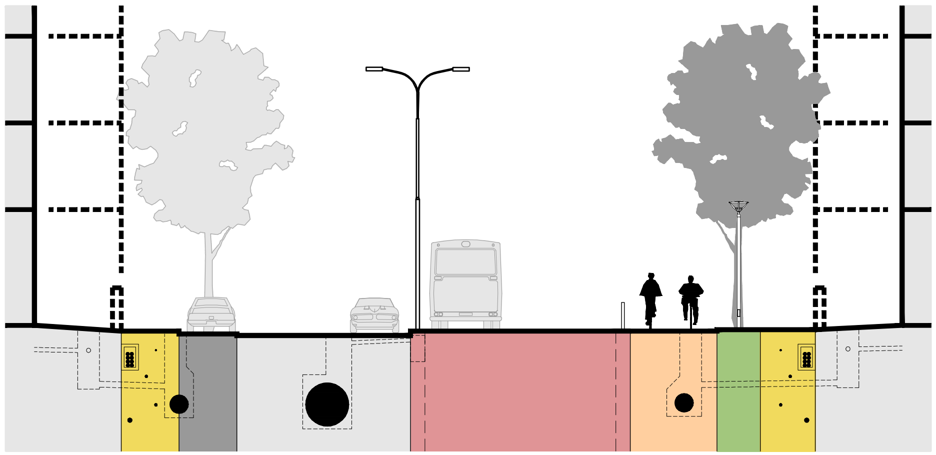





.5
5.5
.5
3.3
4
3.3
.5
3
3.4
Private Property
Buffer
Carriageway
2 Lanes
Buffer
BRT Lane
BRT Station
BRT Lane
Buffer
Cycle
Lane
Sidewalk
with Tree Line
Private Property


2
2
6
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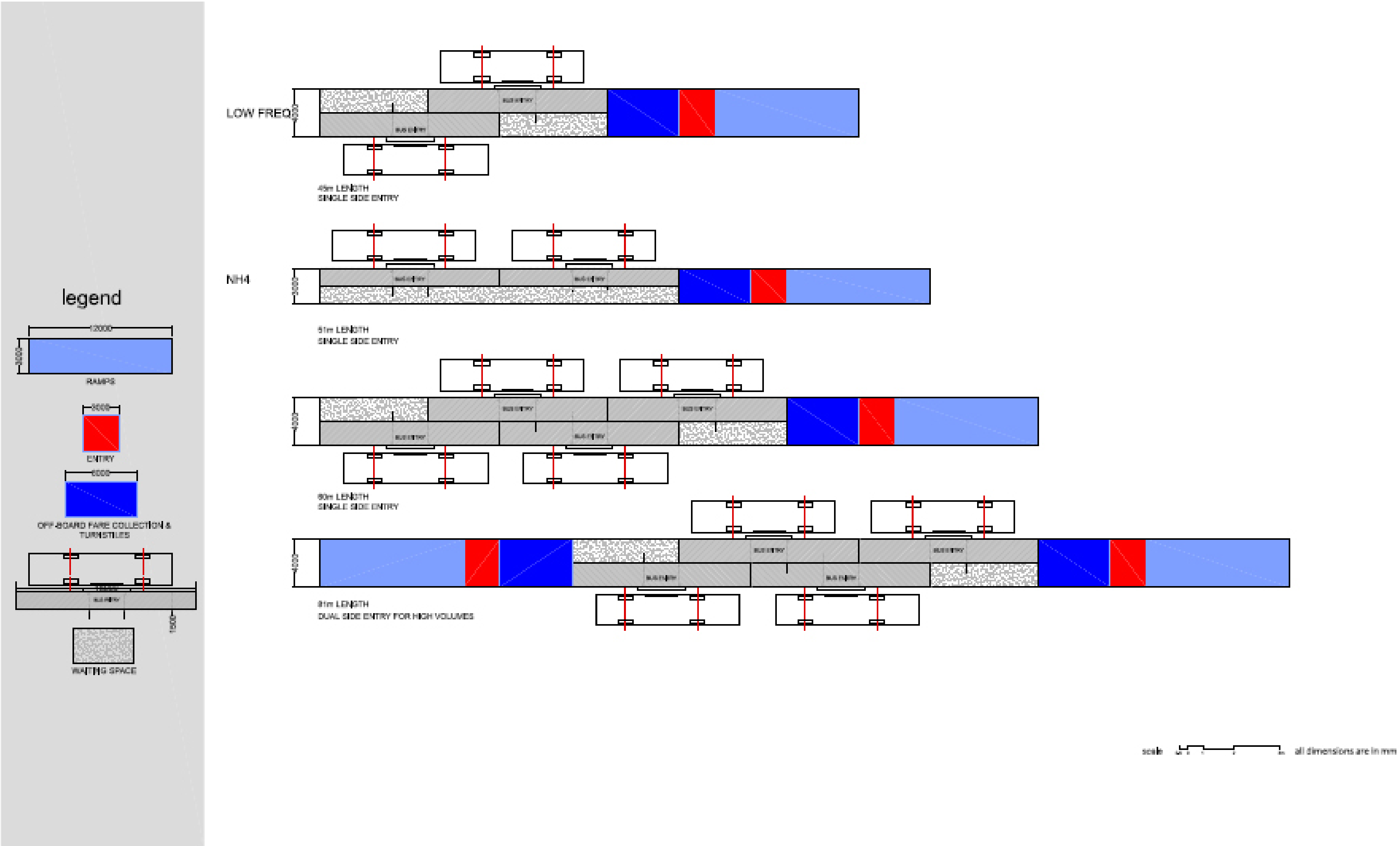
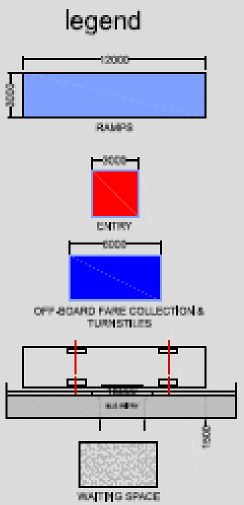
6.6
.5
3
3.4
Private Property
Sidewalk
Parking
Carriageway
2 Lanes
Buffer
BRT Lanes
Buffer
Cycle
Lane
Sidewalk
with Tree Line
Private Property

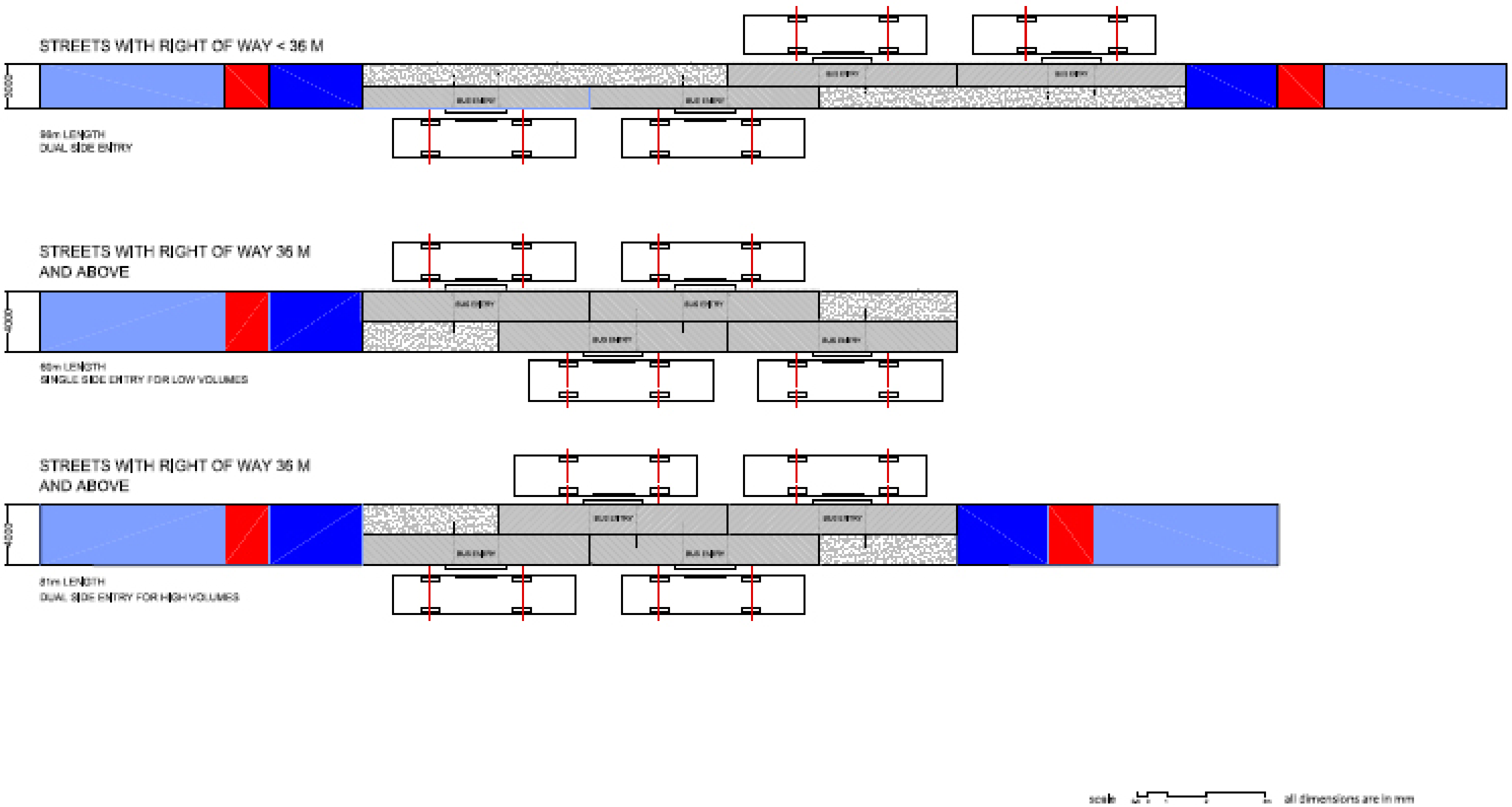
Appendix 4- BRT station modules and sample station design

BRT station modules- Pimpri Chinchwad



BRT station modules- Pune





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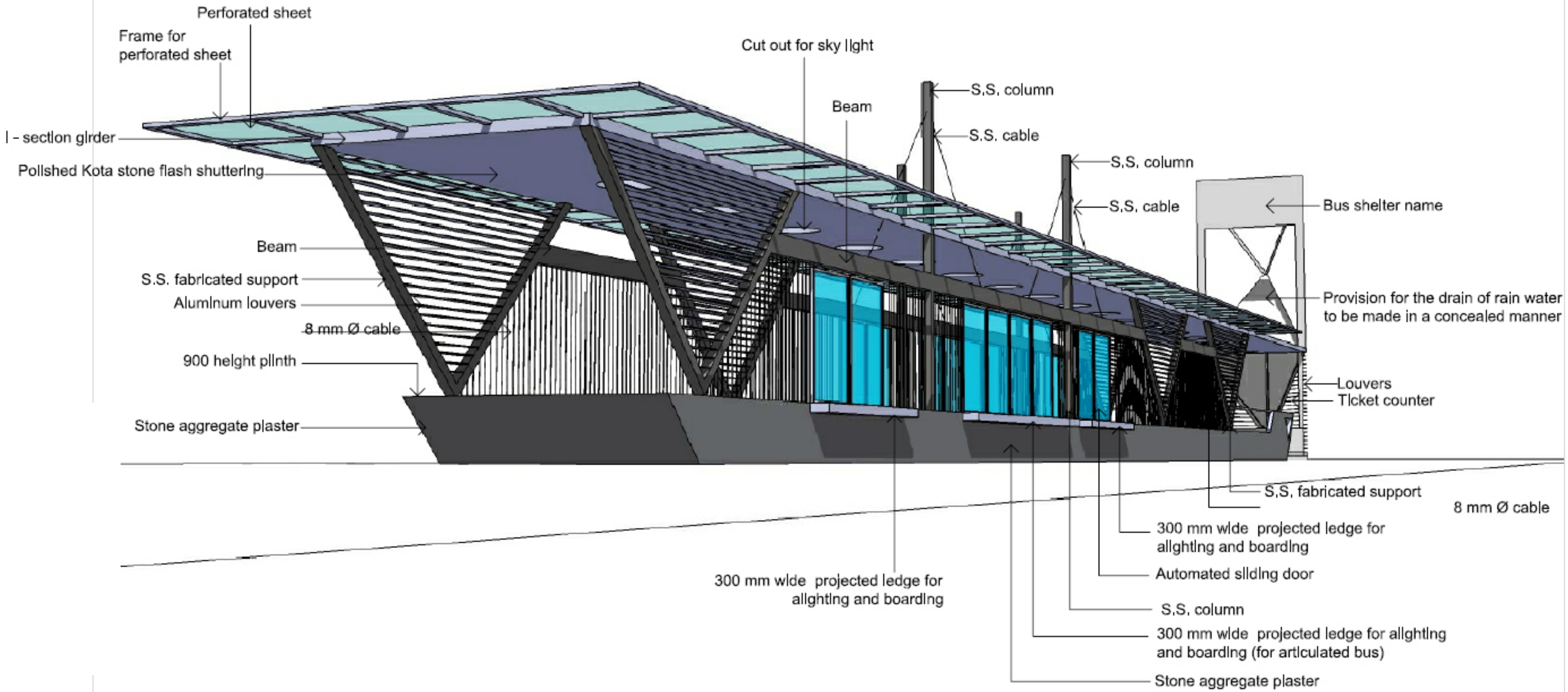
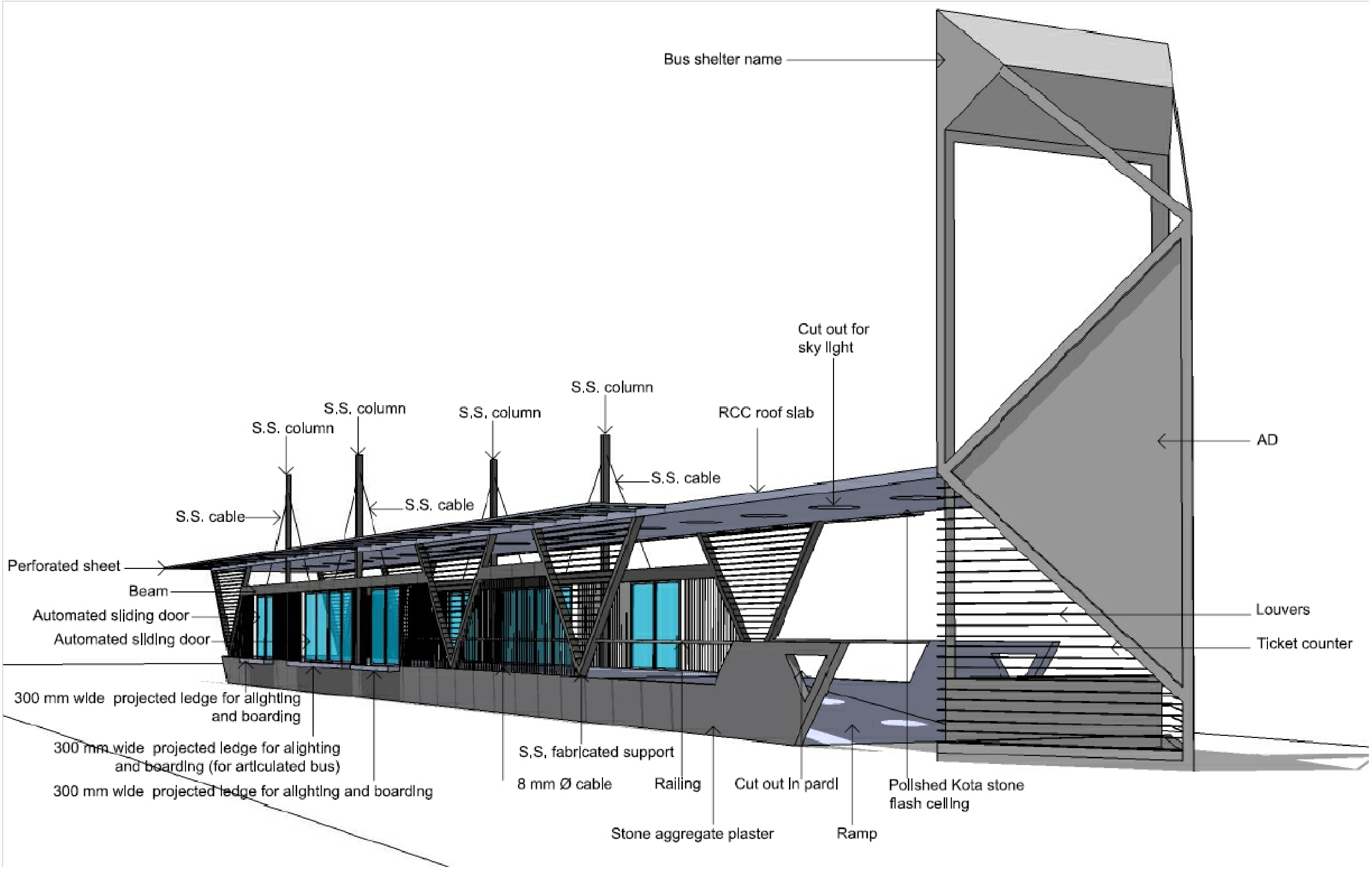
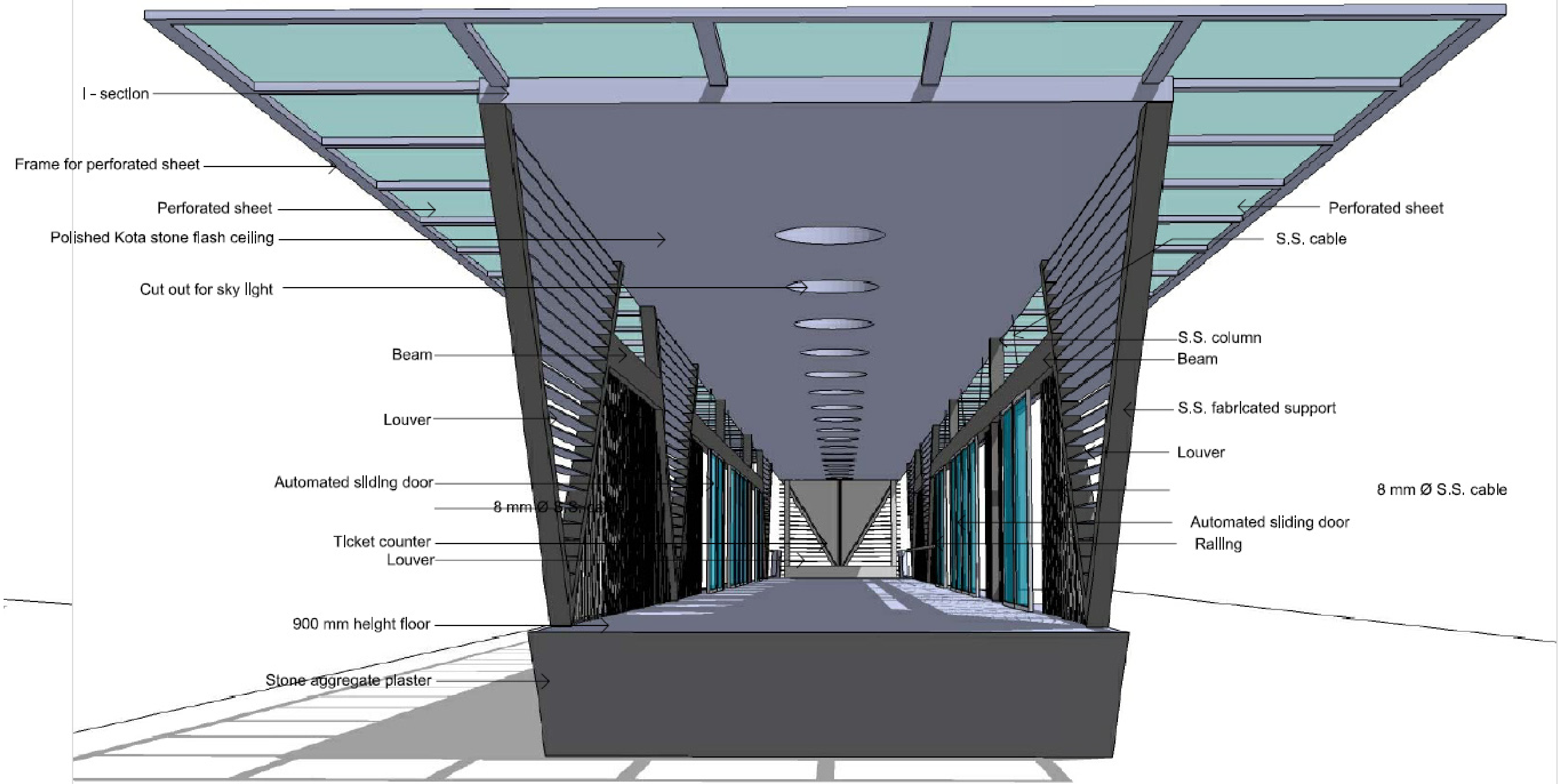
Sample BRT station design




Bus shelter name
Cut out for sky light
S.S. column
S.S. column
S.S. column
S.S. column
RCC roof slab
AD
S.S. cable
S.S. cable
S.S. cable
Perforated sheet
Beam
Automated sliding door
Automated sliding door
Louvers
Ticket counter
300 mm wide projected ledge for alighting and boarding
300 mm wide projected ledge for alighting and boarding (for articulated bus)
300 mm wide projected ledge for alighting and boarding
S.S. fabricated support
8 mm Ø cable
Railing
Cut out in pardl
Polished Kota stone flash ceiling
Stone aggregate plaster
Ramp



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