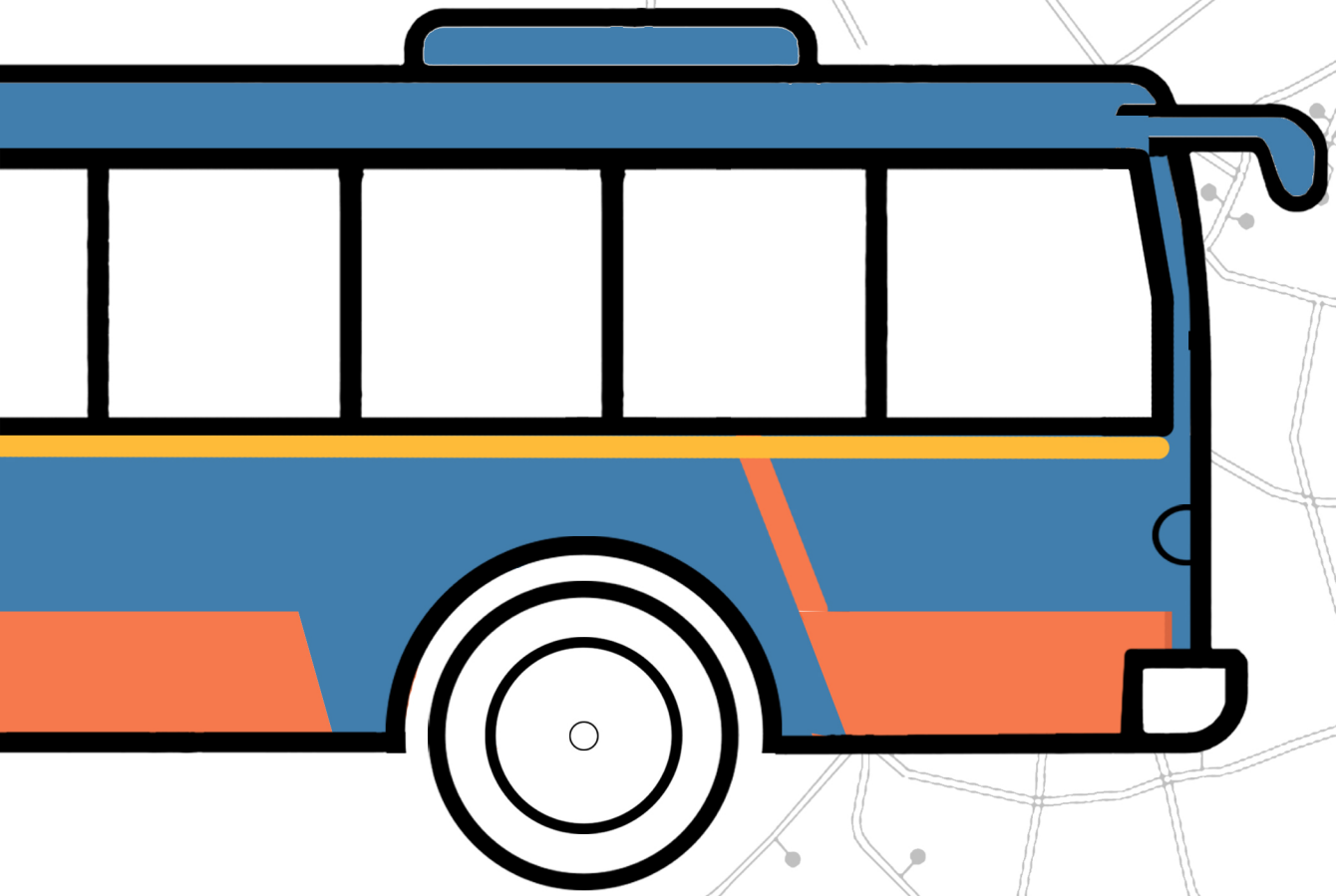
Ministry of Housing and Urban Affairs
Government of India



MAKING WAY FOR BUSES

Guidance for Bus Priority Measures in Indian cities

german cooperation
DEUTSCHE ZUSAMMENARBEIT

Published by
giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Green Urban Mobility Partnership

SUM-ACA
Sustainable Urban Mobility
Air Quality, Climate Action & Accessibility

CEPT UNIVERSITY

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Green Urban Mobility Partnership

About GUMP

India and Germany have been partners for over six decades in making urban development projects environment-friendly. To further deepen this cooperation, in November 2019, the Ministry of Housing & Urban Affairs (MoHUA), the Government of India and the German Federal Ministry for Economic Cooperation and Development (BMZ) signed a Joint Declaration of Intent on Green Urban Mobility Partnership (GUMP). Both countries agreed to collaborate more closely to transform urban transport systems through more efficient, people-centric and low carbon mobility solutions.

BMZ is funding a wide range of sustainable urban mobility infrastructure improvement measures such as city bus transport systems, trams, water transport, cable cars, non-motorised transport, and multimodal integration. In addition, Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ) is providing technical cooperation to enhance the capacities of national, state and local institutions and decision-makers for designing sustainable, inclusive and smart solutions for easy and affordable mobility.

The implementation of this agreement is accompanied by a policy dialogue between the Indian and German sides to achieve effective international contributions to fighting climate change jointly.

About SUM-ACA

Sustainable Urban Mobility - Air quality, Climate action, Accessibility (SUM-ACA) is implemented by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH and the Ministry of Housing and Urban Affairs (MoHUA), commissioned by the German Federal Ministry for Economic Cooperation and Development (BMZ). The project objective is to enable national, state and municipal institutions to promote climate and environmentally friendly, low emission and socially balanced urban mobility systems. The project is part of the Green Urban Mobility Partnership between Germany and India.

CONTENTS

Source : CoE-UT, 2021

Kerb side bus lanes implemented with service lanes in Bengaluru.
Source : https://www.deccanherald.com/city/bengaluru-infrastructure/bollards-marking-bus-priority-lane-on-outer-ring-road-being-removed-1097438.html

INTRODUCTION

This guidance document is intended to bring into focus the advantages that accrue to a cities' commuters and the public transport agencies, with implementing **"Priority for Buses"** and introduce to the readers the array of measures for such prioritisation feasible in an Indian context.

The **objective** of this easy-to-use guidebook is to:

- Encourage city officials and policymakers to mainstream bus priority into city planning processes.
- Guide city officials and policymakes in taking decisions regarding planning and implemantation of bus priority measures in their cities.

The guidebook has been prepared primarily for cities. The target audience consists of :

1. **Decision makers**
   Leaders & officials of urban local bodies and public transport agencies
2. **Practitioners**
   Transport experts who will plan & implement the bus priority measures

The bus transport must essentially be the bedrock of any city's urban mobility system.

50 people in **1 Bus vs 40 Cars**

Space efficiency with respect to private mode

Key features of bus transport

- Connects all parts of the city
- Acts as a feeder to rapid transit
- Affordable mode for urban residents
- Sustainable mode of travel

CHAPTER ONE

NEED FOR PRIORITISING BUSES IN INDIAN CITIES

Challenges in bus operations in Indian cities

Private vehicles in Indian cities are increasing at an exponential rate, which is leading to high congestion levels. Traffic speeds, and in turn, the speed of buses are decreasing every year with the increasing congestion. This resulting in increasing travel times for passengers. The delays affect the reliability of the bus service and result in the reduction of public transport mode share. Based on the estimates, Bengaluru could have potentially saved 215 tonnes of CO_2 in 6 years if there was no decline in ridership.

	Private vehicle growth from 2012-18 (6 years)	Bus speeds reduction from 2012-18 (6 years)	Additional time spent in bus travel per passenger per year (hours)	Annual Economic Loss of passengers during 2018 (Cr. INR per year)
DELHI	50%	13 to 12.5 kmph	11 hours	INR 368 Cr.
MUMBAI	50%	13 to 10.5 kmph	42 hours	INR 559 Cr.
BENGALURU	48%	15 to 13 kmph	59 hours	INR 3,153 Cr.
CHENNAI	28%	20 to 17 kmph	26 hours	INR 833 Cr.
		Average bus speeds has been calculated from average Vehicle Utilisation for year 2012-13 and 2018-19 CIRT reports. Average steering hours is assumed as 13 hours in a day.	Additional travel time estimated based on difference in travel speed (2013 to 2019- based on reduction in VU) and the same has been converted into hours per annum per person	Annual economic loss of passengers is calculcated with value of additional time spent on travelling, which is based on per capita income (2018) of respective cities and 8 hours of working time in a day

Impact on bus operations

Lowering of bus speed has led to significant reduction in vehicle utilization from 2012 to 2018. Reduced vehicle utilization implies that bus agencies/operators have to deploy additional buses to cater to the gap in supply due to reduced speeds. This results in additional costs in the form of capital costs as well as operational costs. Below table illustrates impact of bus operations across four cities.

	Impact on vehicle utilisation (% reduction in daily vehicle-km) from 2012-2018	Estimated buses to maintain the same vehicle km as 2012	Approx capital investment (to buy additional buses) due to reduction in speed and vehicle utilisation (Cr.–INR)	Approximate additional annual manpower cost for operating additional buses (Cr. – INR)
	VU 2012 to VU 2018			
DELHI	170 to 163	158	110	67
MUMBAI	171 to 139	603	422	258
BENGALURU	201 to 170	1006	704	216
CHENNAI	263 to 231	448	313	165

There is reduction in Vehicle Utilisation from 2012-13 to 2018-19 as per CIRT reports. It has been assumed that this reduction is predominantly (not only) because of reduction in speed of buses in the city. Therefore there is an additional requirement of buses to match the desired supply of vehicle km.

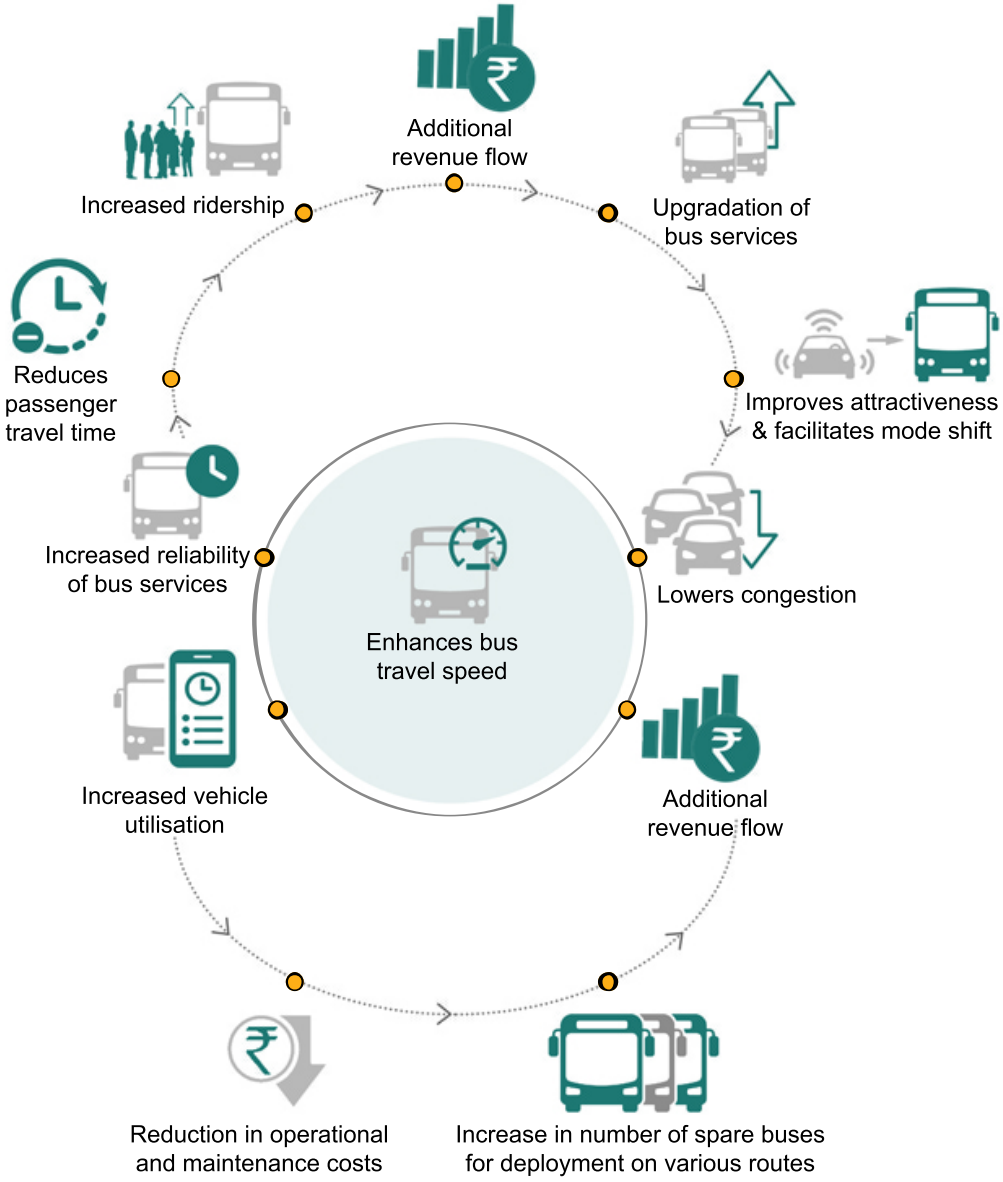
Average personnel cost per bus is computed from CIRT report for year 2018-19 which has been estimated for additional buses required annually.

PRIORITISING BUSES

The challenges faced by buses due to low speeds can be addressed by implementing bus priority measures. **Bus priority measures can be defined as a set of strategies for improving bus speeds leading to better efficiencies, improved bus services, and reduced costs.**

Pioritising buses in Ahmedabad and Hubli Dharwad through Bus Rapid Trasit Systems (BRTS), which is the highest level of bus priority, has increased the speeds of buses to 24 km/hr and 35 km/hr respectively.

How will bus priority help in improving bus services in Indian cities?



CHAPTER TWO

TYPES OF BUS PRIORITY MEASURES

What are the delays faced by buses?

There are three types of delays faced by buses:

1

Delays at the bus stops

Time taken by passengers for boarding and alighting at bus stops and the time taken by the bus to merge in and out of the main lane while accessing bus stops.

2

Delays at junctions

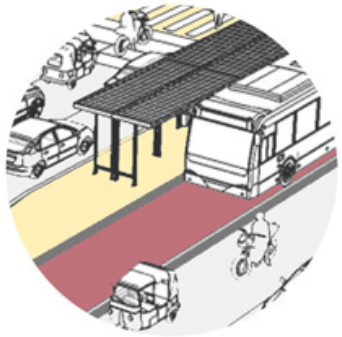
Buses waiting for green signals at junctions (signal delay) and waiting behind mixed traffic to clear the junction (signal queue delay.)

3

Delays due to mixed traffic in lanes

Reduced speeds as buses share lanes with mixed traffic restricting their free flows and time taken to merge in and out of lanes to access bus stops.

Bus priority measures can be classified into three main categories based on the delay targeted to reduce.



1

Bus stop priorities

Reduce delays at bus stops by facilitating median lane movement of buses, level-boarding and alighting, rationalising the number of bus stops, and facilitating off-board ticketing.

2

Junction priorities

Reduce delays at junctions by providing dedicated queuing space for buses and by altering traffic signals to facilitate priority movement of buses.

3

Bus lane priorities

Improve the speed of buses along the roads/ street by giving them dedicated road space by reserving road lanes for buses.

What are the types of bus priority measures?

Various bus priority measures can be adopted to reduce the delay on the target areas.

Types of bus priority measures:

A. Bus stop priorities

- **A-1** Median bus stops
- **A-2** Bus stop rationalization
- **A-3** Level boarding

B. Junction priorities

- **B-1** Queue jumper
- **B-2** Bus signal priority

C. Bus lane priorities

- **C-1** Bus Only Street
- **C-2** Bus Lane

A. BUS STOP PRIORITIES

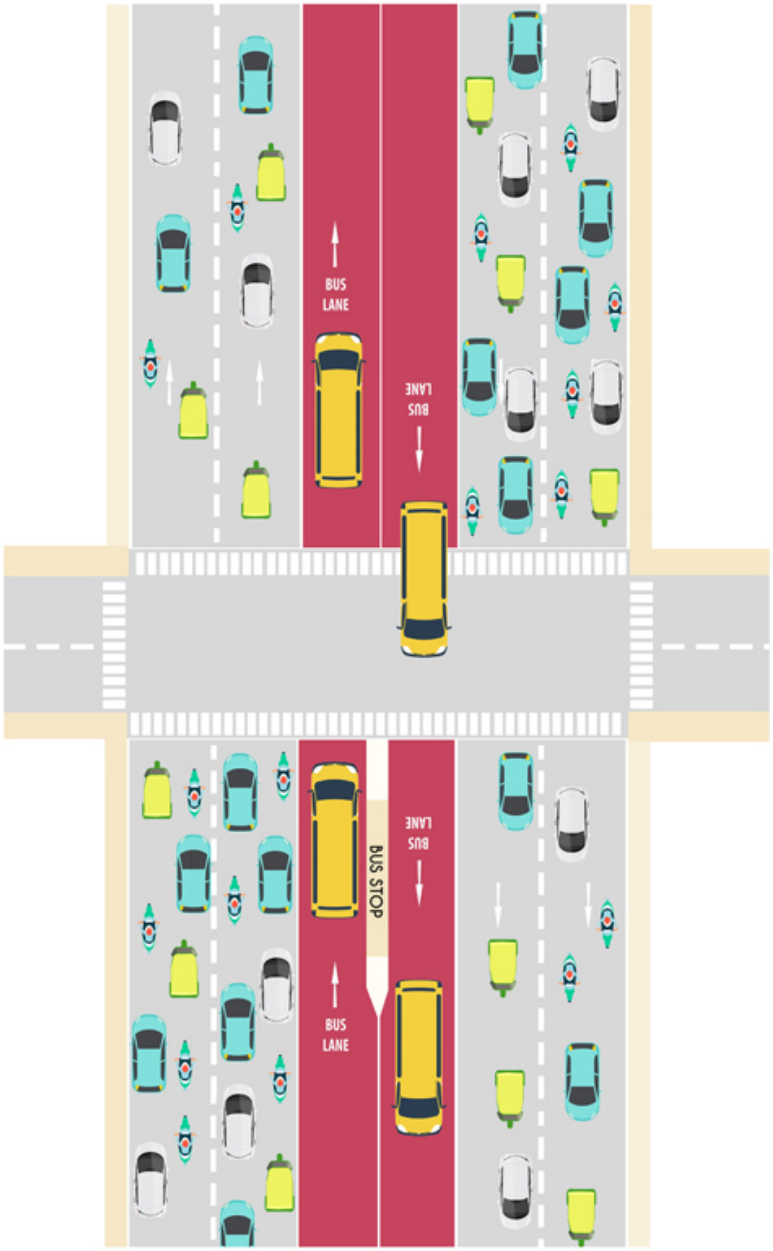
A-1. Median bus stops

Bus stops are located along the median to enable buses to ply along the median lanes and eliminate the need to weave in and out of traffic to access kerb side bus stops.

- Requires adequate RoW at the bus stop locations.
- Single median bus stop or staggered median bus stop to accommodate buses with a right-hand side door opening.
- Staggered median bus stop (with design variations) to accommodate buses with a left-hand side door opening.
- Appropriate buses with multiple wide doors and matching floor height to the median bus stop floor height to faciliate easy boarding and alighting.
- Bus stop design should accommodate for easy passenger flows in and out of the bus stop and allocate sufficient space for waiting area.

Single median bus stops can be used where RoW is wider than 24 m, so that there is enough space to accommodate dedicated bus only-lanes, footpath and two-lane mixed traffic carriageway on either side of the bus station. Staggered median bus stops can be used where RoW is less than 24 m but greater than 19.5 m.

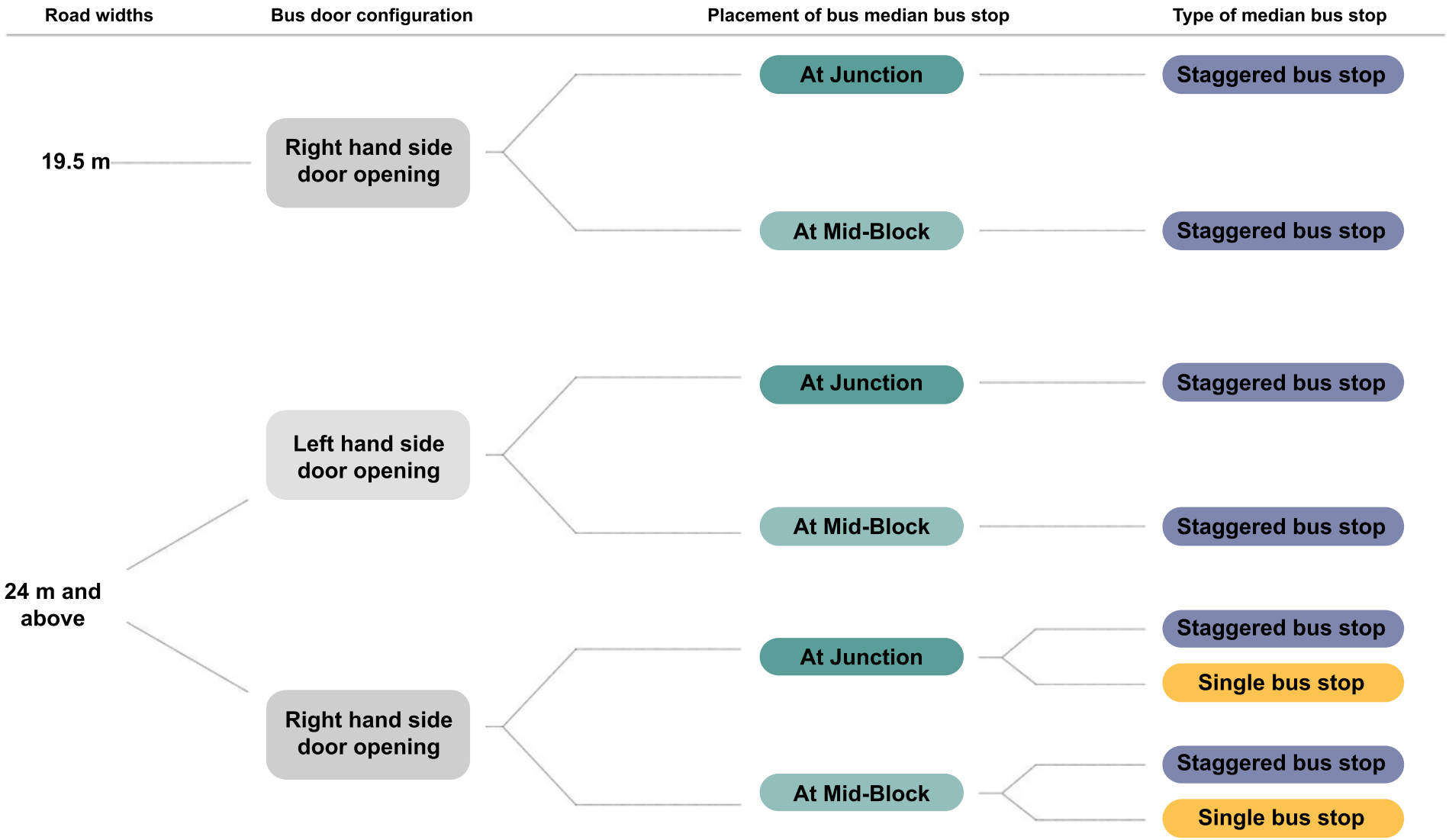
Single Median Bus Stop (Ahmedabad BRTS)
Source: Planning, design and development tof BRT by CRDF



Single median bus stop at Junction

Types of bus priority measures

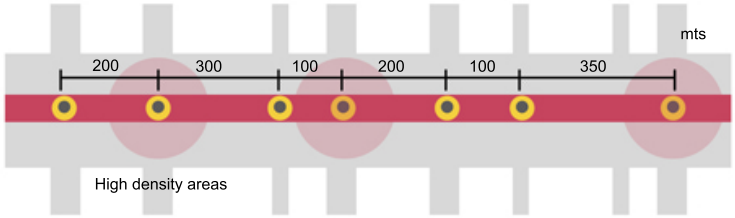
The flow chart below illustrates the various possible types of mid-block and junction bus stations based on road widths and bus door configuration. The detailed design drawings of following types òf median bus stops are given in Annexure A.



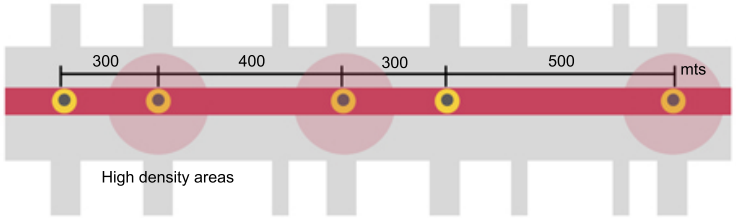
A-2. Bus stop rationalisation

Reducing the number of bus stops which in turn reduces delays associated with entry/exit at the stop and stoppage time.

- Bus stops that are closely spaced or underutilised can be relocated or eliminated based on passenger demand.
- Bus stops with poor passenger access due to inadequate bus stop infrastructure or delays in bus time should be considered. The rationalisation of bus stops is significantly impacted by factors like the land use around and the distance to the next bus stop. Passenger access should be planned to minimise walking distance.
- The ideal spacing between bus stop maybe considered to be 300 - 500 m apart depending on site considerations.
- While rationalisation, one may also consider to locate the bus stop at junction or mid-block. Locating at mid-block may resolve issues of queueing at junction and pedestrian crossing.



Before bus stop rationalisation : Closely spaced bus stops



After bus stop rationalisation : Minimum Bus stops at planned intervals

A-3. Level boarding

This helps to remove the step-down distance and gap between vehicle floor and bus stop platform enabling universal accessibility, easier and faster passenger boarding and alighting, leading to reduction in bus stoppage time.

- Bus boarding platforms can be raised or lowered to match bus floor height.
- Driver training is required to train drivers to dock buses properly to reduce the gap between a vehicle floor and stop platform.
- Procure buses with sufficient number of wide doors and matching the floor height to the floor height of bus stop to facilitate easy boarding and alighting.

Level boarding at Bus stop

Source : Transit Street Design Guide

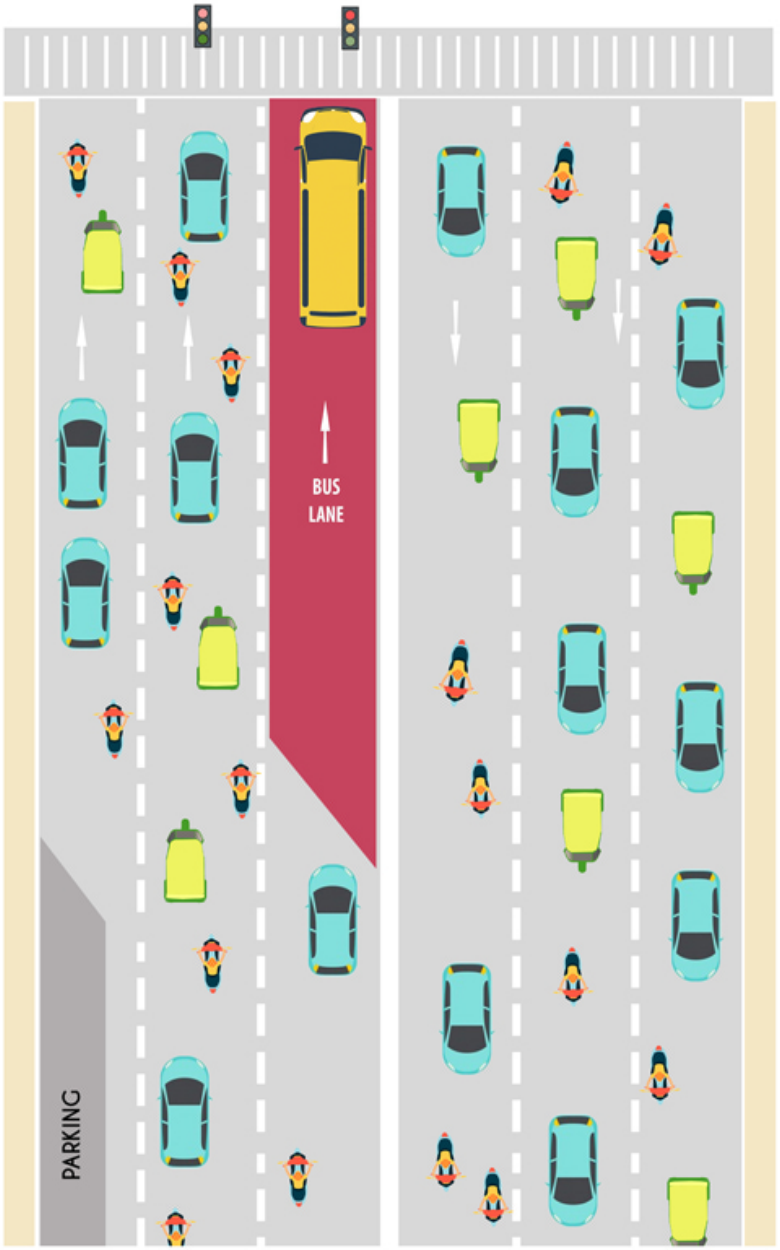
B. JUNCTION PRIORITIES

B-1. Queue jumper

These are dedicated lanes that separate buses from mixed traffic at junctions and allow them to come to the front of the queue. This provides preferential treatment to buses and help them move ahead mixed traffic.

- Queue jumper with bus signal priority can be introduced at junctions where buses are being held up in mixed traffic and face long delays.
- Restrictions on the right turn or mixed traffic lane may be required through bus signal priority.
- To ensure exclusive use of Queue jumper, signage and road markings are required along with strict enforcement.

Ahmedabad BRTS creating an example for Queue jumper
Source : Planning, design and development of BRT by CRDF



Queue jumper at junction

B-2. Bus signal priority

Bus signal priority is used to reduce delay for buses at junctions by providing bus only signal. This is done typically by extending green time to promote the uninterrupted flow of buses.

- Implemented at junctions, where long traffic signal cycles are the major source of delay.
- Should be paired with queue jumper for maximum benefit.

Transit signal priority can be divided as:

I Passive transit signal priority

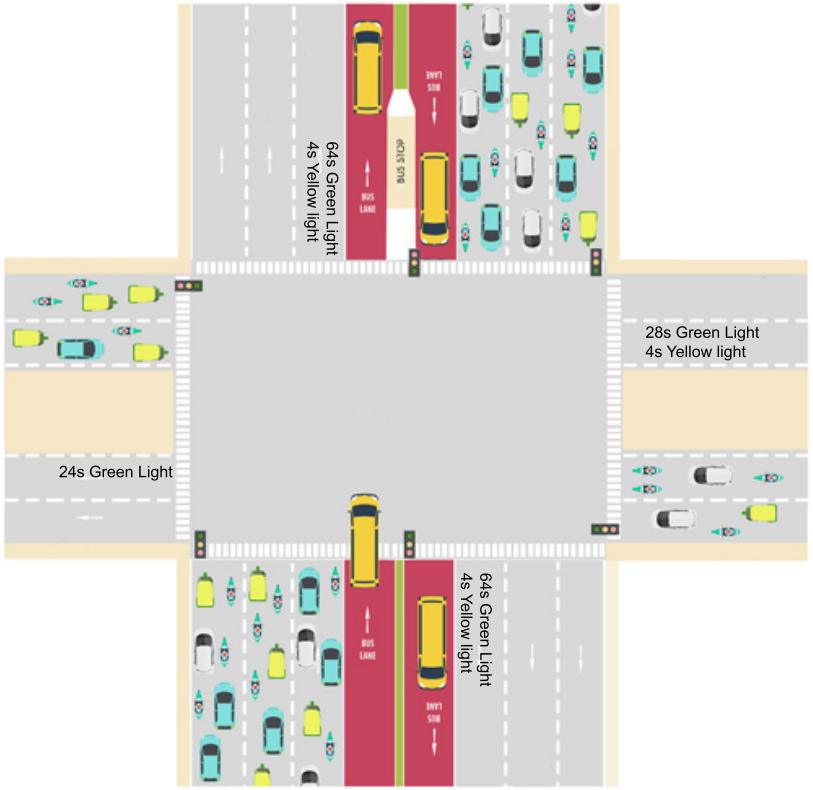
II Active transit signal priority

BRT Signal Priority in Ahmedabad

I Passive Transit Signal Priority

The passive transit signal priority, traffic signal timings are pre-programmed to give priority to buses, ensuring buses to proceed without any interference from general traffic.

- In Ahmedabad, 89 passive bus signal were installed at junctions during its implementation along BRT corridor and it provides green signal for buses after every two phases which reduces wait time by 50%.
- Such signals can be provided for junctions with frequency of bus from 2 to 5 minutes.

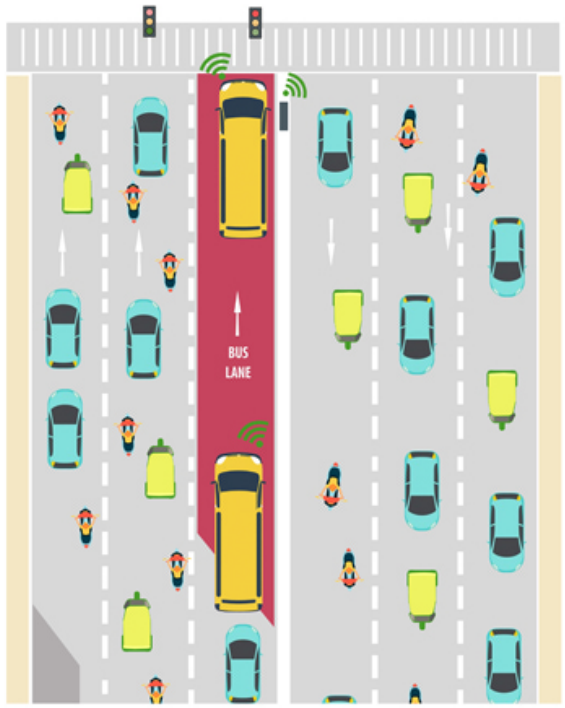


Bus Signals at major junctions along BRT corridor, Ahmedabad

B-2. Bus signal priority

II Active transit signal priority

Junctions with active signals for buses provide green phase as it approaches the intersection with the use of bus detection system and signal controller that are integrated with traffic management system.



Active Transit Signal combined with Queue Jumper

- The bus detection system communicates to signal controller to modify and optimize the running signal cycle to turn green when the buses approaches the junction.
- Junctions with frequency of bus more than 5 minutes shall be equipped with vehicle actuated signals for enabling reduction in travel time.

Various type of Active Signal Phasing technologies are:

Green Extension:

Green phase is extended when the buses approach the intersection.

Early Green Phase:

Signal turns green earlier than normal when a bus approaches the signal.

Source : Transit Street Design Guide, National Association of City Transport Officials

Phase Rotation

The sequence of signals are shuffled for prioritizing buses. But, this create confusion in general traffic.

Fully Actuated Signal

There are no fixed cycle lengths, instead, these phases are called only if a transit vehicle is present.

Implementation of active signal priority requires calibration of the signal according to local factors such as the frequency of buses and the traffic conditions. Some cases of granting priority in Active Signal are:

- In Barcelona, requests are granted only when traffic conditions are good.
- In Dublin, priority is given to only those buses which are running late.
- In London, second bus priority is provided only after the traffic normalises.

Many cities have observed that too many priority requests at peak hour makes it difficult for the system to assess which request should get priority over other.

Source : Identificationand Management of Bus Priority Schemes, Imperial College of London

C. BUS LANE PRIORITIES

C-1. Bus Lane

Exclusive lanes are reserved for buses on the road, while the rest of the lanes are used by mixed traffic. Benefits of the bus lanes are higher when implemented on corridors with high frequency bus services and facing congestions.

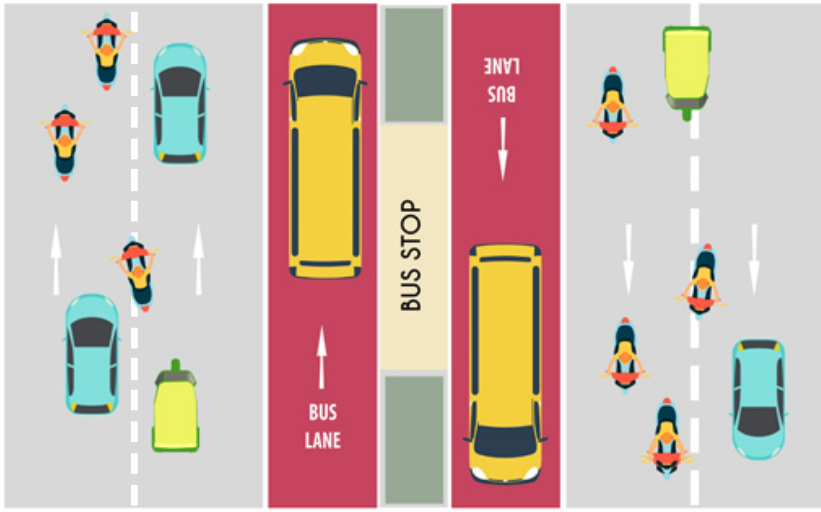
- Bus lanes may be located along the median or kerb side of the road and bus stops placed where appropriate on a network.
- Median or kerb side lane can be planned depending on the road network and RoW having service lane facilities.
- Lanes may be used by emergency vehicles such as ambulances, fire engines, etc.
- Bus lanes maybe physically segregated from mixed traffic using bollards, fencing, kerbs, etc.

Bus only lanes can also be implemented as peak-hour lanes where the bus lanes can be used by mixed traffic outside of specified peak hours. This is however not advised in the Indian context due to challenges in enforcement.

Kerb bus lane - The leftmost lane along the kerb is reserved for buses. However, kerb side lanes are affected by property access, on-street parking, left turns, etc. and could be complecated to design queue jumpers and bus pripority signals in Indian context. Hence, kerb bus lanes are not advised in Indian cities. It is only possible in cases where there are service roads where kerb side lanes function smoothly as in case of bus lanes implemented in Bengaluru.

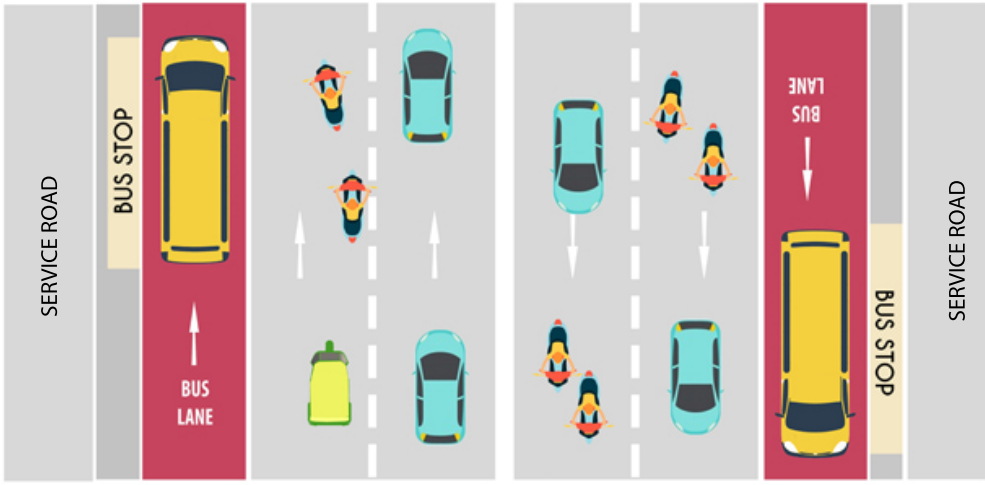
Median bus only lane
Source: Urban Street Design Guide

Kerb bus only lane
Source: https://archive.curbed.com



Median bus lane

Median bus lane - The lane along the median is reserved for buses.



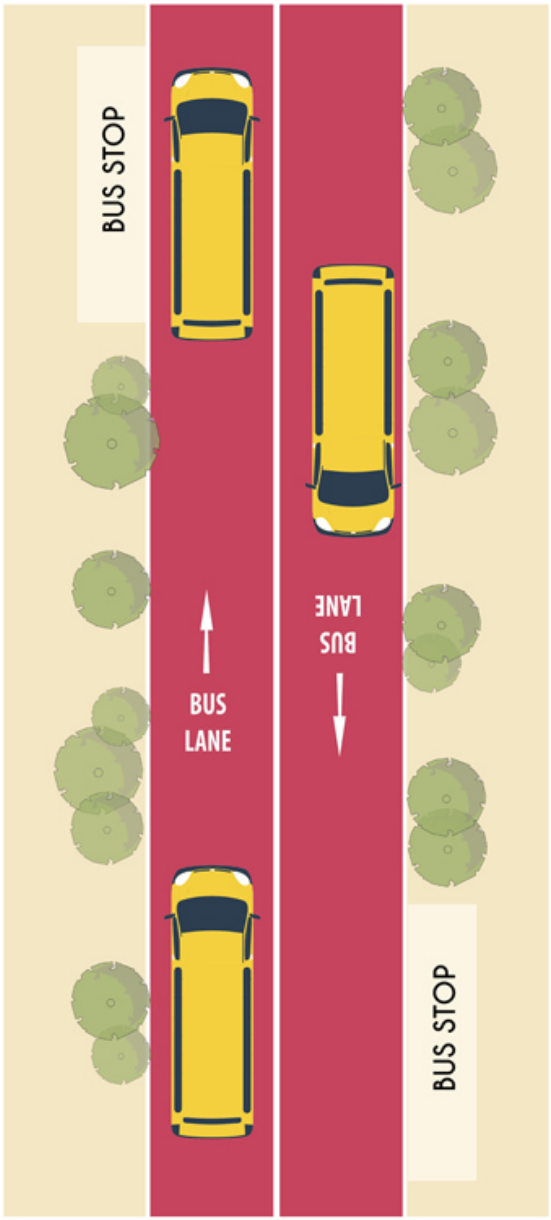
Kerb bus lane

C-2. Bus Only Street

Bus only streets are streets reserved solely for the movement of buses. They are usually allotted on narrow streets with high bus volumes or on a section of road for the bus to take a shorter direct route. It is usually implemented in congested inner or old city areas where other traffic is/can be restricted.

- Existing streets may need to be repurposed. To accommodate a one-way bus roadway and a footpath on both sides, the RoW should be at least 7.1 m.
- Signage for clear indication of entry permit only for bus, time of operations, and an alternate route for other vehicles needed.
- Separate vehicular access from another side may need to be provided for residential and commercial buildings.
- Bus only streets can be considered for short road segments, to reduce inconvenience, where bus frequency is high.
- There should also be an alternate route for mixed traffic to ply when certain roads are converted to bus only streets.

Bus Only Street
Source: https://www.nidirect.gov.uk/articles/bus-lanes-and-bus-only-streets



Bus only street

Bus turning lane & Bus stop

Source:https://londragazete.com/english/205304/the-full-list-of-the-new-24-7-london-bus-lanes/

Bus only lanes – painted red

Source:https://futuretransport-news.com/24-hour-bus-lanes-trial-set-to-become-permanent-in-london/

Bus only lane – separated

Source:https://londragazete.com/english/205304/the-full-list-of-the-new-24-7-london-bus-lanes/

LEARNINGS FROM INTERNATIONAL CASE STUDIES

Bus priority measures have been adopted by various cities across the world proving beneficial in improving bus services. These cities expanded and improved their bus priority measures over the years through a diverse range of policy and design choices.

Few case studies have been illustrated here :

London, United Kingdom

Area - 1,572 km²
Population - 90 lakhs (2021)

London boasts of one of the most comprehensive bus priority systems in the world. London has an unusually decentralized approach to bus lane administration. In order to draw in more people and reach net zero by 2030, Transport for London (TfL) developed a long-term plan for buses in March 2022. TfL's Bus action plan focus on five areas - An inclusive customer experience, safety and security, Faster journeys, Improved connections and decarbonisation and climate resilience.

Measures

29% of bus network has dedicated bus lanes.
25% of bus network has bus priority lanes reserved for 12 hours per day.
54% of bus network has peak hour bus lanes.
30% of traffic signals are equipped with traffic signal priority.
95% of violations are successfully detected by enforcement.

Benefits

7%
rise forecasted in bus demand by 2020/21

i.e 8.3 million in 2013 to 9.4 million in 2023

10 minutes
an average decrease in travel time

Source : IShared-Use Bus Priority Lanes on City Streets: Case Studies in Design and Management, 2012
Deborah Mundy, April 2017
https://www.imperial.ac.uk/media/imperial-college/research-centres-and-groups/centre-for-transport-studies/rtsc/The-Identification-and-Management-of-Bus-Priority-Schemes---RTSC-April-2017_ISBN-978-1-5262-0693-0.pdf
https://nacto.org/docs/usdg/shared_use_bus_priority_lanes_on_city_streets_agrawal.pdf

Bus turning lane & Bus priority box

Bus lanes – for day time

Bus only lane – in Red painted belt

Source - https://www.lta.gov.sg/content/ltagov/en/who_we_are/our_work/public_transport_system/bus/bus_priority_schemes.html

Singapore

Area - 728.6 km²
Population - 59 lakhs (2021)

In Singapore, buses are the major mode of the public transportation system. The catchment areas of the bus network are very extensive with almost 90% of the population living within 300 m of the bus stop. In 2005, Transit Priority Corridors (TPCs) network of 23 km was introduced in the city centre. Currently, a 21.5 km TPC (North-South Corridor from Woodlands to the city) is being developed. It is Singapore's first integrated transport corridor with continuous bus lanes and NMT routes.

Measures

- Kerbside bus lanes and traffic signal priority called B-signals were implemented.
- TPCs are combined with several forms of bus priority measures, such as bus lanes, bus-only roads, and signal priority for buses.
- 332 bus stops equipped with bus priority boxes till March 2016.
- 28.9% dip in bus lane offenses due to strict enforcement in the last six years. Enforcement is done using vehicle detectors, radio antennas and enforcement cameras.

Benefits

62%
decrease in passengers boarding time

Source - https://www.witpress.com/Secure/elibrary/papers/9781853127991/9781853127991007FU1.pdf
http://www.eolss.net/sample-chapters/c14/E1-18-06-04.pdf

Bus Stop with PIS

Designated bus lane

Bus only median lane

Seoul, South Korea

Area - 605.2 km²
Population - 97.6 lakhs (2021)

Seoul has bus priority lane network of about 205 km making it one of the largest in the world. Initially, the city implemented dedicated kerb side lane for buses but experienced bus traffic interruptions by illegal roadside parking, right turning and even mixed traffic using the bus lane. Hence, dedicated median side bus lanes were established in 1996 which has then continuously grown by an average of 15 km per year. These dedicated bus lanes are demarcated by differentiated pavement color, markings and signs and not with fixed physical barriers.

Exclusive median bus lanes are in operation on 12 corridors (134 km).

Measures

- Three types of bus lanes i.e. median lane with bus stops, kerb side peak hour and kerb side daytime lanes are part of the bus priority network.
- Fare collection is done using a smart card.
- Bus priority systems use articulated low floor buses with CNG fuel.

Benefits

4% to 7%
increase in average number of passengers as compared to ridership before implementation of bus priority measures

30%
improvement in average speed of buses from about 15 km/h before the opening of the lanes to about 20 km/h

6X
more passengers on BRT along the median lane as compared to other lanes in the same corridor

Source - Seoul Urban Solutions Agency SUSA, 2017
Shared-Use Bus Priority Lanes on City Streets: Case Studies in Design and Management, 2012
http://susa.or.kr/en/content/brt?ckattempt=1
https://nacto.org/docs/usdg/shared_use_bus_priority_lanes_on_city_streets_agrawal.pdf

Measures	Strategies	Reduce delays at bus stop	Reduce delays at junctions	Reduce delays due to mixed traffic in lanes	Case Cities
Bus priority at bus stations	Level Boarding	✓			Ahmedabad, Surat, Hubli-Dharwad
	Bus stop rationalization (Bus stop spacing/ Rebalancing)	✓			Hubli-Dharwad, Portland
Bus priority at junctions	Queue jumper		✓	✓	Chicago, New York
	Transit Signal Priority (TSP)		✓	✓	Ahmedabad, Hubli-Dharwad, Singapore
Bus Lane Strategies	Bus Only street			✓	New York, Birmingham
	Bus Only Lane (BOL)			✓	Taipei, Washington DC
	a. Kerb side bus lane			✓	Bengaluru , Singapore, London
	b. Median side bus lane			✓	Ahmedabad, Surat, Hubli-Dharwad, Indore

CHAPTER THREE

DECISION MAKING FRAMEWORK FOR BUS PRIORITISATION

Cities contemplating bus service improvements are faced with some important questions such as:

- What benefits, is the city likely to achieve with the introduction of bus priority measures?
- How to shortlist the network for implementing bus priority?
- How to identify priority corridors to intervene first?
- What bus priority measures should be considered for implementation?

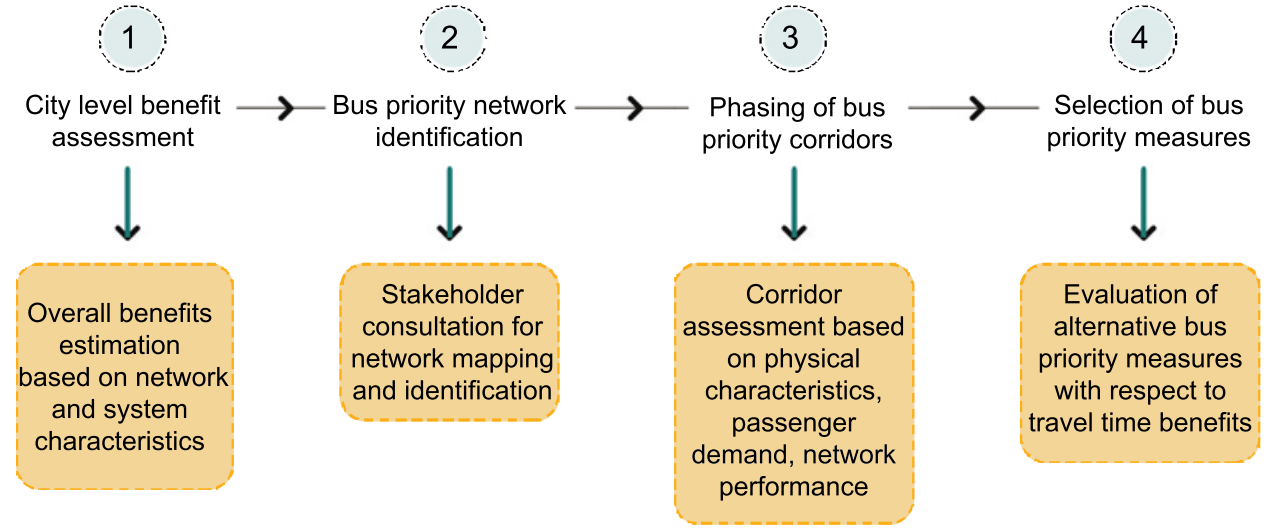
This chapter will elaborate on these major decision areas for implementing bus priority measures.

Cities having bus services or planning to introduce bus transport systems must consider bus priority measures and integral to their system design.

The best time is now!

Benefits of implementing bus priority can be reaped anytime

Planning framework for implementation of bus priority measures through phased approach



What benefits, is the city likely to achieve with the introduction of bus priority measures?

The application of bus priority measures across a public transit network will indicate a significant benefit in terms of operations and for passengers. To help with benefit assessment, under “SUM-ACA” project of GIZ India, has developed a Bus Priority Benefit Estimation Tool to understand the weightage of implementation of measures for the entire bus system.

Link to the tool: https://crdf.org.in/crdf-resources/bus-priority-benefit-estimation-tool

Inputs for benefit estimation

Transit Network Characteristics

- Name of the system
- Network Length
- Length of the network with ROW <=19.5 m
- Count of existing Bus Stops and Junctions
- No. of Bus stops after rationalization
- Fleet Size
- No. of Routes
- Predominant bus and fuel type

Bus Operation Characteristics

- Delay at Bus Stops and Junctions*
- Average Speed of Bus/ Travel Time*
- Average Vehicle Utilization of a bus in a day
- Average Passenger Trip Length
- Revenue per passenger
- Service Hours
- Load Factor

*Values shall be computed through speed and delay assessment by physical survey or based on GPS database across various bus corridors in the city. The remaining inputs shall be provided in consultation with the public transport agency/ operator.

Selection of Bus Priority Measures

The following are the strategies included in the tool to take decisions on effective bus priority measures for the network and corridor.

1. **Bus Stop Rationalization**
   Rationalisation of the bus stops or reducing the number of bus stops will result in lesser stoppages, hence reducing the travel time.

2. **Improvement of Signalized Junction with queue jumper and signal priority**
   Consideration of transit approach lane with the re-purposing of signal phasing for high frequency bus service and vehicle actuated signaling for low frequency service can show reduction in delay at signalized junctions.

3. **Shifting Bus Stops to Median**
   Median bus stops can be accommodated on corridors with RoW greater than or equal to 19.5 m. The median bus stops can be paired with level boarding shall result in a reduction in delays at bus stops.

4. **Reservation of Median Lane exclusively for Bus**
   Reservation of median traffic lanes only for buses will ensure smooth operation of high-frequency service along congested roads with improvement in running time.
   *Generally, 5-7 minutes headways are applied to high frequency services in urban areas.

City level benefit assessment - A case of Ahmedabad

Based on the input data, the tool illustrates the operational and passenger benefits with respect to various bus priority measures. The table below showcases the impact of bus priority measures over the transit network in Ahmedabad.

Input on System Characteristics

Network Length (km)	780
Length of the network with <=19.5 m width	289
No. of Bus Stops	2401
No. of bus stops after rationalisation	982
No. of signalised junctions	261
No. of un-signalised junctions	350
Avg. Speed of the Bus (kmph)	17
Fleet Size	870
Avg. Vehicle Utilization in km	180
Predominant bus type	Midi CNG
Revenue/ Passenger	12
Service Hours	18
Load Factor	0.6

	Strategies				Operational Benefits			Passenger Benefit
	Bus Stop Rationalisation	Improvement of Signalised Junction	Shifting Bus Stops to the Median	Reservation of Lane for Bus	Avg. Vehicle Utilisation	Ridership (In thousands)	Avg. Cost per km	Average Travel Speed in km/hr.
Current Scenario	Without Bus Priority Measures				180	445	62.8	16
Scenario 1	●				198	488	59.4	17.6
Scenario 2		●			186	461	61.5	16.6
Scenario 3			●	●	194	479	60.1	17.2
Scenario 4	●	●	●	●	223	551	55.2	19.8

How to identify priority corridors to intervene first?

What are the parameters used for phasing of corridors?

Decision on phasing is important during implementation. Potential corridors offering the highest benefit should be implemented first to have larger visibility of benefits. A pre-condition to implementing bus priority measures is that the corridor width should be atleast 19.5 m.

Corridors can be identified using the following parameters:

1. **Length of the corridor – km**
2. **Percentage of the length of the corridor with bus flows (buses/ peak hour) >=12 buses/ hr**
3. **Passenger boarding/ km/ day**
4. **Existing bus speed on the corridor – kmph**

I. LENGTH OF THE CORRIDOR

Length of the corridor in km

- A corridor must be of sufficient length for implementing bus lanes so that buses can ply smoothly for longer distances. Longer corridors should be prioritised for implementation of bus priority lanes.

Data Source

- Road maps with RoW available with the city administration.
- Can also be calculated from the Google Earth application. In some cases, width constraints for short sections may exist, and the decision on the type of priority measures would need to be taken accordingly.

II. PERCENTAGE OF THE LENGTH OF THE CORRIDOR WITH BUS FLOWS

Number of buses per route per hour

- Bus flows are the number of buses moving in a particular corridor/road in unit time (hour). Corridors with bus flow greater than or equal to 12 buses per hour must be identified as high-frequency bus flow for the predominate road segment.
- Corridors with the highest bus flows and meeting road width requirements (should be considered in the first phase so that the benefits of bus priority can be reaped by the maximum number of buses and passengers using them.

Data Source

- Inputs from bus agency on high concentration of bus services.
- Bus frequency/bus schedule data available with bus agency/operator indicating number of buses operating on a particular route per hour, may also be overlaid on the road network using GIS.
- Alternatively, rapid assesment through bus counts on major corridors could be undertaken.

III. PASSENGER BOARDING

Passenger boardings per kilometer per day for a corridor/route

- Passenger throughput is the number of people moving through the corridor.
- Corridors with high passenger throughput should be selected as priority area as this will benefit maximum passengers and reduce their travel time.
- Similarly, bus stops with high number of boarding and alighting may be selected as priority area for implementing bus stop priority measures.

Data Source

- Electronic ticketing machine (ETM) data available with bus agency/operator.
- Ridership can be estimated by collecting data on number of passengers on bus priority routes from bus operators. Electronic ticketing machine data can also be used to obtain statistics on passengers including ridership.

IV. EXISTING BUS SPEED ON THE CORRIDOR

Existing speed on corridor in kilometer per hour

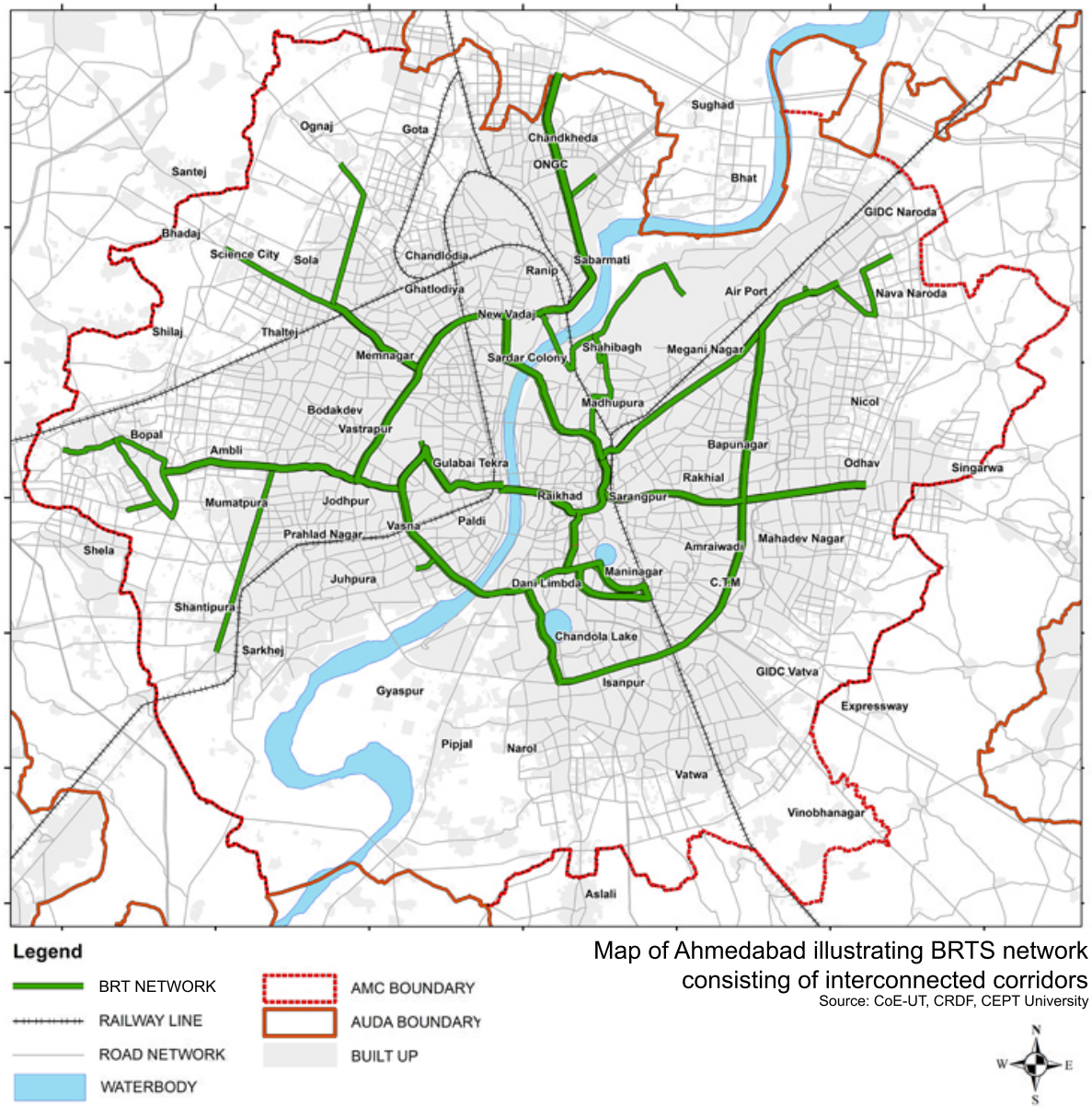
- Corridors with low bus speeds may be prioritised for implementation of bus priority measures. This will help reduce passenger travel time and improve oparational efficiency.
- Traffic junctions with long signal phases where buses face long delays should also be prioritised over other junctions as this affects bus speeds.

Data Source

- Google Map may provide indication of low speed or congestion affected corridors. However, bus speed would have to be computed.
- Automatic Vehicle Location System (AVLS) data of observed run times between any two locations (stop pairs, time points, or route endpoints) to calculate travel times and speed.
- By conducting speed and delay surveys to measure time (including delays) taken to complete a trip on board (an average of 5 trips on the same route can be surveyed) and understand the delay faced at bus stop, junctions and segment lanes and cause of the delay.

How to shortlist the corridors/ network for implementing bus priority?

The city may carry out a stakeholder consultation process to identify and select major corridors in the city for implementation of bus priority measures. The identified corridors should form a connected network as to reap maximum benefits. The implementation of the identified bus priority network can be carried out in a phased manner.



Map of Ahmedabad illustrating BRTS network consisting of interconnected corridors

Source: CoE-UT, CRDF, CEPT University

Decision on Phasing of Corridor

A simple scoring method has been developed to prioritise corridors for bus prioritization based on length of corridor, existing bus speed on corridor, bus flows and passenger boardings. This will help in arriving at relative scores for different corridors which can be used to prioritize and phase identified bus priority corridors.

Four corridors from the city of Ahmedabad have been assessed for phasing below as an example. A city can choose its own levels and scoring methodology.

Levels for scoring (Lower the levels – higher the potential for Phase I)	Parameters				Weightage (%)	Score
	1. Length of the corridor - km	2. Existing bus speed on the corridor – kmph	3. Percentage of the length of the corridor with bus flows (buses/ peak hour) >=12 buses/ hr	4. Passenger boarding/ km/ day *(Total boardings on all the stops on a corridor/ corridor length)*		
Level 1	> 10	< 12	100%	> 1500	100%	25.0
Level 2	8 - 10	12 - 15	80 - 100%	1000 - 1500	75%	18.8
Level 3	5 - 8	15 - 18	60 - 80%	500 - 1000	50%	12.5
Level 4	< 5	> 18	< 60%	< 500	25%	6.3

The table below presents the scoring for four shortlisted corridors/networks identified through stakeholder consultation. Based on the scoring methodology, Corridor 2 (C2) and Corridor 4 (C4) ranks 1st and 2nd. C2 and C4 can be selected for Phase I implementation.

Corridor No.	1	2	3	4
Corridor Name	**C1 Nutan Mill Road**	**C2 Ashram Road**	**C3 Sola Road**	**C4 Satellite Road**
Length of the corridor - km	5-8	8-10	5-8	8-10
Speed - kmph	15-18	12-15	15-18	12-15
Length of the corridor with bus flows >= 12 buses/hr. (%)	60-80%	100%	80-100%	60-80%
Boardings/kmday	500-1000	1000-1500	500-1000	500-1000
Total Score	**50.0**	**81.3**	**56.3**	**62.5**

What bus priority measures should be considered for implementation?

Once the corridor is selected, the public transit agency needs to identify suitable bus priority measures for implementation. The following parameters may be considered for identifying the measure:

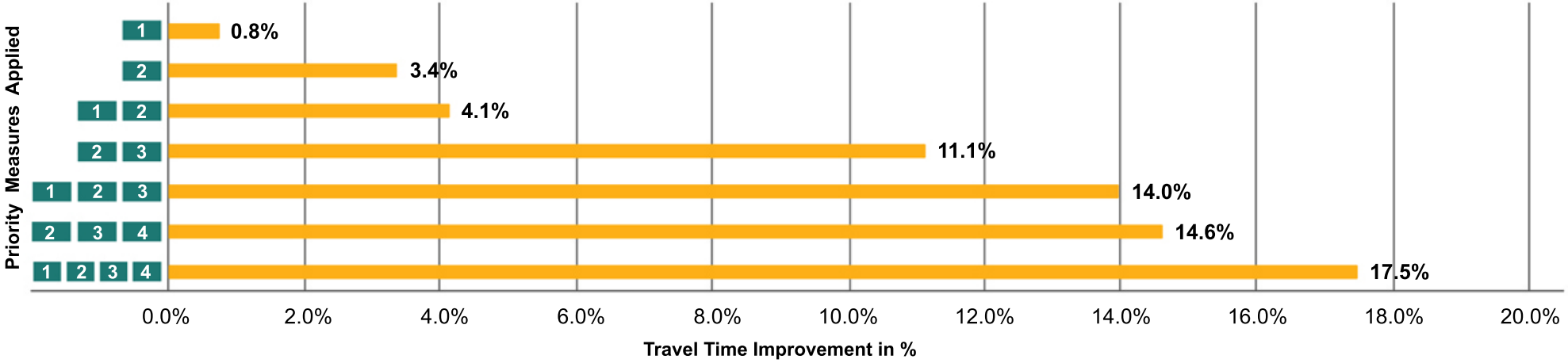
Location of maximum delays	Estimated travel time improvement using bus priority measure	Cost of implementation

Speed profiling of the corridor is suggested to be undertaken to understand delays occurring at bus stops, junctions and segment lanes. The speed delay survey will indicate the locations and the cause of the delay. For high delays at bus stops, measures such as bus stop rationalization, level boarding and alighting and median bus stops may be examined. Junctions with high delays can be identified and treated with queue jumper or signal priority to improve the travel time.

Key bus priority measures

1. **Bus stop rationalization**
2. **Improvement of signalised junction with queue jumpers and signal priority**
3. **Shifting bus stops to median**
4. **Reservation of median lane exclusively for bus**

A combination of measures may also be examined to improve the travel speeds. The tool also provides an indicative travel time savings that various measures can generate on a particular corridor. The below graph illustrates the improvements with various bus priority measures can take place for a corridor of 6.5 km length in Ahmedabad that comprises of 10 bus stops, 2 signalized and 5 unsignalized junctions, and operates 20 midi CNG buses for 18 hours with load factor of 0.49.



Decision regarding priority measure can be taken by comparing the operation and passenger benefits. Feasibility in implementation of BPM measures has to be looked upon with the ground condition of road and develop detailed design that was based on survey such as topographic survey, traffic movement at junctions, etc.

Investment Required for Implementation of Bus Priority Measures

Implementing bus priority measures would require certain investment and this section looks at per km cost for various design options. The following assumptions have been considered to arrive at cost estimates for the year 2021:

- Lanes next to the bus station are constructed as rigid pavement.
- Footpaths are newly developed as per cross section with 60mm thick paver blocks.
- Kerbs are added for queue jumpers and to segregate bus lane from other traffic in certain templates.
- The existing carriageway is retained with a profile correction and a bituminous concrete (BC) layer of 25mm on top.
- Parking surface is constructed with 80mm thick paver blocks.
- The bus station cost includes civil construction cost plus electrical costs.
- An open junction is assumed at every 500m. A contingency of 5% is added to the overall cost.

The costs per km for various road with configurations are given in the table below:

ROAD WIDTH CONFIGURATION	APPROXIMATE COST PER KM
18m RoW	INR 1.43 Cr
24m RoW	INR 2.18 Cr (for non-staggered bus station option)
24m RoW	INR 2.90 Cr (for staggered bus station option)
30m RoW	INR 3.53 Cr (for staggered bus station option)
30m RoW	INR 3.15 Cr (for non-staggered bus station option)

The public transit agency will also need to assess the implementation costs vis-a-vis the benefits accrued through the measures. While measures such as the bus stop prioritisation, dedicated bus lanes and passive transit signal prioritiy (TSP) system do not cost much, active signal priority is generally very expensive as it involves installation of equipment like controllers, detection devices, communication devices. It also requires upgradation of existing technology on-board and signal controller. As per international standards, the implementation of TSP system costs up to INR 15 lakhs per intersection and its operations/ maintenance cost per year charges up to INR 75,000 for the year 2020.

Source : Transit Technology Implementation Guidelines - Appendix D, Alameda County Transportation Commission, Californinia

CHAPTER FOUR

IMPLEMENTATION STRATEGIES

What are the key implementation strategies that should be taken care of?

Implementation strategies help to work towards achieving the objectives of bus priority schemes and build a comprehensive idea of how the objectives can be achieved based on local context. This helps in the successful implementation of the project. The four main implementation strategies that need to be taken care of for bus priority schemes are:

1. **Stakeholder engagement** that deals with identifying the key stakeholders and their roles and carrying out stakeholder consultations at appropriate stages of the project and the institutional process for implementing the bus priority scheme.

2. **Phase – wise execution** initially with tactical urbanism shall demonstrate the benefits to road users, help to monitor the benefits through temporary changes across right of way or junctions and subsequently carry out permanent construction.

3. **Marketing and outreach program** will provide a general support for the implementation through awareness creation amongst the public, which is highly critical to ensure acceptance of the measures from the start.

4. **Enforcement agency** and effective enforcement strategies to ensure smooth functioning of the bus priority schemes and induce behavioural change among other road users.

5. **Evaluation and monitoring** to continuously track the performance of the scheme, assess whether the project can achieve its set objectives and identify intervention areas.

I. Stakeholder Engagement

Identification of stakeholders and understanding their role in public transport are important for the implementation and efficient operation of bus priority measures in the city. It is vital that the stakeholders need be identified at very early stage with respect to their roles required for the project and consult them from conceptual stage to planning, construction, implementation, and evaluation and monitoring. This shall ensure stakeholder buy in, review of project plans, technical inputs/ comments based on ground reality and incorporation of expertise in the field.

Stages of the Project		Bureaucrats*	Traffic Police	Bus Transit Agency/ Operators	Research Institutes/ Consultant
		Lead Agency	Collaborators		Agency supporting the Lead
Planning	Identifying and shortlisting corridors for prioritization	Acts as a lead agency in planning BPM for the city			Supports the lead authority with studies and recommendations
	Identifying feasible measures				
	Analysing city level benefits				
	Stakeholder consultation and approvals	Stakeholders including city authority, political wing, sector experts from different parts of the country, etc. bring their perspective and contribute insights on plans for implementation of BPM. Collaborators can make informed decision and adjustments during implementation phase by communicating the necessary steps to be considered.			
Construction & Implementation	Preparation of detailed design & cost estimates	Provides inputs on corridor development to maximize the benefits of BPM			Develops designs to ensure BPM integrates well with existing road & traffic flow
	Implementation of Bus Priority Measures	Collaborate with contractor throughout the process to ensure that construction is in line with agreed plans	Educate officers on the specific regulations and the importance of enforcing them	Train staff to utilize bus lanes and take advantage of transit signal priority to ensure efficient operations	Supports the lead authority to ensure that execution of plans are in-line, and associates with collaborators in training program
	Regulation and Enforcement	Defines rules and regulations for the priority system	Ensure enforcement and monitors priority areas to prevent violations		
	Branding and Marketing	Creates a brand identity and to market the benefits of BPM in alignment with public preferences			Advises lead agency on branding strategies, marketing campaigns and public engagement
Evaluation & Monitoring	Documentation and Recording User Response	Takes decision on areas for improvement or adjustment	Provides supporting data on effectiveness of enforcement	Provides supporting data on bus operational performance	Supports lead agency in evaluation of the effectiveness of BPM and provides necessary recommendation

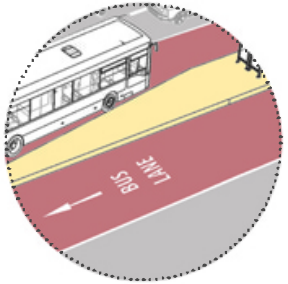
*Bureaucrats include Municipal Corporation and Metropolitan Transport Authority

II. Tactical Measures and Construction

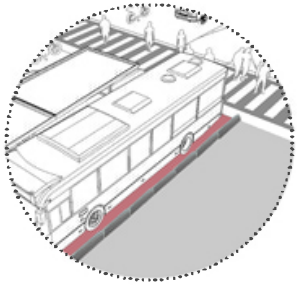
Bus Lanes can be demarcated by employing special surface treatment along the lane and at junctions. This will make bus lane to be more visible for bus drivers as well as other road users and help traffic police to identify encroachments.

The corridor identified for Phase 1 implementation can be treated differently through tactical measures. The performance of implementation can be monitored and assessed in comparison to the benefits evaluated in Bus Priority Benefit Estimation Tool. Further, proceed on infrastructure changes with permanent construction.

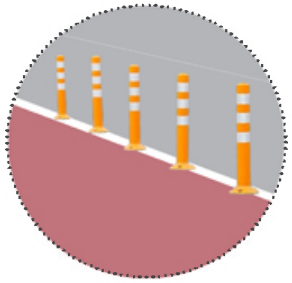
Permanent tools to replace tactical measures:

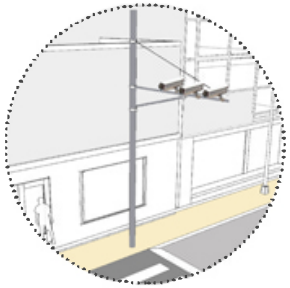


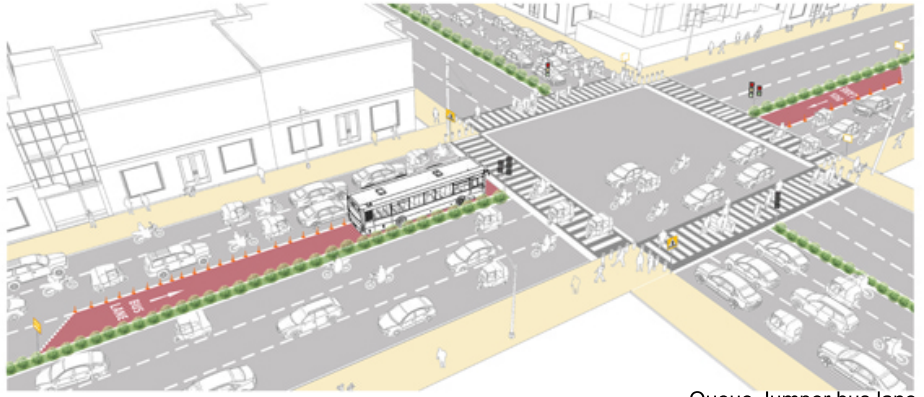
Line Marking

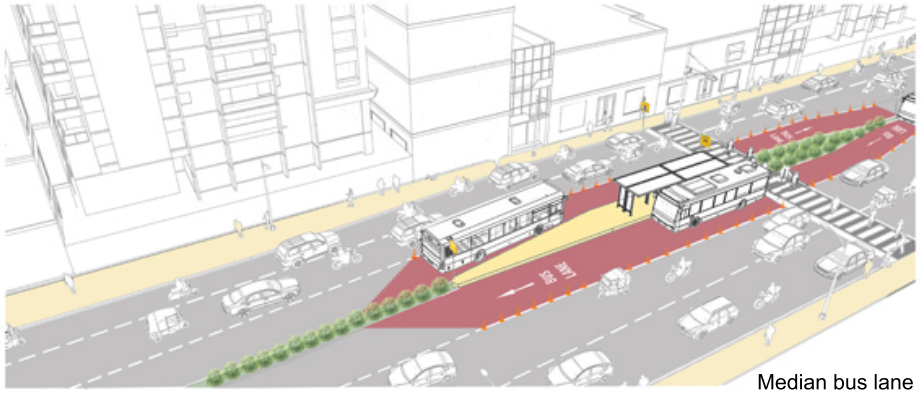

Kerbs to segregate Bus lane

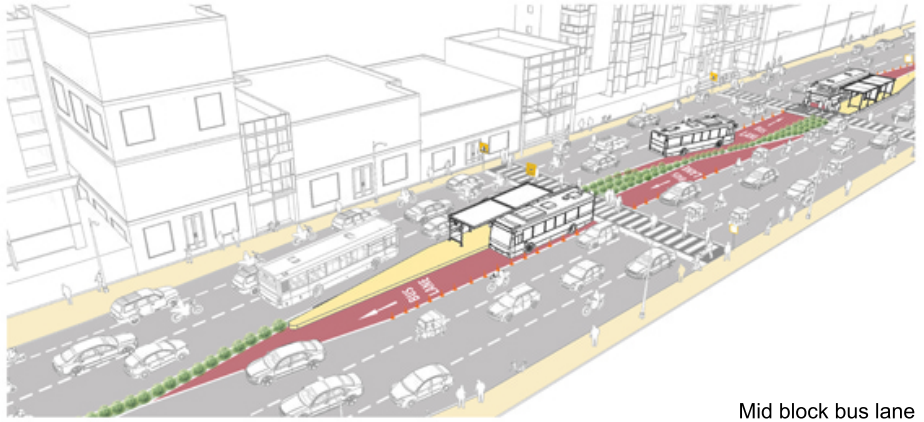

Permanent Sinage


Bollards


Security Cameras


Queue Jumper bus lane


Median bus lane


Mid block bus lane

III. Marketing and outreach programs

Marketing and outreach programs are the important tools with which the Urban Local Bodies (ULB), public transport agencies and traffic police can effectively reach out to the public who use and benefit from the bus priority measures. Without such programs, the bus priority measures can result in unpopularity due to ignorance or fear of the new system. Marketing and outreach programs can be conducted by carrying out the following:

1. Develop a strong **brand identity** for the bus priority scheme with a help of project name, logo and a tag line.

2. Conduct **marketing and awareness campaigns** with the primary focus of reaching out to the public regarding the new system.

   - Educate the public on bus priority corridors, new routes, improved frequencies/schedules, median lanes, median bus stations, benefits, etc.
   - Conduct separate user education programs to instruct existing passengers about the changes in the bus system.
   - Inform potential passengers who are currently using private vehicles regarding higher speeds of buses and reduced journey times to facilitate mode shift.
   - Attract attention of other road users regarding bus only reserved lanes, transit priority lanes, transit signal priority, etc. and the related penalties and fines for violations.
   - Obtain general support of the public - passengers, other road users and property owners along the corridor.

3. Carry out awareness campaigns before construction stage, so that it prevents confusion and help with smooth project implementation.

4. Make information regarding the bus priority scheme easily available to public through various platforms such as posters, hoardings, pamphlets, social media, websites, radio messages, etc.

IV. Enforcement and management

Continued and strict enforcement measures will induce a behavioural change from all road users, especially the motorists who share road space with buses and the number of violations can go down.

Which are the agencies involved?

In Indian context, the traffic police will be responsible for enforcement of the bus priority measures and provides notification related to rules, fines/ penalties for non-compliance. Manual or technology aid can be used for effective enforcement to reduce violation along bus priority lane and junctions.

What are the various enforcement strategies that may be adopted?

1. Camera on Road

CCTV cameras on road along bus lane, bus stop and queue jumper can be used for surveillance and enforcement

2. On-board CCTV Cameras

Cameras deployed in buses has effectively reduced bus lane violations in Singapore and New York.

3. Automated Number Plate Recognition

The system provides fully automated enforcement and notices/fine are mailed to the violators

4. Visual road Design

Colored pavement highlights the prominence of the transit system

5. Restricting access to bus lanes

Physically segregated (using temporary bollards) bus lanes in Manila

It should be noted that enforcement and management is a constant process in the operations of bus priority schemes/projects. Effective enforcement, high violation detection rates and penalties/fines will induce a behavioural change among road users. This will help in smooth operation of buses along priority lanes and signalised junctions.

V. Performance evaluation and monitoring

Performance evaluation and monitoring of systems/ services is an essential and continuous process. It helps to evaluate the impacts both qualitatively and quantitatively and compare them against the target set during project inception. The city should adopt set of Key Performance Indicators (KPIs)1 which can be measured on regularly to assess the benefits. This will also help to track the progress of the benefits and also identify the issues for not having benefits as desired.

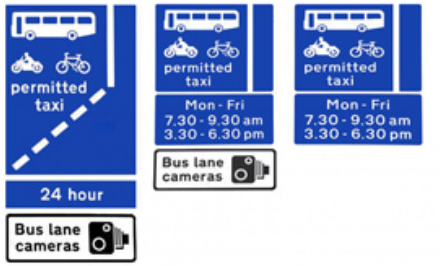
The benefits of bus priority can be classified under public transport users, transit operators, and overall social benefits. The KPIs are also listed below under the same category – it is to be noted that some of these KPIs can be monitored weekly/ monthly, whereas a few of them can be measured annually.

Key Performance Indicators	Units of measurement
Passengers' perspective	
Journey time	Average travel time saving in minutes
Waiting time	Average waiting time savings at bus stop
Comfort	Load factor at bus trip level
Passengers' satisfaction	Overall satisfaction levels of passengers
Operators' perspective	
Increased Vehicle Utilisation (VU)	Average VU on routes on the bus priority corridors
CPKM	Reduction in CPKM
Overall ridership	Daily ridership on corridors
Revenue	Increase in revenue with increased in ridership
Headway regularity at bus stop	Schedule adherence at intermediate bus stops, -5 min to +5 min
Spare buses	Number of spare buses and its redeployment
Accidents	Accidents/ 10,000 bus travel km
Societal perspective	
Mode share	Increased mode share because of increase in ridership
Reduction/ stability in congestion level	Average travel time in minutes of private vehicle along the corridor
Reduction in GHG emission	Tones of CO_2 emission

(1) KPIs are the critical indicators of progress toward an intended result. KPIs provides a focus for strategic and operational improvement, create an analytical basis for decision making and help focus attention on what matters most. (2) Please note that vehicle utilisation is dependent on various parameters such as total fleet size, inefficient scheduling, shortage of driving and/or conducting staff, or road or weather conditions which prevent the operation of some services. A high level of vehicle utilization does not necessarily mean a high degree of efficiency or profitability. Ideally, vehicle utilization should be maximized, with each vehicle spending as much time in revenue-earning service as possible.

VI. How to improve Bus lane visibility?

Improving bus lane visibility is an essential pre-requisite. Bus lanes can be made conspicuous (i.e., more visible and understandable) for bus drivers as well as for other road users through special surface treatment to bus lanes. This will help to demarcate the space allotted especially for buses and help traffic police identify encroachments. Key points to keep in mind while implementing bus lanes to improve conspicuity are given below:



1 **Adequate signages should be provided especially at access points of bus lanes clearly defining restrictions.**

2 **Provide lane markings using white solid lines or using signs of buses painted on the pavement surface.**

3 **Lane text indicating special use of the bus lane may be provided. Text such as "Bus", "Bus only", or eligible vehicles in case of shared lanes or bus lane timings may be specified on the lanes.**

4 **The bus lane surface treatments should be highly visibility to road users and drivers, durable to withstand the bus traffic, safe (with adequate skid resistance), cost effective, easy to install and easily repairable.**
Bus lanes can be given a different color (red color is commonly used indicating prohibition) using epoxy paints or by giving a thin colored surface coating to the top layer of the lane. Bus lanes can be colored bus lanes a different color than adjacent lanes.

5 **In the Indian setting, physical segregation is advised to define bus lanes**. Additionally, physical segregation can be accomplished through both permanent segregation, such as railings, and temporary segregation, such as cones or bollards.

CHAPTER FIVE

SUMMARY

1. Bus priority can transform the existing bus transport system in Indian cities and convert it to a preferred mode of transport in the city.
2. Implementing a bus priority scheme in a city is more than just few infrastructural changes and requires careful planning.
3. Identifying bus priority corridors, measures and infrastructure design need to be based on local context.
4. Engage stakeholders at all stages of the project for smooth implementation.
5. Bus priority schemes can maximize benefits to customers as well as provide viable business models to public transport agencies and bus operators at comparatively low infrastructure investment costs.
6. Bus priority schemes must therefore become integral part of urban road design and public transport planning.

Way Ahead – Building bus ready streets

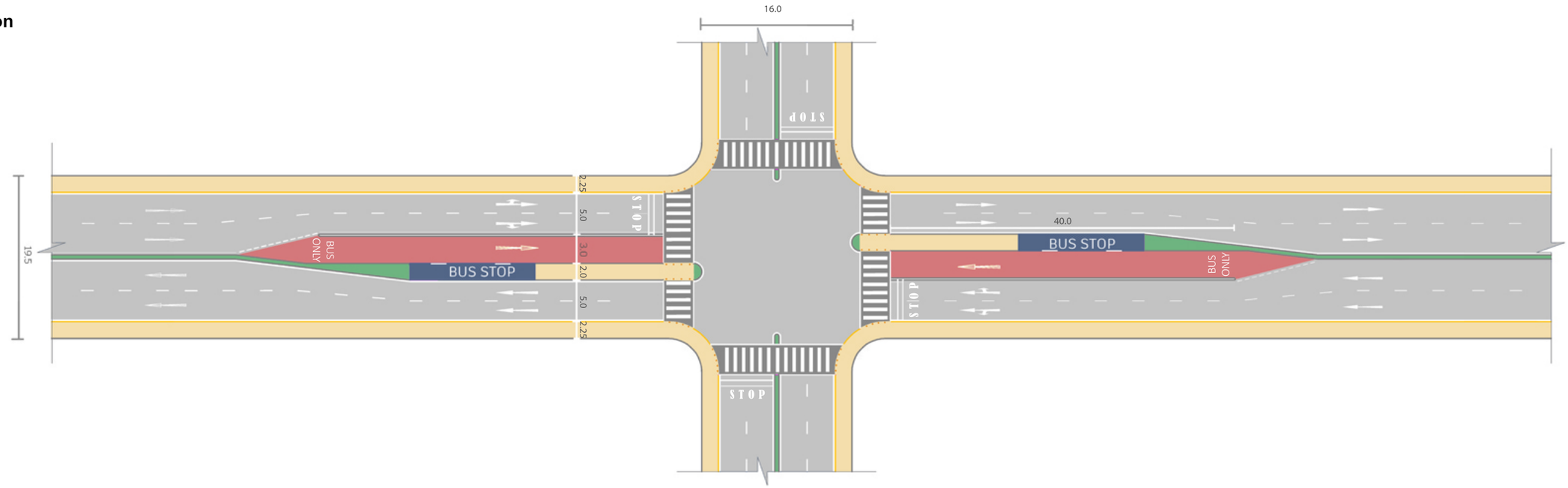
New roads need to be planned and developed as transit-ready streets. This will help avoiding present challenges (specially road width requirements) faced while converting conventional road designs to bus priority corridors.

ANNEXURE A

Types of bus priority measures

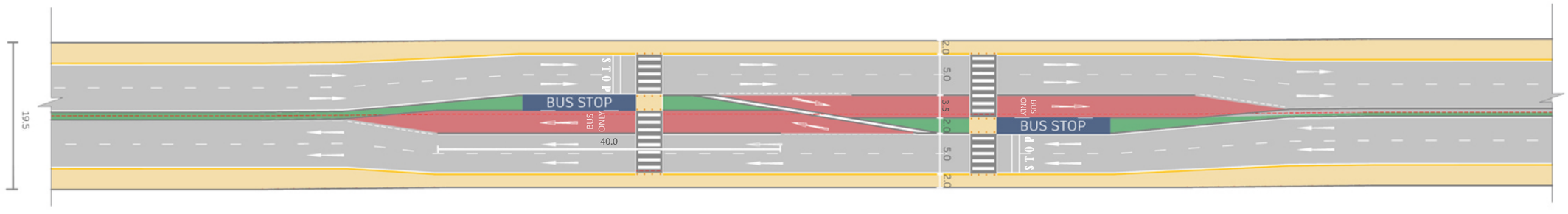
FOR 19.5 M WIDE ROAD WITH RIGHT HAND SIDE DOOR OPENING

At Junction



Staggered bus stops at junction for 19.5 m road

At Mid-Block



Staggered bus stops at mid-block for 19.5 m road

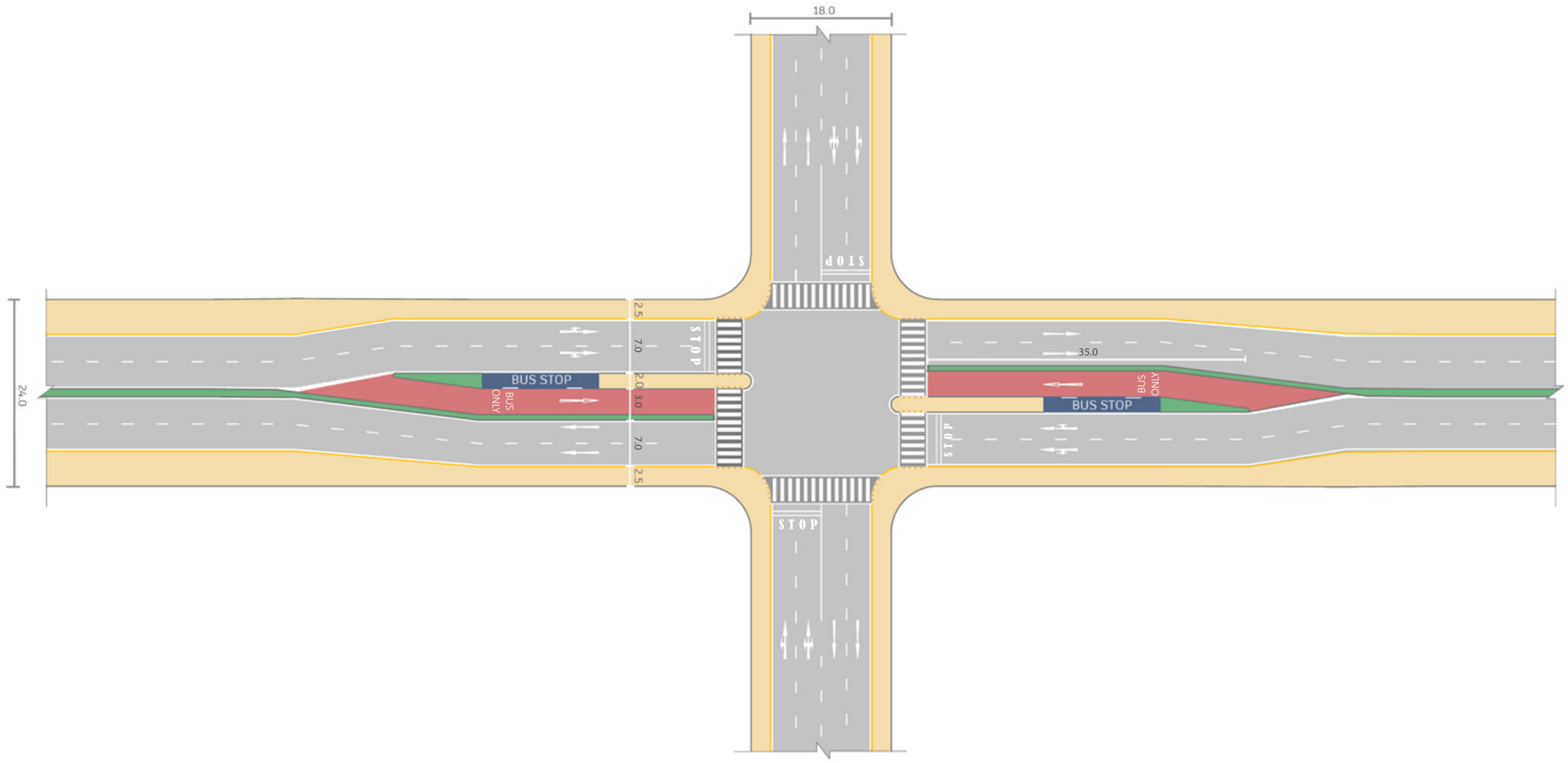
LEGENDS

BOLLARDS
BUS LANE
BUS STOP
CARRIAGE WAY
LANDSCAPE
PEDESTRIAN PATH

All dimensions are in meter.

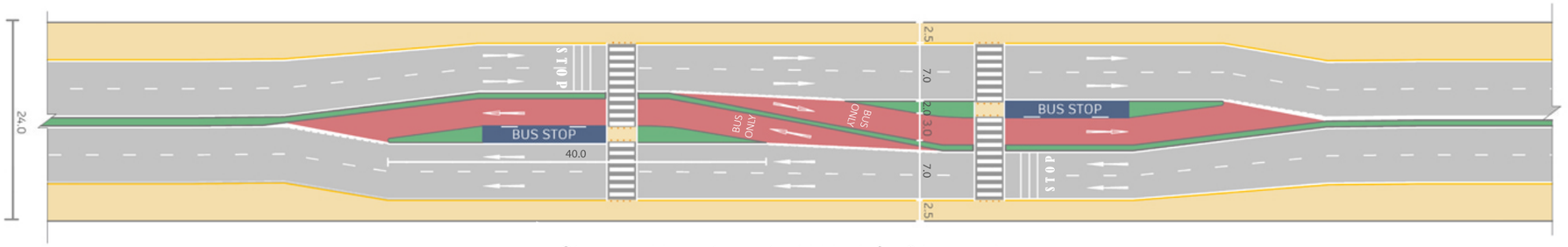
FOR 24 M WIDE ROAD WITH LEFT HAND SIDE DOOR OPENING

At Junction



Staggered bus stops at junction for 24 m road

At Mid-Block



Staggered bus stops at mid-block for 24 m road

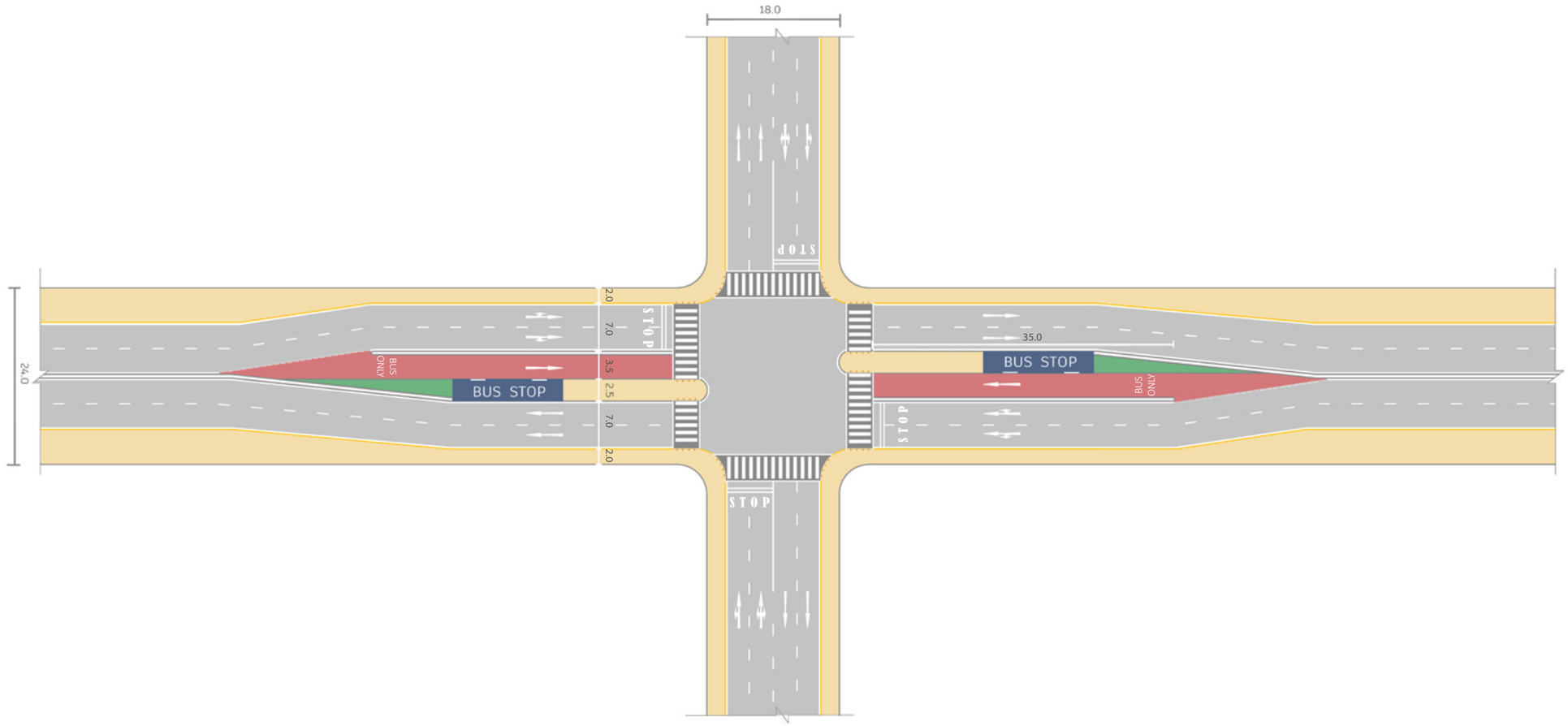
LEGENDS

BOLLARDS
BUS LANE
BUS STOP
CARRIAGE WAY
LANDSCAPE
PEDESTRIAN PATH

All dimensions are in meter.

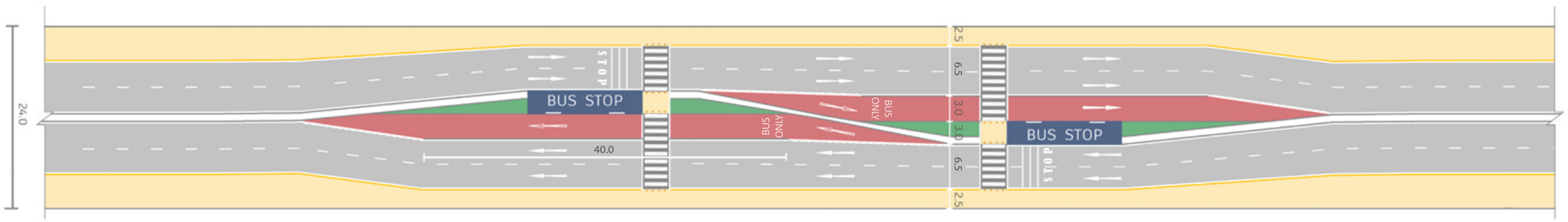
FOR 24 M WIDE ROAD WITH RIGHT HAND SIDE DOOR OPENING

At Junction



Staggered bus stops at junction for 24 m road

At Mid-Block



Staggered bus stops at mid-block for 24 m road

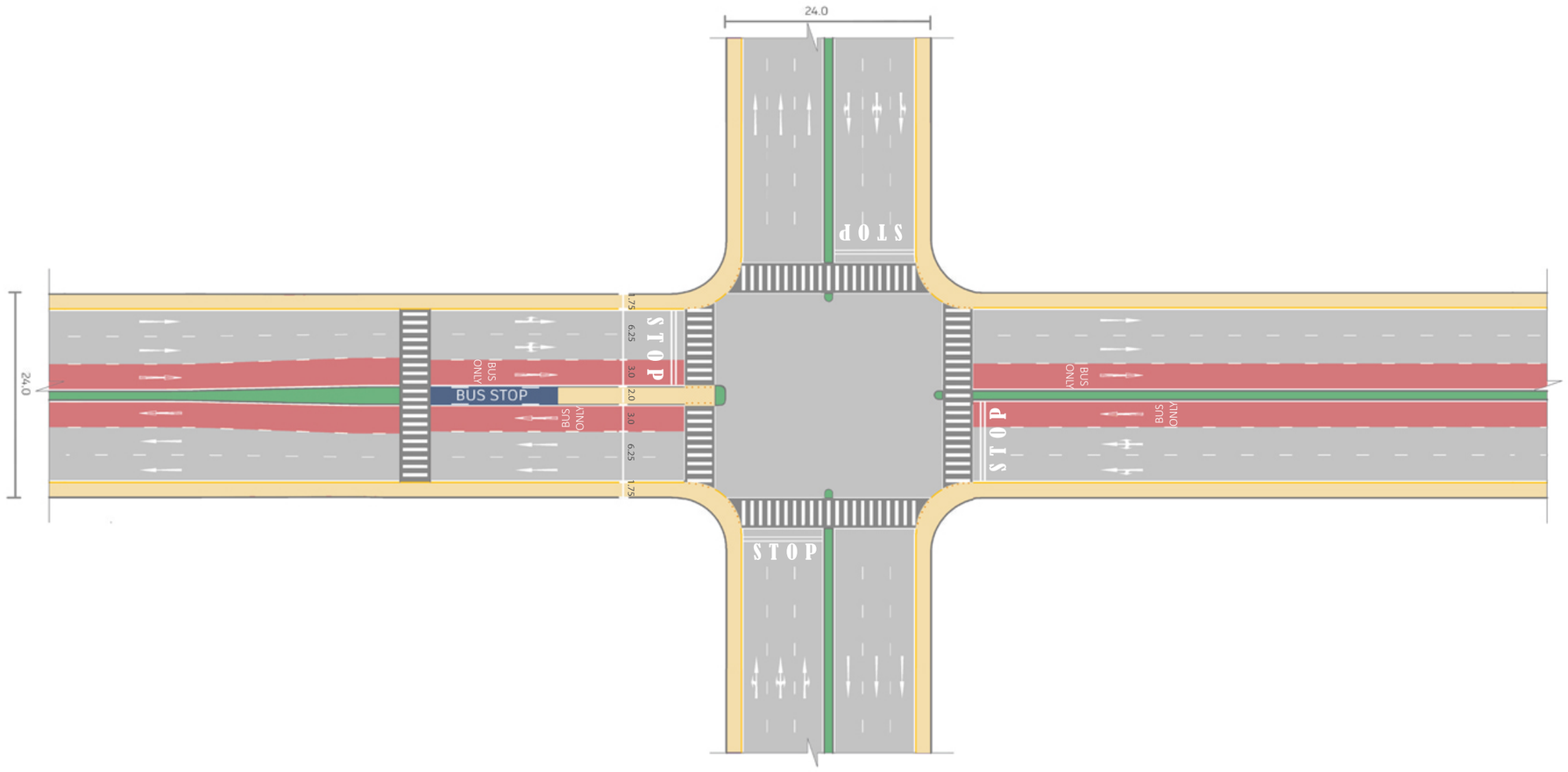
LEGENDS

- BOLLARDS
- BUS LANE
- BUS STOP
- CARRIAGE WAY
- LANDSCAPE
- PEDESTRIAN PATH

All dimensions are in meter.

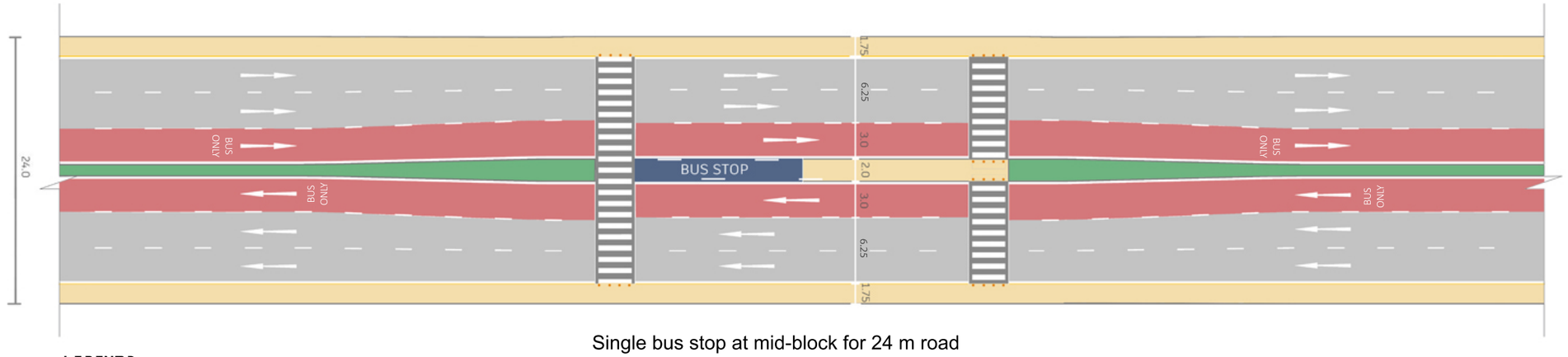
FOR 24 M WIDE ROAD WITH RIGHT HAND SIDE DOOR OPENING

At Junction



Single bus stop at mid-block for 24 m road

At Mid-Block



Single bus stop at mid-block for 24 m road

LEGENDS

- BOLLARDS
- BUS LANE
- BUS STOP
- CARRIAGE WAY
- LANDSCAPE
- PEDESTRIAN PATH

All dimensions are in meter.

Source : CoE-UT, 2021