TOD KP

PD-R02

TOD PLANNING PRINCIPLES

A series of detailed planning principles and design components to formulate TOD plans at various scales of intervention

Type: Reference Document

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Disclaimer: *The Transit-Orientated Development Implementation Resources & Tools knowledge product is designed to provide a high-level framework for the implementation of TOD and offer direction to cities in addressing barriers at all stages. As the context in low and middle-income cities varies, the application of the knowledge product must be adapted to local needs and priorities, and customized on a case-by-case basis.*

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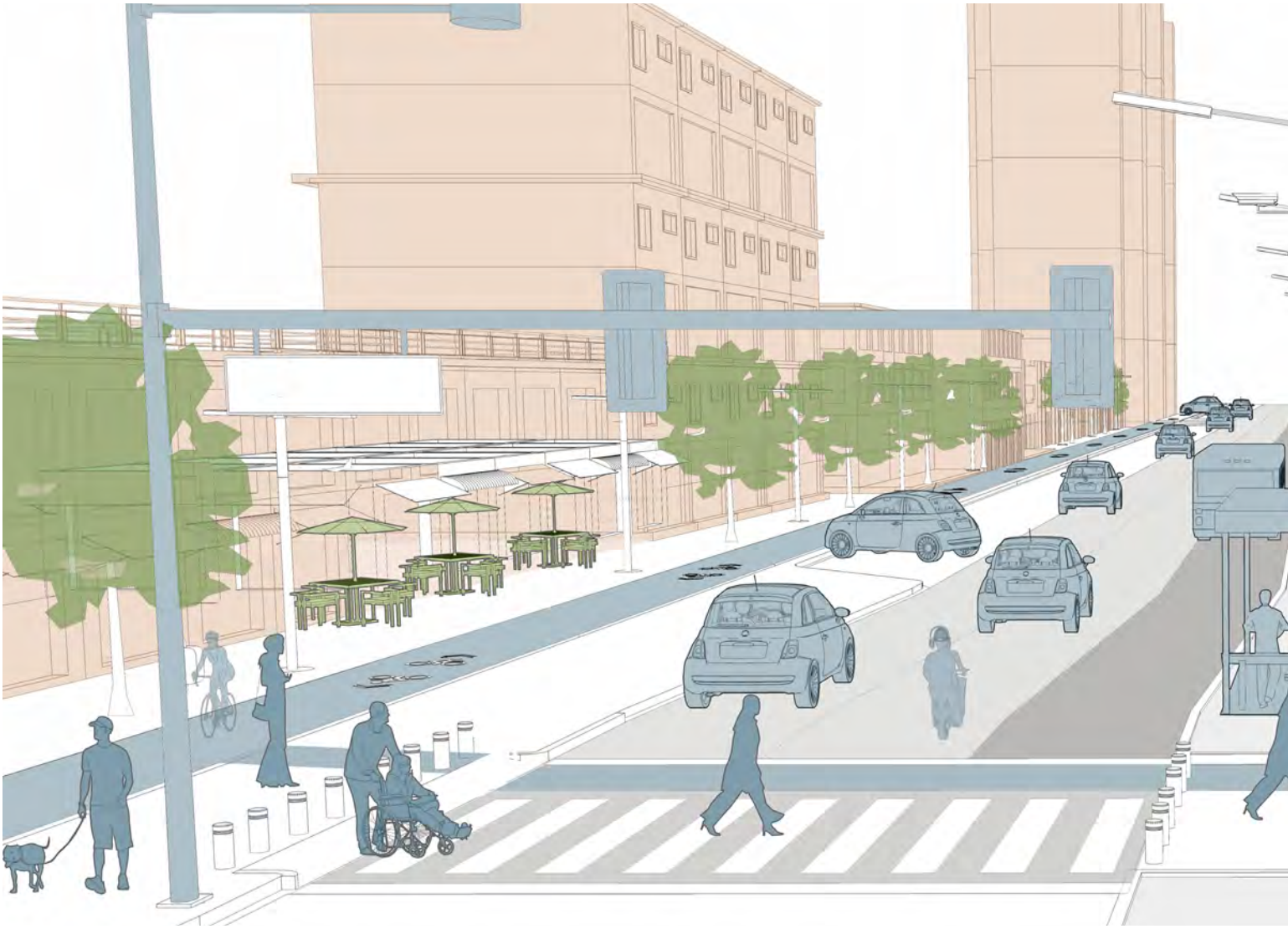
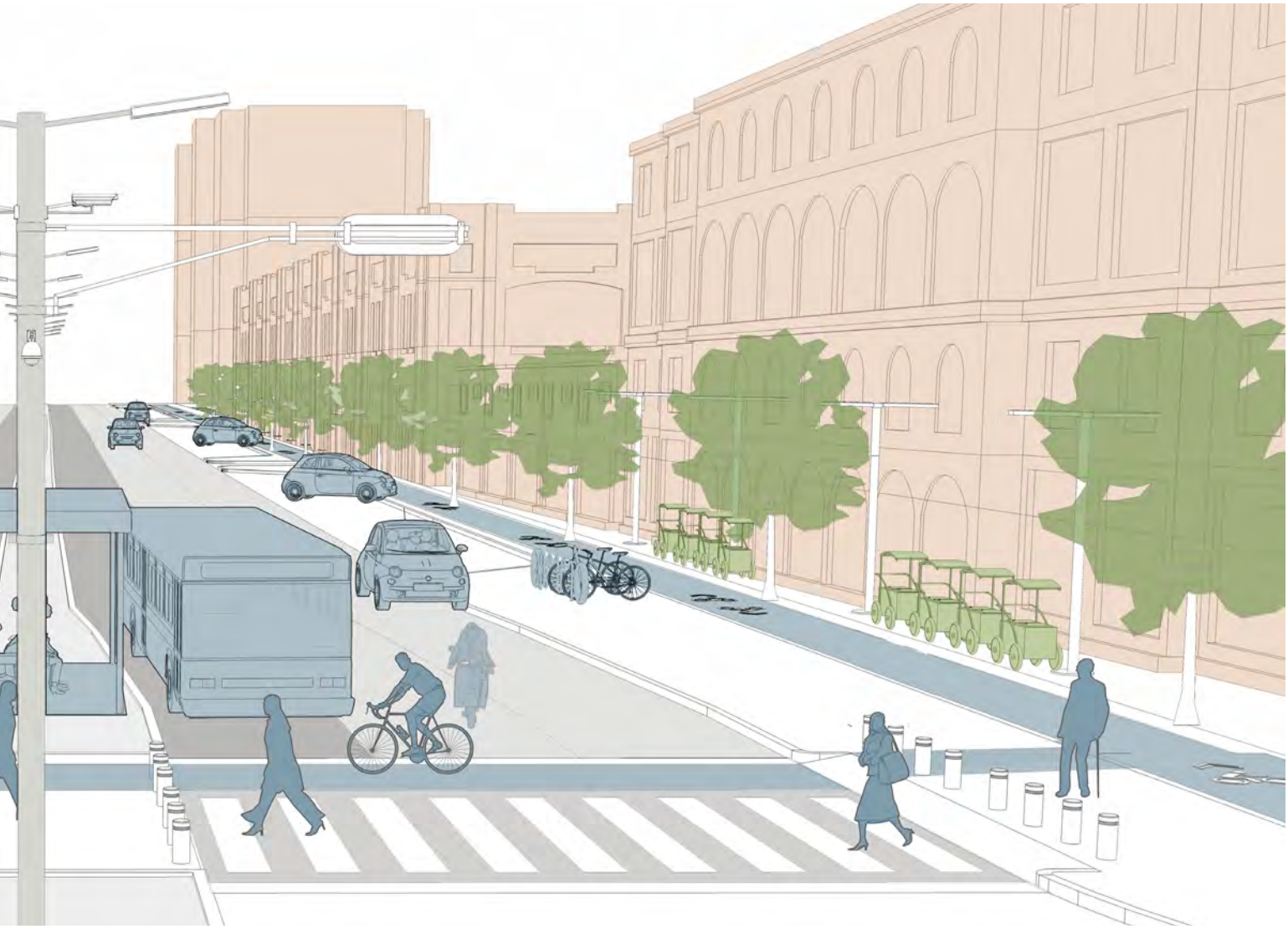
TOD DESIGN PRINCIPLES



TRANSIT (TRANSPORTATION)

The different transportation modes (transit, walking, bicycle, cars, taxis, etc.) and the infrastructure and amenities (lanes, parking spots, transit stops, stations, sidewalks, etc.) that allow residents to travel safely, conveniently, and comfortably, whichever mode they choose.

ORIENTED (OPEN SPACE)



The public spaces (plazas, patios, parks, sidewalks, etc.) that form the transition between transportation facilities and buildings, also known as 'the spaces between' where the life of the city plays out. Can be public or private property, but should be designed to be accessible, friendly, and fun for all.

DEVELOPMENT (BUILT ENVIRONMENT)

The built-up areas, primarily private parcels, where different human activities occur that support varied housing, employment, shipping, and other uses. In the TOD model, buildings should relate to and activate surrounding open spaces and support transit ridership by adequate density.

TRANSIT (TRANSPORTATION) COMPONENTS

WELL DESIGNED TRANSIT SYSTEM

T1

Encourage high-quality station architecture and public realm that is sensitive to the surrounding built context and must provide amenities, including retail, to ensure a comfortable and seamless commuter experience.

MULTI-MODAL INTEGRATION

T2

Seamless integration of transit modes, systems, and routes must be ensured, while considering efficient links to all modes of access, users and abilities, to and from the station.

COMPLETE STREETS

T3

Enable street design that ensures safe access for all users, including pedestrians, cyclists, motorists and transit riders, by providing equitable distribution of road space.

TRAFFIC MANAGEMENT

T4

Incorporate safe speed strategies for traffic around transit stops along with measures on traffic demand management and reduced parking demand to promote sustainable mobility choices.

ORIENTED (OPEN SPACE) COMPONENTS

TRANSIT PLAZA

O1

Promote congregational activities through inclusive and context-sensitive variety in architecture and landscaping around transit stations.

WALKABILITY

O2

Focus on providing an attractive pedestrian environment that is continuous, forms a network and offers an array of experiences and amenities.

PUBLIC REALM

O3

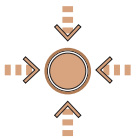
Provide visual interest at the pedestrian scale through thoughtful landscaping and building design, which will encourage people to use the public realm and help contribute to an active street life.

URBAN PARKS & OPEN SPACES

O4

Create open areas such as amenity spaces, green spaces, playgrounds, parks and natural areas, plazas, civic squares, etc. within a five-minute walking radius of residents.

DEVELOPMENT (BUILT ENVIRONMENT) COMPONENTS



COMPACT DEVELOPMENT

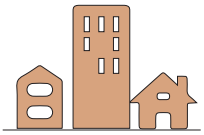
D1

Optimize employment and residential densities along a transit corridor or station area, based on the carrying capacities of transit and NMT infrastructure, to promote walking and transit use.

MIX OF USES

D2

Promote more efficient land use patterns by providing residents with access to retail, commercial and civic services, employment and recreational facilities without needing to travel by automobile.



HOUSING DIVERSITY

D3

Provide a diversity of housing choices, which includes a mixture of types, styles, price ranges and tenure, within a 10-minute walking distance from a transit station, to foster the creation of equitable TODs.

INFORMAL SECTOR INTEGRATION

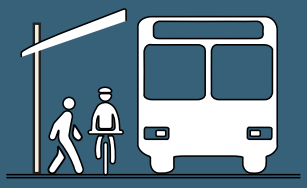
D4

Strive to achieve inclusive development in TODs by addressing the needs of the informal sector in all aspects of policy, planning and design for street vendors, settlements and transportation services

TOD SUPPORTIVE PRINCIPLES

CLIMATE RESILIENCE	**S1**	Identify high-risk areas to design TOD projects in consideration with the anticipated hazards and failures associated with climate change & environmental variations. ***Reference: Climate resilient development index: theoretical framework, selection criteria & fit-for-purpose indicators, European Commission*** *https://ec.europa.eu/jrc/sites/jrcsh/files/ReqNo_JRC94771_lb-na-27126-en-n.pdf*
INCLUSIVENESS	**S2**	Adopt inclusive development of TOD areas at all stages & scales by means of incorporating the needs of diverse user groups including gender, age, abilities & socio-economic segments. ***Reference: Towards an Inclusive and Low Carbon Transit Oriented development in Indian Cities, Shakti Foundation*** *http://shaktifoundation.in/wp-content/uploads/2017/11/TOD-India.pdf*
LAND VALUE CAPTURE	**S3**	Adopt development based land value capture as a financial mechanism for upgrading infrastructure along TOD corridors and station areas. ***Reference: Financing Transit Oriented Development with Land Values, World Bank Group, 2015*** *https://openknowledge.worldbank.org/handle/10986/21286*
UNIVERSAL ACCESSIBILITY	**S4**	Meet and exceed the requirements of accessibility guidelines and standards of all users with different abilities in building or retrofitting pedestrian environments. ***Reference: Environment for Disabled and Elderly Persons, CPWD (1998)***
SUSTAINABLE INFRASTRUCTURE	**S5**	Prioritize and implement innovative green building practices in all aspects of providing or upgrading infrastructure including, energy, water, landscape and waste management. ***Reference: LEED for Neighborhood Development*** *www.nrdc.org/cities/smartgrowth/files/citizens_guide_LEED-ND.pdf*
BICYCLE FRIENDLY	**S6**	Expand accessibility in TOD areas by promoting bicycles as an alternate or preferred sustainable and healthy mode of choice. ***Reference: National Guidance Document on Public Bicycle Sharing, MoHUA*** *(http://mohua.gov.in/cms/sustain-sutp-PBS.php)*
TECHNOLOGY INTEGRATION	**S7**	Adopt smart technologies within TOD projects such as fare integration, smart parking, real-time information, to provide public transit service an edge over automobiles. ***Reference: ITS Toolkit, IUT*** *(http://www.iutindia.org/capacityBuilding/Toolkits.aspx)*

T1



WELL DESIGNED TRANSIT SYSTEM

Encourage high-quality station architecture and public realm that is sensitive to the surrounding built context and must provide amenities, including retail, to ensure a comfortable and seamless commuter experience.

RISK & MITIGATION

- Transit agencies have a strong say on where the transit infrastructure is built, and hence influence the potential of TOD. Often, the transit stops are planned in less expensive locations, far from jobs and housing areas, which diminish the outcomes early on.
  Transit station designs are many times planned by transit agencies without considering options for joint developments or other mechanisms to improve integration at the station area scale.
- Placement of transit stops has to be in concurrence with the emerging locations that foster private development.

Recreio Shopping BRT station, Rio de Janeiro, Brazil

1. DESIGN CONTEXT-SPECIFIC TRANSIT SYSTEMS

- Transit corridors must be located in proximity to a city's current or planned urban footprint. City officials must assess where enough transit demand exists to sustain public transportation, or where there is potential for future development (based on integrated land use and transportation plans), and route primary and secondary transit systems to these areas in order to accommodate and create demand.

  -Module 4: Design Components of TOD, WRI, 2015

- A TOD corridor should be designed with the goal of incorporating and connecting as many types of transit systems to one other to create a more robust transit network, but not all stations across a corridor will demand the same variety and capacity of transit options. The types of transit options will depend on various factors including proximity to the urban core, and to dense residential and economic hubs.

  -Module 4: Design Components of TOD, WRI, 2015

- When planning a TOD corridor, it is necessary to understand the existing demand at each station, based on existing and projected economic conditions. This will help to prioritize the stations that should plan for the greatest hierarchy of public transit systems.

  -Module 4: Design Components of TOD, WRI, 2015

- Consider a transit alternative analysis to determine the most effective and cost-efficient mode for the context.
  - Bus Rapid Transit System should be considered for demand greater than 2000 passengers per hour per direction.

  -TOD Guidance Document, MOUD, 2016

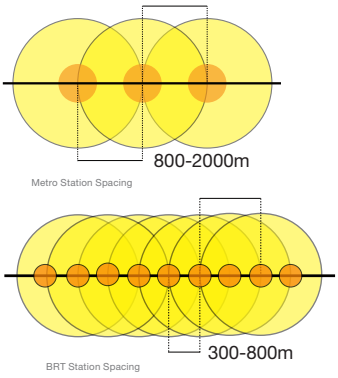
  - Metro Rail should be considered for demand greater than 15000 passengers per hour per direction.

  -TOD Guidance Document, MOUD, 2016

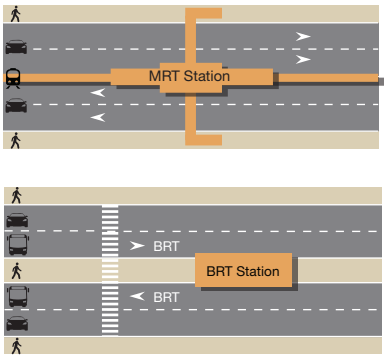
Refer E **PRIMARY STATION AREA DESIGN** for design guidance on station area design

+ REFER OTHER PRINCIPLES

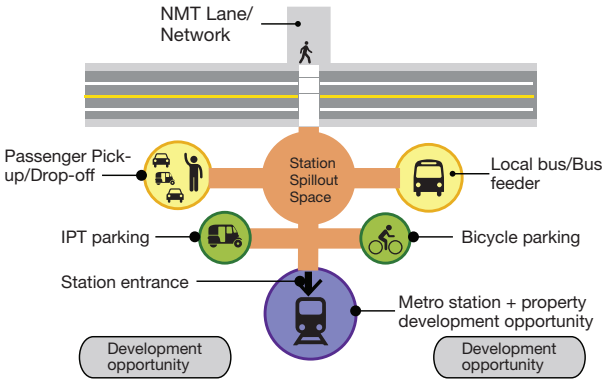
T1 T2 T3 T4 | O1 O2 O3 O4 | D1 D2 D3 D4



Station Spacing | *source: MOUD, 2016*



Station Placement | *source: MOUD, 2016*



Multi-modal integration at transit station | *source: MOUD, 2016*

2. CREATE BARRIER FREE MOVEMENT SPACES

- The maximum acceptable walking distance to the nearest rapid transit station is defined as 1,000m and 500m for a frequent local bus service that connects to a rapid transit network within less than 5 kilometers.

  -Adapted from TOD Standard, ITDP, 2017

- The transfer station should be designed for short, convenient and all-accessible connections with the rapid transit service.

  -Adapted from TOD Standard, ITDP, 2017

- In addition to variety, efforts should be made to integrate the various forms of public transit. This can be achieved through measures such as integrated fare systems across the different systems; easy access to transfer between systems, and combined operations to ensure higher quality, complementary and complete public transit system network.

  -Module 4: Design Components of TOD, WRI

3. PROVIDE CUSTOMER AMENITY TO ENHANCE COMFORT, SAFETY AND INFORMATION

- Convenience: Provide retail opportunities at transit stations to offer food, drink and services such as banks or dry cleaners.
- Comfort and Safety: Transit stations should provide comfortable and secure places to sit and wait with amenities such as washrooms and secure bike storage.
- Information: Provide a high level of customer service at stations, including staffed customer service kiosks, real-time and static information displays, wireless internet and pay telephones.

  -Adapted from Mobility Hub Guidelines, Metrolinx, 2011

+ REFER OTHER KNOWLEDGE PRODUCTS

AS A01, A02, H02, P02 | EN C01, C02, H01, R01, P01 | PD H01, H02, H03, H07, R03, P01 | FI A01, A02, H01, H02, R01, R02, R03 | IM A01, A02, H01, H02, P01

T2

MULTI-MODAL INTEGRATION

Seamless integration of transit modes, systems, and routes must be ensured, while considering efficient links to all modes of access, users and abilities, to and from the station.

RISK & MITIGATION

- Different agencies for various modes of transit, with lack of inter-agency coordination, hinders the seamless and efficient integration of transit for users.
- A multi-agency task force could be set up to address the interdependent needs of multi-modal integration at various levels from planning routes to provision of PPUDO at transit stops.

Informal transit at MG road metro station, Delhi, India

1. DESIGN FOR EFFICIENT INTER-MODAL TRANSFERS TO CREATE A SEAMLESS TRANSIT EXPERIENCE

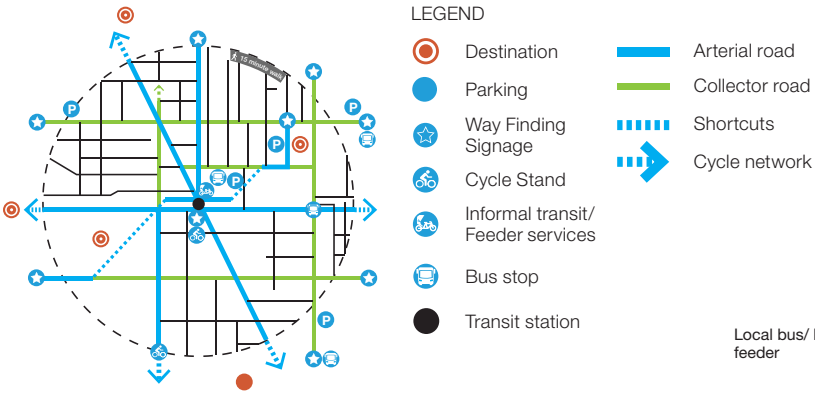
- Coordinate local feeder transit service schedules and routes to provide seamless connectivity between local, regional, and rapid transit services by reducing waiting times.
- Adopt transit priority measures to ensure the efficient movement of surface transit to and from the station area. Intermodal integration of formal public transport, paratransit and cycle sharing should be within 200m from each other.

APPROX. WALKING DISTANCE FROM EXITS	FACILITY/AMENITY AND PREFERRED LOCATION:
Within 100 m	Bus stops; vendor zones; convenience shopping; cycle-rental station, high occupancy feeder stop/ stand, public toilets; pedestrian-only plazas.
Beyond 100 m	Private car/taxi “drop-off” location only; validated car parking facility for metro users (park & ride) may be provided.
Within 500m	Cycle-rickshaw stand; cycle-parking stand; informal transit and ride-sharing services/auto-rickshaw stand, improved lighting, proper signage, information for modal interchange and way-finding; interchange between any two mass rapid transit modes (Railway, Metro, BRTS, etc.)

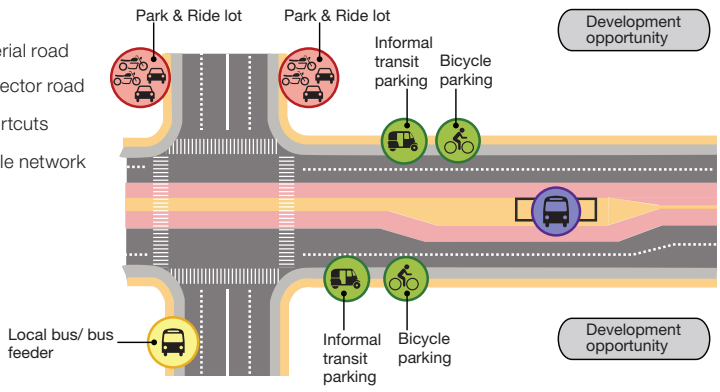
Refer E **PRIMARY STATION AREA DESIGN** for multi-modal integration guidance

+ REFER OTHER PRINCIPLES

T1 T2 T3 T4 | O1 O2 O3 O4 | D1 D2 D3 D4



Different access and mobility solutions around transit station | *source: MOUD, 2016*



Multi-modal options at transit station | *source: MOUD, 2016*

2. FOCUS ON THE NEEDS OF FIRST AND LAST MILE CONNECTIVITY

- Dedicated and physically segregated bicycle tracks with width of 2m or more, one in each direction, should be provided on all streets with total motor vehicle carriageway larger than 10m (not ROW) after providing adequately sized footpaths in each direction based on pedestrian traffic.

  -Adapted from TOD Guidance Document, MOUD, 2016

- Provide designated parking for informal transit within 150m of walking distance from the station exit.

  -Adapted from TOD Guidance Document, MOUD, 2016

- Cycle rickshaw parking and three-wheeler parking bays of 1.5m width should be provided near the junctions.

  -Adapted from TOD Guidance Document, MOUD, 2016

- Desired average waiting time for a pedestrian is not more than 45 seconds.

+ REFER OTHER KNOWLEDGE PRODUCTS

AS A01, A02, A04, H02, P02 | EN C01, C02, H01, R01, P01 | PD H01, H02, H03, R03, P01 | FI A01, A02, H01, H02, R01, R02, R03 | IM A01, A02, H01, H02, P01

T3

COMPLETE STREETS

Enable street design that ensures safe access for all users, including pedestrians, cyclists, motorists and transit riders, by providing equitable distribution of road space.

RISK & MITIGATION

- Addressing competing needs of space from diverse user groups in an existing built context deters the objective of designing complete streets due to lack of available space.
- Street upgrades within various agencies and different timelines hinders the implementation of complete streets.
- Prioritizing other initiatives that help support the complete streets objective including traffic management, promoting walking & bicycling culture to be addressed in parallel.
- Inter-agency coordination and institutional support to bring the agencies together mitigates the risks on differing timelines.

W Pender Street & Hornby Street, Vancouver, Canada

1. DESIGN THE STREETS FOR THE ENTIRE RIGHT OF WAY

- Multi-Utility Zone (MUZ) of minimum 1.8 m width should be provided on all Collector and Arterial Roads, to accommodate bus stops, street utilities, trees, street furniture, planting for stormwater management; informal transit and ride-sharing services/ NMT stands, paid idle parking, etc.

-Adapted from TOD Guidance Document, MOUD, 2016

2. CREATE A BALANCE BETWEEN NEEDS OF ALL USERS AND MODES OF TRAVEL

- No vehicular street R/W within 500m of TOD station shall be more than 30m unless already notified in the Master Plan.

-Adapted from TOD Guidance Document, MOUD, 2016

- In a slow-speed local street (below 30km/h), the optimum width for a carriageway is 3 m for one-way movement and 4.5 m for two-way movement.

-Adapted from TOD Guidance Document, MOUD, 2016

- Create dedicated and protected bike lanes, at least 3m wide in each direction, on all streets except low-speed local streets.

-Adapted from The Energy Foundation, 2012

Refer

A **WALKING INFRASTRUCTURE,**

B **CYCLING INFRASTRUCTURE,**

C **FEEDER TRANSIT AND PARATRANSIT INFRASTRUCTURE and**

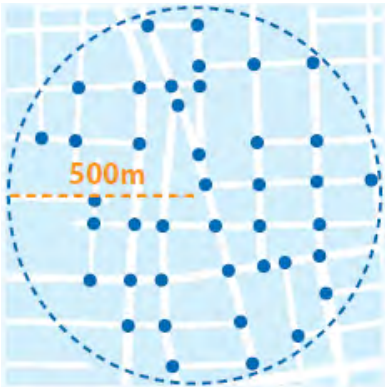
D **TRAFFIC CALMING MEASURES FOR SHARED STREETS**

for design guidance on Complete Streets design

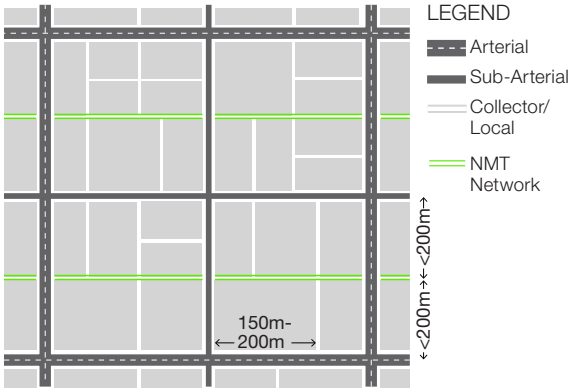
+ REFER OTHER PRINCIPLES

T1 T2 T3 T4 | O1 O2 O3 O4 | D1 D2 D3 D4

Building Edge-to-Edge Design | *source: MOUD, 2016*



Intersection Density | *source: MOUD, 2016*



Block Sizes & Street Hierarchy | *source: MOUD, 2016*

3. DESIGN STREETS IN CONTEXT TO ITS ABUTTING LAND USES

- A continuous unobstructed footpath on each side of all streets with ROW wider than 12m. Commercial/Mixed Use- 2.0m, Shopping frontages- 2.5m, Bus Stops- 3m, High-Intensity Commercial Areas-4m.

  -Adapted from TOD Guidance Document, MOUD, 2016

- Building edges and building frontages should be incorporated in the street design.
- Building frontages should be accessible to the public as far as possible.

4. DEVELOP AN INTERCONNECTED STREET NETWORK TO PROVIDE DIRECT CONNECTIONS TO THE TRANSIT STATION

- Block sizes should be minimized to avoid the creation of inhospitable super-blocks. These types of long blocks can deter walking, as they increase the perceived distance between locations. Recommended block size: 150-200m (WRI +MOUD)

  -Adapted from TOD Guidance Document, MOUD, 2016

  -Module 4: Design Components of TOD, WRI, 2015

- Area of blocks surrounded by public access pedestrian/cyclist streets or pathways not to exceed 2 ha. In existing built-up areas, statutory planning to be done for breaking up blocks with an area of more than 2 Ha, to provide publicly accessible pedestrian thoroughfare.

  -Adapted from TOD Guidance Document, MOUD, 2016

- Preferred density of pedestrian-friendly intersections: 50 intersections per squarekm.

  -Adapted from TOD Guidance Document, MOUD, 2016

- Hierarchy of street network:
  - Arterial - 50m to 80m - 50km/hr
  - Sub-Arterial - 30m to 50m - 50km/hr
  - Distributor - 12m to 30m - 30km/hr
  - Access - 6m to 15m - 15km/hr

+ REFER OTHER KNOWLEDGE PRODUCTS

AS H03, P03 | EN C01, C02, H01, R01, P01 | PD H01, H02, H03, H07, R03, P01 | FI A01, A02, H01, H02, R01, R02, R03 | IM A01, A02, H01, H02, P01

T4

TRAFFIC MANAGEMENT

Incorporate safe speed strategies for traffic around transit stops along with measures on traffic demand management and reduced parking demand to promote sustainable mobility choices.

RISK & MITIGATION

- Growing dependency on automobile coupled with the tendency to sprawled development.
- Lack of appropriate parking policies and provision of distinct parking supply to address the needs for parking.
- Sensitizing officials in charge of traffic and transportation towards the needs of transit and NMT users.
- Adequate measures on updating policies and enforcement of traffic rules to focus on NMT users and their needs.

Park and Ride facility at Chattarpur Metro Station Parking, Delhi, India

1. REDUCE VEHICULAR TRIPS IN THE STATION AREA

- Vehicle Demand Management (VDM): Adopt strategies and policies to reduce or redistribute travel demand for private vehicles. Discouraging use of private vehicles by means of congestion pricing, registration fee, alongside with provision of high-quality public transit facilities are some of the means to address VDM.

  -Module 4: Design Components of TOD, WRI, 2015

- On streets with ROW of 18m or less, if pedestrian traffic is greater than 8000 per hour in both directions together, the entire ROW should be notified for pedestrianization.

  -Adapted from TOD Guidance Document, MOUD, 2016

- Streets meant primarily for NMT movement as well as all streets of ROW 12m or below, should be limited to a maximum speed of 20km/hr by design.

  -Adapted from TOD Guidance Document, MOUD, 2016

- Narrow streets that allow one-way motor traffic, as well as bicycles and pedestrians, will significantly reduce congestion. Replace major arterials wider than 45m with efficient one-way couples (two narrower one-way couples).

  -Adapted from The Energy Foundation, 2012

Refer

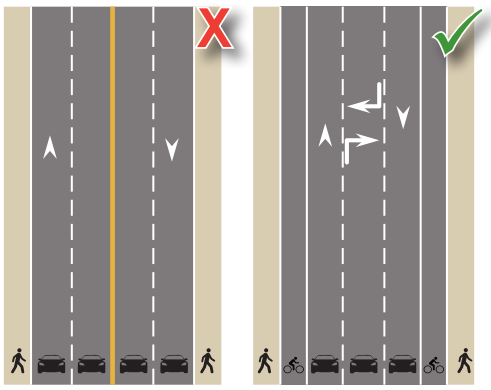
C FEEDER TRANSIT AND PARATRANSIT INFRASTRUCTURE and

for guidance on Traffic speeds management

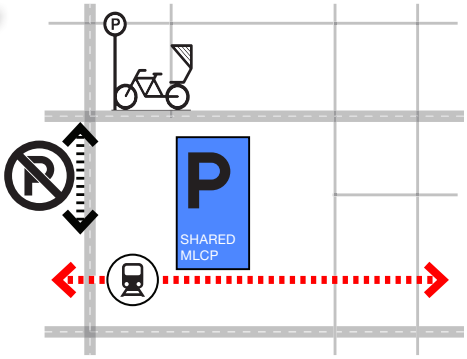
+ REFER OTHER PRINCIPLES

T1 T2 T3 T4 | O1 O2 O3 O4 | D1 D2 D3 D4

Traffic calming | *source: WRI, 2015*



Appropriate allocation of road space | *source: MOUD, 2016*



Station Parking | *source: MOUD, 2016*

2. OPTIMIZE TRAFFIC SPEEDS ON HEAVY TRAFFIC ROADS TO PROTECT MULTI-MODAL USERS AT TRANSIT STATIONS

- Disperse high traffic volumes over multiple parallel human-scale streets rather than concentrating traffic on fewer major arterial streets.

  -Adapted from TOD Guidance Document, MOUD, 2016

- Limit speed on urban arterial roads and sub-arterial streets to 50kmph and on collector and local streets to 30kmph.

  -Adapted from TOD Guidance Document, MOUD, 2016

- Traffic calming of all streets with ROW of 12m or less through the narrowing of driveways and meandering path with the use of trees, islands and street furniture.

  -Adapted from TOD Guidance Document, MOUD, 2016

- Mid-block crossings every 250m on average. Min: 5 safe street-level crossings/km.

3. REGULATE PARKING NEEDS AROUND THE STATION AREA

- Short-Term Parking (on-street & off-street): Approximately 70% of the total parking space/slots capacity to be kept for short-term parking near the station.

  -Adapted from TOD Guidance Document, MOUD, 2016

- Park-and-Ride Lots: Park-and-Ride facilities for private modes may be provided only at Terminal MRTS Stations or major Multi-modal Interchanges.

  -Adapted from TOD Guidance Document, MOUD, 2016

- Special parking spaces should be designated on-street for differently abled, at a ratio of 1 for every 25 parking spaces. These parking spaces should have 1.2m access zones.

- At least 50% and preferably 100% of the total parking facilities (based on ECS) provided for any new/ redevelopment/retrofit project greater than 2000 sqm plot area, shall be provided as a Shared Parking facility.

- Minimum parking rates may be fixed but maximum rates be variable based on market forces, similar to all real estate space in the city.

- Increase fee exponentially with decreasing distance to BRTS/Metro Rail stations.

+ REFER OTHER KNOWLEDGE PRODUCTS

AS A01, A02, A04, H02, P02 | EN C01, C02, H01, R01, P01 | PD H01, H02, H03, R03, P01 | FI A01, A02, H01, H02, R01, R02, R03 | IM A01, A02, H01, H02, P01

O1

TRANSIT PLAZA

Promote congregational activities through inclusive and context-sensitive variety in architecture and landscaping around transit stations.

RISK & MITIGATION

- Transit route planning involves alignments passing through various contexts and space constraints, risking the provision of transit plazas at stops. Provision of standardized transit stop designs that lack distinguished character prohibits consideration of transit plaza Lack of sufficient land ownership by the transit agency.
- Station area plans should be made along with transit plans so that appropriate plazas are also designed. Space for transit plaza could be created through urban design guidelines or regulations over private properties.

Transit Plaza at center square MRT, Raffles Place, Singapore

1. ADOPT MEASURES TO CREATE EFFICIENT AND DISTINCT CIRCULATION AREAS THAT CATER TO INTER-MODAL TRANSFER AROUND TRANSIT STOPS

- Adopt transit priority measures to ensure the efficient movement of surface transit to and from the station area.

-Adapted from Mobility Hub Guidelines, Metrolinx, 2011

- Provide clearly marked and protected access for pedestrians and cyclists at station areas to minimize conflicts, particularly at passenger pick-up and drop-offs (PPUDO), bus facilities, and parking access points.

-Adapted from Mobility Hub Guidelines, Metrolinx, 2011

- Provide secure and plentiful bicycle parking at station entrances with additional cycling amenities at high volume locations.

-Adapted from Mobility Hub Guidelines, Metrolinx, 2011

Refer

D TRAFFIC CALMING MEASURES FOR SHARED STREETS

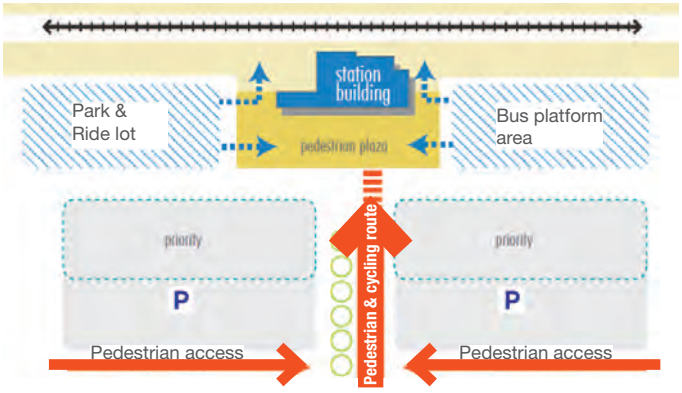
E PRIMARY STATION AREA DESIGN

for design guidance on Transit plaza and Station a design

+ REFER OTHER PRINCIPLES

T1 T2 T3 T4 | O1 O2 O3 O4 | D1 D2 D3 D4

Protected pedestrian zone at transit station | *source: MOUD, 2016*



Transit plaza connections | *source: Metrolinx, 2011*

2. PEDESTRIAN FIRST MEASURES HAVE TO BE PRIORITIZED AROUND THE TRANSIT PLAZA

- Provide an attractive pedestrian environment with a high level of priority, safety, and amenities.

  -Adapted from Mobility Hub Guidelines, Metrolinx, 2011

- Ensure the plazas respond to local needs both functional and architectural.

  -Adapted from Mobility Hub Guidelines, Metrolinx, 2011

- Public plazas with community amenities such as gathering places, public information kiosks, public art displays and opportunities for small convenience-oriented retail uses.

  -Adapted from Mobility Hub Guidelines, Metrolinx, 2011

- In waiting areas, include a variety of comfortable seating types and locations.

  -Adapted from Mobility Hub Guidelines, Metrolinx, 2011

- Use fountains, landscaping and building elements (such as low walls) to buffer traffic noise.

  -Adapted from Mobility Hub Guidelines, Metrolinx, 2011

- Incorporate natural landscape elements and other green design features such as drought-resistant plantings, permeable surfaces and recycled/able materials.

  -Adapted from Mobility Hub Guidelines, Metrolinx, 2011

- Recommended area of pedestrian spill out space > 1.9 sqm/ped.

  -Adapted from TOD Guidance Document, MOUD, 2016

+ REFER OTHER KNOWLEDGE PRODUCTS

AS | EN C01, C02 | PD H03, H04, H05, H06, P01 | FI A02, H02, R01, R03 | IM A01, A02, H01, H02, P01

O2

WALKABILITY

Focus on providing an attractive pedestrian environment that is continuous, forms a network and offers an array of experiences and amenities.

RISK & MITIGATION

- Lack of technical capacities and sensitivity towards pedestrian needs.
  Lack of a walkable mix of uses because of discordant land use regulations.
- Consider formulation of NMT cells within at relevant levels within the local authorities to address the needs of walking.

Pedestrian Amenities, Tianjin, China

1. PROVIDE APPROPRIATE NETWORK AND WIDTH OF CONTINUOUS FOOTPATHS

- A concerted effort to create connected & contiguous networks for cycling & walking must be made at the corridor level, detailed to the level of each station area.
- Adopt sidewalks to be designed using a three-section strategy:
  - Service zone: contains space allocation for urban furniture, vegetation, stormwater management and infrastructure
  - Pedestrian flow zone: strictly dedicated to pedestrian movement, free of all obstructions. This zone must cater to all users with different abilities and age groups moving in both directions.
  - Front-of-building zone: transition zone from public to private property, could be utilized for outdoor seating, signage, porches, planting etc.
  - Additionally, a fourth zone could be added, if space permits for bicycles, as an additional section of the sidewalk of as part of the street.

Refer

A WALKING INFRASTRUCTURE

for design guidance on Walkability

+ REFER OTHER PRINCIPLES

T1 T2 T3 T4 | O1 O2 O3 O4 | D1 D2 D3 D4

Pedestrian environment | *Source: MOUD, 2016*

Active street edge | *Source: MOUD, 2016*

2. MAKE WALKING A COMFORTABLE CHOICE

- Street trees:
  - At least 125 trees perkm for streets with ROW smaller than 12m.
  - At least 125 trees perkm per footpath on streets with ROW greater than 12m.
- Street Lighting: Spacing should be uniform with the distance based on the minimum illumination required.
- Street Furniture: Benches, trash, receptacles, bollards, vending kiosks, signage to be provided adequately.
- Public Facilities: Provide Accessible Public Toilets at every 500-800m distance – preferably located close to bus stops for easy access by pedestrians and public transport users.

-Adapted from TOD Guidance Document, MOUD, 2016

3. MAINTAIN ACTIVE STREET EDGES TO CREATE SAFE WALKING

- Active frontages include arcades, shopfronts, entrance doorways, access points, entry/exits and transparent windows of active areas facing the primary access street.

-Adapted from TOD Guidance Document, MOUD, 2016

- Primary pedestrian access for buildings from the main street, with location as per shortest walking distance from nearest bus stop.

-Adapted from TOD Guidance Document, MOUD, 2016

- Vehicular/service access should be from secondary street wherever access to the building is possible from multiple streets.

-Adapted from TOD Guidance Document, MOUD, 2016

- Compound walls, if present, should be transparent above a height of 100cm. High-security government buildings may apply for an exemption.

-Adapted from TOD Guidance Document, MOUD, 2016

+ REFER OTHER KNOWLEDGE PRODUCTS

AS A01, A02, A04, P02 | EN C01, C02, H01 | PD H03, H04, H05, H06, P01 | FI A02, H02, R01, R03 | IM A01, A02, H01, H02, P01

O3

PUBLIC REALM

Provide visual interest at the pedestrian scale through thoughtful landscaping and building design, which will encourage people to use the public realm and help contribute to an active street life.

RISK & MITIGATION

- Lack of micro-planning mechanisms or allocation of budgets with public agencies hinders the investments in public realm improvement projects.
- Investments in infrastructure to support the quantum of development envisioned for a particular place is critical to TOD. The public sector needs to invest in infrastructure to alleviate the cost burden from prospective private developments.

Public Realm, Sao Paulo, Brazil

1. INCORPORATE PROVISION OF PUBLIC REALM AT ALL SCALES OF TOD PLANNING

- A neighborhood park accessible by 800m walking or bicycle trip, and a public sports venue accessible by 1,200m walking or bicycle trip.

-Module 4: Design Components of TOD, WRI

- Public spaces must be designed to integrate with existing urban space and meet the needs of local residents. To properly integrate a public space network, the public spaces within the network should connect with each other and with a neighborhood's primary leisure spaces. This network can be connected through a system of sidewalks, pedestrian paths, or cycling paths.

-Module 4: Design Components of TOD, WRI, 2015

- When streets are thought of as public spaces, opportunities for community enhancement are created. Community streets can be used for a variety of purposes, including such events as food fairs, festivals, games, and parades.

-Module 4: Design Components of TOD, WRI, 2015

- Through the establishment of mixed-use districts, encouragement of streetscape that are created for all user experiences (not just vehicles), sidewalks that are built for multiple purposes including green space, pedestrian experience, and aesthetic transitioning to adjacent businesses and residences, zoning codes can be powerful tools.

-Module 4: Design Components of TOD, WRI, 2015

Refer

A WALKING INFRASTRUCTURE,

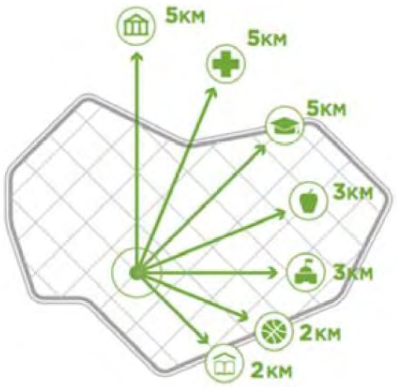
B CYCLING INFRASTRUCTURE,

D TRAFFIC CALMING MEASURES FOR SHARED STREETS

for design guidance on Public Realm design

+ REFER OTHER PRINCIPLES

T1 T2 T3 T4 | O1 O2 O3 O4 | D1 D2 D3 D4



Regional facilities | *source: WRI, 2015*

Shared community streets | *source: WRI, 2015*

Place identity | *source: WRI, 2015*

2. PROVISION OF PUBLIC SPACES IMPROVES QUALITY OF LIFE

- Provision of public and green spaces can seem in direct conflict with TOD's density goals; however, the two design components must be thought of as complementary. Balancing the two design components to achieve high density and green and public space is not only possible, but necessary.

  -Module 4: Design Components of TOD, WRI, 2015

- Important local landmarks, including heritage buildings, churches, and monuments, must be preserved to keep a community's history alive. TOD design can serve to increase access to historical locations; for example, pedestrian zones can be created around important monuments and buildings, improving connectivity between important historical sites.

  -Module 4: Design Components of TOD, WRI, 2015

  -Adapted from TOD Guidance Document, MOUD, 2016

3. DESIGN OF PUBLIC SPACES MUST BE SENSITIVE TO LOCAL HERITAGE AND CONTEXT

- Preservation of local identity is key in defining unique places and creating a sense of belonging among residents, which are central for TOD projects. Effort should be made to recognize local assets when planning a TOD project. TOD design can serve to complement, enhance, and reflect local cultural, heritage/historical, and environmental features.

  -Module 4: Design Components of TOD, WRI, 2015

- The architectural features of a TOD project should take local context into consideration. Existing buildings can be used as prototypes, and properties of local architecture, including construction materials and facade colors, can influence TOD design.

  -Module 4: Design Components of TOD, WRI, 2015

- TOD projects should also take a community's cultural traditions into consideration when designing development for a neighborhood. If a community has traditional festivals, parades, or weekly markets, these customs must be accommodated through design.

  -Module 4: Design Components of TOD, WRI, 2015

+ REFER OTHER KNOWLEDGE PRODUCTS

AS | EN C01, C02 | PD H03, H04, H05, H06, H07, P01 | FI A02, H02, R01, R03 | IM A01, A02, H01, H02, P01

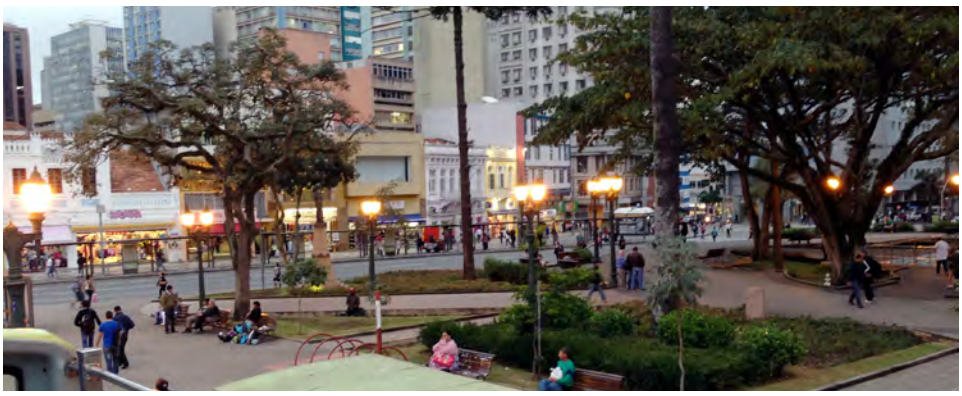
O4

URBAN PARKS & OPEN SPACES

Create open areas such as amenity spaces, green spaces, playgrounds, parks and natural areas, plazas, civic squares, etc. within a five-minute walking radius of residents.

RISK & MITIGATION

- Lack of focus on open spaces in planning, along with an inappropriate allocation of funds towards upgrading facilities in parks and open spaces.
  Open spaces as potential areas for encroachments requires adequate measures on design and enforcement.



Public open space, Curitiba, Brazil

1. PROVIDE OPTIONS FOR OUTDOOR RECREATION, LEISURE AND PLAY AREAS TO PROMOTE HEALTHY COMMUNITIES WITHIN TOD AREAS

- Access to parks and playgrounds is particularly important to the urban poor, who have little access to private facilities and few opportunities to break away temporarily from urban life.

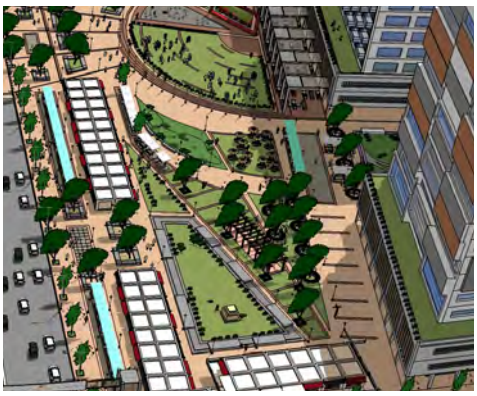
-Adapted from TOD Standard, ITDP, 2017

- A TOD project's designed green spaces should be open to the general public, and access to these areas should be prioritized for non-motorized means of transit.

-Module 4: Design Components of TOD, WRI, 2015

+ REFER OTHER PRINCIPLES

T1 T2 T3 T4 | O1 O2 O3 O4 | D1 D2 D3 D4



Open space within TOD area | *source: MOUD, 2016*

Strategic green areas | *source: WRI, 2015*

Public space networks | *source: WRI, 2015*

2. IMPROVE ECOLOGICAL FOOTPRINT OF TOD AREAS

- Public parks and playgrounds have multiple benefits—from improved air quality, to reduced heat island effects, to the increased physical and mental health and comfort of residents.

  -Adapted from TOD Standard, ITDP, 2017

- TOD design can be integrated with the local environment, including such features as rivers, cliffs, agricultural lands, forests, and regional fauna and floral. Natural areas should be protected from development for the capturing of CO2, aquifer replenishment, and maintenance of biodiversity.

  -Module 4: Design Components of TOD, WRI, 2015

- Public and green spaces also provide opportunities for city officials to incorporate risk and natural resource management into city planning.

  -Module 4: Design Components of TOD, WRI, 2015

- Preservation of sensitive or critical ecosystems and creation of buffers along waterways protect against habitat loss and species extinction, while at the same time improving aesthetics, access to green space, and natural resource production.

  -Module 4: Design Components of TOD, WRI, 2015

3. PROMOTE ENHANCED CONNECTIVITY TO TRANSIT THROUGH PARKS

- While retail and playgrounds should, ideally, be no further than 600m away from any point within a neighborhood, schools and markets should be less than a 1km trip.

  -Module 4: Design Components of TOD, WRI, 2015

- Identify opportunities to provide 'cut-throughs' (i.e. across parking lots or through parks, where such cut-throughs shorten access routes.)

  -Adapted from TOD Guidance Document, MOUD, 2016

+ REFER OTHER KNOWLEDGE PRODUCTS

AS | EN C01, C02 | PD H03, H04, H05, H06, P01 | FI A02, H02, R01, R03 | IM A01, A02, H01, H02, P01

D1

COMPACT DEVELOPMENT

Optimize employment and residential densities along a transit corridor or station area, based on carrying capacities of transit and informal transit infrastructure, to promote walking and transit use.

RISK & MITIGATION

- Undue focus on increasing FARs and densities independent of market forces and absorption capacity fails the objective of achieving compact development. On the contrary, highly compact built up environments may result in deteriorating quality of life with lack of appropriate public open spaces.
- Engaging with private sector early on to create awareness and capacity building would benefit to promote TOD.

City development, Bogota, Colombia

1. ADOPT DIFFERENTIAL LAND USE DENSITIES AS PART OF STATUTORY PLANS

- Incorporate varying densities based on the development potential of different areas.

-Adapted from TOD Guidance Document, MOUD, 2016

- Distribution of FSI has to be varied depending upon the FSI already consumed, proposed land use zoning, and accessibility, particularly, areas in proximity to public transit stations, in order to ensure efficiency of use of land.

-Adapted from TOD Guidance Document, MOUD, 2016

- To establish articulated densities along transit corridors, Building codes can be changed to increase the maximum floor-area-ratio (FAR) permitted and allow for development on smaller plot sizes.

-Module 4: Design Components of TOD, WRI, 2015

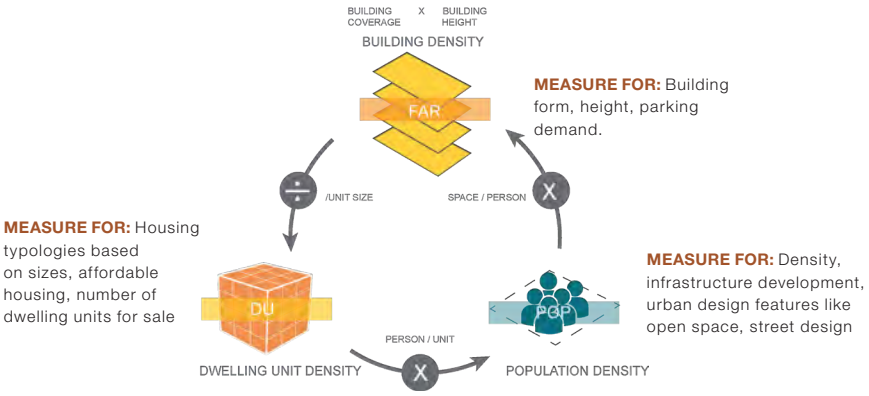
- Land consolidation can be facilitated for larger developments.

-Module 4: Design Components of TOD, WRI, 2015

+ REFER OTHER PRINCIPLES

T1 T2 T3 T4 | O1 O2 O3 O4 | D1 D2 D3 D4

Transition between built form | *source: Metrolinx, 2011*



Quantitative measurements of density | *source: MOUD, 2016*

2. CREATE HIGH-DENSITY NODES BY MEANS OF PREMIUM FARS OR BONUSING

- A typical density bonus program sets a base density that a development may achieve 'by right' and a maximum density that can be achieved by conformance to higher standards or through the provision of qualifying amenities/ benefits/premium paid.
- High-quality design, improved infrastructure, and high-quality amenities also attract and support additional density without producing the sensation of congestion.

  -Module 4: Design Components of TOD, WRI, 2015
- Planning should take into account the level of connectivity of a station, to align human and economic densities, mass transit capacity and network characteristics for greater accessibility.

  -Module 4: Design Components of TOD, WRI, 2015

3. ENSURE OPTIMUM POPULATION AND HOUSING DENSITIES

- Design for buildings and unit sizes can also be adopted to increase density. On smaller size properties, micro-unit apartments or offices can be introduced to increase density; their compact design can raise the number of units able to be constructed within an apartment or office building.

  -Module 4: Design Components of TOD, WRI, 2015
- Minimum standards must be prescribed for urban areas that begin to be transit supportive developments.

  -Adapted from TOD Guidance Document, MOUD, 2016
- New development in the peripheral zone should be allowed only if it abuts existing developed areas with prescribed minimum density and mix of uses.

  -Adapted from TOD Guidance Document, MOUD, 2016
- Both residential & commercial density should be designed to match the area's peak-hour transit, walk and bike capacity.

  -Adapted from The Energy Foundation, 2012

+ REFER OTHER KNOWLEDGE PRODUCTS

AS A01, A02, A03, H01, R01, P01 | EN C01, C02 | PD H01, H02, H03, H04, H05, H06, R02, R03, R04, P01 | FI A01, A02, H01, H02, R01, R02, R03 | IM A01, A02, H01, H02, P01

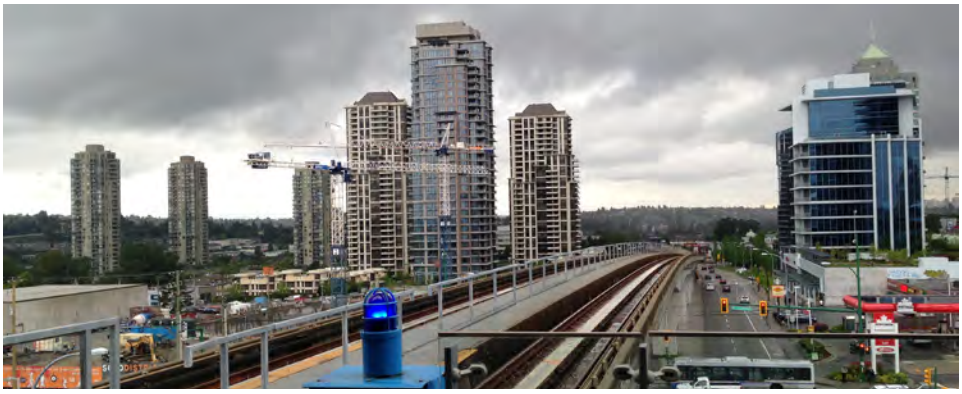
D2

MIX OF USES

Promote more efficient land use patterns by providing residents access to retail, commercial and civic services, employment and recreational facilities without needing to travel by automobile.

RISK & MITIGATION

- Miscalculation in feasibility studies of development projects due to added risks associated by working with the public sector, specific TOD requirements of projects on providing street-facing buildings, a mix of uses or green building techniques, hamper the success rates of TOD projects.
- Lack of market acceptance for mixed-use properties.



Mix of uses at Burnaby, Vancouver, Canada

1. RESIDENTIAL AND NON-RESIDENTIAL USES COMBINED WITHIN THE SAME OR ADJACENT BLOCKS

- **Internally Complementary**: residential and nonresidential uses form a complementary mix within the development. A development is defined as internally complementary if residential uses account for no less than 15% and no more than 85% of the total developed floor area.

-Adapted from TOD Standard, ITDP, 2017

- **Contextually Complementary:** the project's predominant share of floor area is dedicated to uses complementary to the uses predominant in the surrounding station catchment area. A development is defined as contextually complementary if either: more than half of its floor area is dedicated to uses that balance the category of uses predominant in the station catchment area, or the development is internally complementary and located in a station area with a residential use balance between 40% and 60%.

-Adapted from TOD Standard, ITDP, 2017

+ REFER OTHER PRINCIPLES

T1 T2 T3 T4 | O1 O2 O3 O4 | D1 D2 D3 D4

Land ownership | *source: MOUD, 2016*

Use setbacks in some areas to create plazas

View of building maintained through transparency

Commercial or mixed-use street frontages

Various types of active building frontages | *source: MOUD, 2016*

2. ACCESS TO LOCAL SERVICES

- Entrances within a 500m walking distance of fresh food sources and a 1,000m walking distance of primary or elementary schools and a healthcare service or a pharmacy.

  -Adapted from TOD Standard, ITDP, 2017

- Provide effective basic accessibility from the residences to facilities and commerce.
  - Retail that is, at most, a 600m trip
  - A playground that is, at most, a 600m trip.
  - A preschool and an elementary school that are, at most, a 1km trip.
  - A space destined for open or movable markets that is, at most, a 1km trip.

  -Module 4: Design Components of TOD, WRI, 2015

3. ACTIVE GROUND FLOOR

- **Boundary Walls:** In all TOD projects, boundary walls along any edge facing a public open space, pathway, road, park, etc. shall be prohibited. In case enclosure of sites is required, translucent fencing shall be used.

  -Adapted from TOD Guidance Document, MOUD, 2016

- **Active Frontage:** Active frontages include arcades, shop-fronts, entrance doorways, access points, entry/exits and transparent windows of active areas facing the primary access street. It is considered visually active if 20% or more of the length of its abutting building frontage is visually active.

  -Adapted from TOD Standard, ITDP, 2017

  -Adapted from TOD Guidance Document, MOUD, 2016

- **Setbacks:** For Integrated TOD Schemes, provide zero front setback and other setbacks no greater than 5m for private buildings and 10m for public buildings, and for any of the other façades.

  -Module 4: Design Components of TOD, WRI, 2015

  -Adapted from TOD Guidance Document, MOUD, 2016

+ REFER OTHER KNOWLEDGE PRODUCTS

AS A01, H01, R01, P01 | EN C01, C02 | PD H01, H02, H03, H04, H05, H06, R02, R03, R04, P01 | FI A01, A02, H01, H02, R01, R02, R03 | IM A01, A02, H01, H02, P01

D3

HOUSING DIVERSITY

Provide a diversity of housing choices, which includes a mixture of types, styles, price ranges and tenure, within a 10-minute walking distance from a transit station, to foster the creation of equitable TODs.

RISK & MITIGATION

- High standards of development burden the project with additional costs, coupled with hampered financial returns due to affordability, provision of services & amenities.
  Land speculation at the onset of transit infrastructure implementation burdens the affordability of housing demand.
- Incorporating opportunities for zoning code exceptions, re-scaling projects, identifying new funding sources are a few measures that could help successful provision of housing supply.

Neighborhood of Copacabana Beach, Rio de Janeiro, Brazil

1. PROVIDE FORMAL SUPPLY OF AFFORDABLE HOUSING STOCK WITHIN TOD AREAS

- All apartments/group housing private and government scheme with a plot size exceeding 2000 sqm must compulsorily reserve a minimum FAR for affordable housing units, as mandated by local acts or policies.
- Ensure all TOD projects provide for the needs of diverse income groups including Economically Weaker Sections (EWS), Lower Income Groups (LIG) & Middle-Income Groups (MIG) as an integral component of the housing units with relevant unit sizes.

+ REFER OTHER PRINCIPLES

T1 T2 T3 T4 | O1 O2 O3 O4 | D1 D2 D3 D4

Housing typologies | *source: MOUD, 2016*

Balanced mix of housing choices along transit corridor | *source: MOUD, 2016*

2. ENSURE MINIMUM SUPPLY OF AFFORDABLE HOUSING OPTIONS FOR LOW & MIDDLE-INCOME GROUPS

- Minimum percentage of FAR for all TOD projects to be allocated to rental or for sale housing or low-income families.
- Housing options should accommodate a mix of income levels and age groups. (China)
- Mix housing, shops and services within commercial districts to create 24-hour communities.

-Adapted from The Energy Foundation, 2012

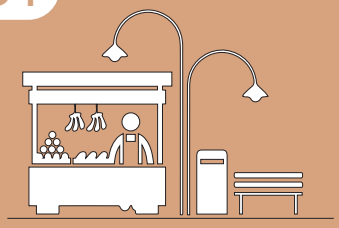
3. ADOPT INCENTIVES IN PROMOTING HOUSING FOR ALL IN TOD AREAS

- The developer may be entitled to receive additional FAR equivalent to 100% of the built-up area utilized for EWS and 50% of the built-up area utilized for LIG units.
- Projects providing affordable housing within TOD areas shall be eligible for following incentives to the extent of EWS and Housing mix by units LIG housing in terms of FAR used, over and above the mandatory reservations:
  - Fast track approval process
  - Exemption from Building Plan sanction fee

+ REFER OTHER KNOWLEDGE PRODUCTS

AS A01, A03, H01, R01, P01 | EN C01, C02 | PD H01, H02, H03, H04, H05, H06, R02, R03, R04, P01 | FI A01, A02, H01, H02, R01, R02, R03 | IM A01, A02, H01, H02, P01

D4



INFORMAL SECTOR INTEGRATION

Strive to achieve inclusive development in TODs by addressing the needs of the informal sector in all aspects of policy, planning and design for street vendors, settlements and transportation services

RISK & MITIGATION

- Lack of detailed inventory and dynamic variations that require continuous updates on the inventory hinders the provision of space and facilities
- Lack of a comprehensive policy for incorporating informal sector in planning processes.
- Creation of a digital inventory of the informal sector with regular updates resonates with the provision of space and amenities
- Incorporate the informal sector in all planning and infrastructure interventions to work in conjunction to with them.

Slum development at Asalpha metro station housing diversity, Mumbai, India

1. INCORPORATE STREET VENDORS AND THEIR NEEDS IN PUBLIC REALM

- Vending zones shall be provided at regular intervals (approx. 10-minute walk from every home/workplace).

  -Adapted from TOD Standard, ITDP, 2017

- Vending spaces should be marked in addition and adjacent to the walking path, especially along high pedestrian volume areas to activate the street and make it safe.

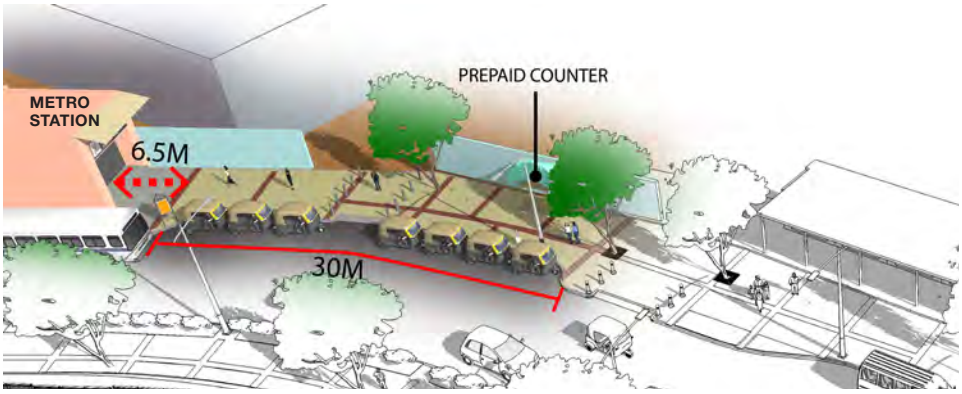
  -Adapted from TOD Guidance Document, MOUD, 2016

- Determination of vending zones as restriction-free-vending zones, restricted vending zones and no-vending zones.

  -Adapted from TOD Guidance Document, MOUD, 2016

+ REFER OTHER PRINCIPLES

T1 T2 T3 T4 | O1 O2 O3 O4 | D1 D2 D3 D4



Designated informal transit zone | *source: MOUD, 2016*

Designated vending zones | *source: MOUD, 2016*

2. DESIGN FOR INTEGRATED INFORMAL TRANSPORT SECTOR NEEDS AT TRANSIT STOPS AND STATION AREAS

- Organize informal transit and ride-sharing services within 800m from transit station facility through Dial-an-auto/rickshaw services, prepaid booths, Passenger Pick-up & Drop-off areas or Remote Informal Transit/Taxi Parking lots.

  -Adapted from TOD Guidance Document, MOUD, 2016

- Multi-Utility Zone (MUZ) of minimum 1.8m width should be provided to accommodate bus stops, street utilities, trees, informal transit/NMT stands.

  -Adapted from TOD Guidance Document, MOUD, 2016

3. INFORMAL SETTLEMENTS HAVE TO BE CONSIDERED IN REDEVELOPMENT PROPOSALS

- Preparation of Slum Redevelopment Plan as per relevant Guidelines; or Slum Redevelopment with private sector participation; or Town Planning Schemes for land pooling and plot reconstruction in greenfield areas.

  -Adapted from TOD Guidance Document, MOUD, 2016

+ REFER OTHER KNOWLEDGE PRODUCTS

AS A01, A02, A03, H01, R01, P01 | EN C01, C02, H01 | PD H03, H04, H05, H06, P01 | FI A01, A02, H01, H02, R01, R02, R03 | IM A01, A02, H01, H02, P01

A WALKING INFRASTRUCTURE

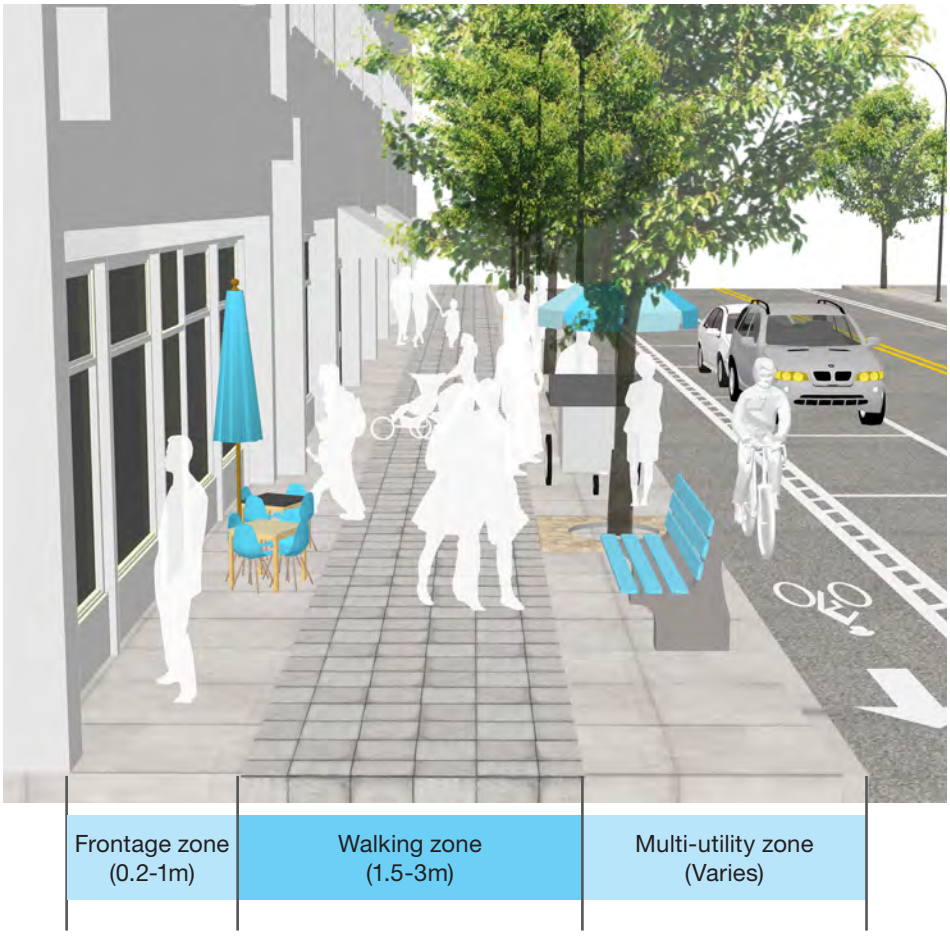
Walking is the most important mode in any station area, not just for direct access to the transit station, but also, as the most likely means of first and last mile connectivity to other commute modes. The most crucial component of the walking network is obviously the footpath; that is the area along the general right-of-way that is assigned specifically for pedestrians. A cohesive and dense network of footpaths, (of adequate capacity), ensures a high level of safety for walking in the station areas.

Footpath Design

The footpath is the most crucial component of the walking network. The footpath is that component of the street that is assigned for the specific use of pedestrians.

Not all the space on a footpath is meant exclusively for walking. A well-functioning footpath will have spaces assigned for other important elements and uses. A footpath comprises of three components:

1. Frontage zone: This is the area touching the boundary of the right-of-away, that is, abutting the property edge line or compound wall. It is meant to accommodate spill-over uses from the adjacent property. This area is not considered to be part of the walking zone, because, normally, pedestrians avoid walking in close proximity to a wall or a building.
2. Walking zone: It is the area immediately adjacent to the frontage zone which is actually used by pedestrians to walk. This space should be kept free of encumbrances that impede walking.
3. Multi-utility zone: It is the area, normally located between the walking zone and the traffic or parking lane. It's use will vary depending on the context, to accommodate street vending, street furniture, trees, utility boxes, light poles, signal posts, signage posts, crossing waiting areas, etc.



Three components of a footpath

The three stated components of the footpath are notional. Their actual space requirements are likely to vary along the corridor, depending upon the context along the right-of-way, as well as the adjacent land-use.

FRONTAGE ZONE CONSIDERATIONS

- The width of the frontage zone can be thought out to be between 0.2 to 1 meter. In the case of a residential area, the frontage zone needn't be very wide.
- If there is a commercial establishment along the road edge, then the frontage zone should be assumed to be wide enough to accommodate spill-over activity, like waiting, window-shopping, etc.
- In the case of large developments, such as a shopping mall, office complex, public or institutional building, it is a good practice to ensure that building setbacks are designed to serve as additional frontage zones.
- This ensures that there is no spillage of activity onto the walking zone and can be achieved through design regulations that stipulate a soft edge between the property and the right-of-way, without f a boundary wall.

Compound wall impact on the walking path

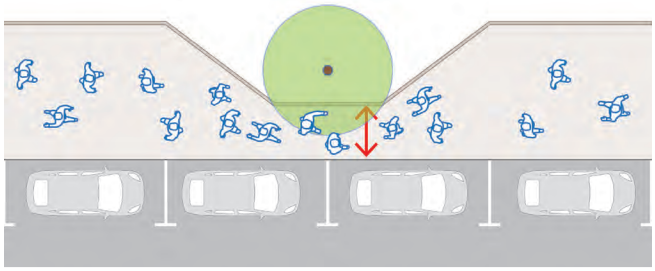
- In many high-density areas, there may be a gap between a desirable frontage zone width and what is practically possible on-ground. In such cases, compromises are unavoidable.
- One strategy that can be adopted to reduce the necessary width of the frontage zone is to place regulations that eliminate or control the height of the compound wall. If the compound wall is absent, (or below waist level), then pedestrians are more likely to use the space near the edge of the footpath. Moreover, high compound walks encourage the misuse of the footpath edge, which is then prone to decay over time. This further dissuades pedestrians from walking close to the road-edge, and if left unchecked, this decay can gradually encompass the entire footpath.
- Regulations should also be put in place to disallow the use of pointed / barb-wired fencing and to restrict vertical obstructions, (such as shop hoardings, gates, planter pots, low-height canopy roofs, etc). All these elements discourage pedestrians from walking close to the road edge.

WALKING PATH WIDTH

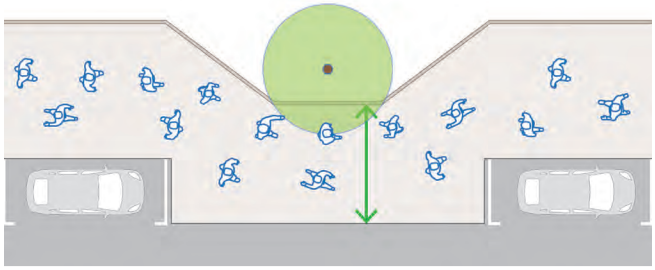
- The most important design consideration for the walking zone is to ensure it has adequate width and is free of any hindrance. For feeder lines to the main walking routes, a walking path width of 1.5m minimum may be acceptable, as this allows two pedestrians to cross each other without hindrance.
- In compromised situations, provisions for the frontage zone or the multi-utility zone may be reduced, before considering reducing the walking path width beyond 1.5m.
- For the main trunk walking routes leading to the transit station, the ideal provision will depend on projected commuter volume, the desired pedestrian Level of Service and total available right-of-way.
- Typically, 3m should be the minimum width for the walking zone on a trunk route.

Deviations in the walking path

In some situations, deviations in the walking path are unavoidable - on account of the presence of a tree or a difficult-to-relocate utility box. In such cases, the walking path should be designed to curve around the encumbrance, preferably with



Immovable obstructions on the footpath restrict pedestrian movement



Deviations made around immovable obstructions along walking path

a gradual transition.

Distinguishing the walking path

- Visual cues to distinguish the walking zone, may be provided by using softer design elements, such as a different pavement style or surface treatment (paved versus landscaped), or creating a marginal height difference.
- These cues aid in guiding road user behavior, informing people about the appropriate use of the space.

Walking path continuity

- An important design consideration for the walking zone is to ensure a uniform height along the entire length of the footpath by maintaining the same height for the walking path across property entrances and exits. There are two aspects as to how this can be achieved:
    1. Planning aspect - restricting vehicular access on main pedestrian routes; and
    2. Design aspect - bringing vehicles up to the footpath height using ramps (accommodated in the multi-utility zone on the traffic lane side, and in the frontage zone or within the property on the property edge side.

Footpath height

- The recommended footpath height for any urban area, including a station area, is normally 10 to 15cm.
- Footpaths greater than 15cm high are cumbersome for pedestrians, especially mobility impaired users.
- They make the provision of accessibility ramps very challenging as they take up the entire width of the footpath. In many cases, footpaths are not wide enough to accommodate the ramp, without significantly increasing the steepness of the slope and make the ramp inaccessible.
- When footpaths are not wide enough to accommodate the 15cm high ramp, then consider reducing the height of the footpath to 10 cm in this section. A 10cm high footpath requires a 50% shorter ramp than a 15 cm high footpath.
- This measure must be used sparingly and with caution, because a 10 cm high footpath is easier to be mounted by vehicles, which may encourage erring motorists to park or drive on the footpath.
- Footpath can also be at the same level as the road with separation achieved by bollards, curbs or different pavement material.

MULTI-UTILITY ZONE DESIGN

There is no standard width for this zone, as it will depend on context and the available right-of-way. Typically, this zone is the best place to absorb any variations in the width of the right-of-way, as this space can be widened or narrowed as required.

- The multi-utility zone can accommodate the uses and functions that are essential for the pedestrian environment, apart from the walking space like seating and waiting areas and street-vending.
- This zone can also accommodate other fixed elements in the right-of-way, such as trees, lamp posts, signal posts, signage posts, utility boxes, etc.
- Multi-utility zone also as a buffer between pedestrians and fast moving traffic, increasing the level of safety.
- It is also essential to have an 'active sidewalk' that can be achieved through active frontage from commercial and recreational activities at the street level of the developments as well as encouraging vending and other activities in the multi-utility zone. This ensures there

Active building frontage and on-street vending along a sidewalk in Mumbai, India

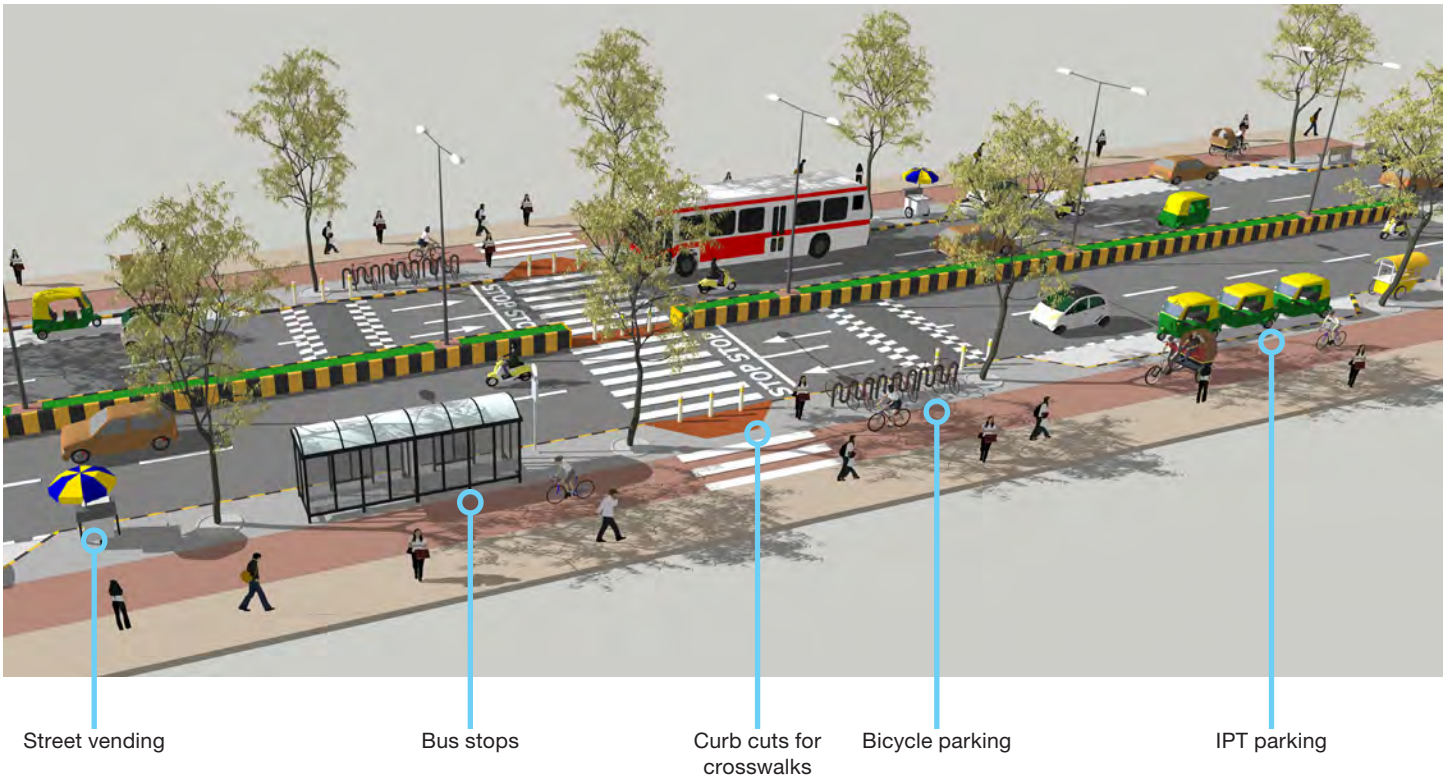
are 'eyes-on-street' and provides a sense of security to pedestrians.

STREETLIGHTS

Improved street lighting, along with providing a sense of security, contributes towards increased safety and prevents road traffic crashes, injuries and fatalities due to improved visibility. It enables motor vehicle drivers, cyclists and pedestrians to move safely and comfortably, by reducing the risk of traffic accidents and improving personal safety.

Lack of activities on the sidewalk and inadequate streetlighting can create unsafe experience for pedestrians and force them to use the vehicle travel lanes which are typically more well lit. This raises conflicts between the different road users leading to potential crashes.

- The streetlights should preferably be placed in the multi-utility zone, clear of pedestrian walkways. It's placement can be coordinated with other street elements such as trees, signage, seating, vending etc. so that they do not impede proper illumination.
- Lighting must be directed downwards as up lighting might result in spillage of light, wastage of energy, and create night sky light pollutions.
- Lighting needs of pedestrians are different from those of vehicular traffic, and therefore need to be designed and integrated within the overall lighting strategy for the street.
- Additional lighting should be provided at conflict points.



Typical multi-utility zone with different types of uses

Crossing Design

The design of safe crossings is a crucial component of the walking network for a station area. There are many important considerations for pedestrian crossings, which are discussed over the following sub-sections.

CROSSING FREQUENCY AND LOCATION

The most important aspects of pedestrian crossing provision is their frequency and location. From the perspective of access to the transit station, crossings must be provided such that the continuity of the walking network is maintained.

A station area with a higher density of crossing opportunities is typically safer and better for walking:

- Crossing infrastructure must be provided at all intersections.
- Block sizes should be limited such that intersections crossings are not more than 150-200m apart in the high-density areas close to the station. In already developed areas, it may not be possible to modify block sizes, hence mid-block crossings may be provided.

It should be noted here that in the earlier Knowledge Product of PD-H07, the subsection on “Capacity” recommends reduction of interruptions on trunk routes, in order to keep the traffic moving. These interruptions arise due to access points for vehicles into the buildings or land parcels. It has been recommended that these access related interruptions be shifted to parallel tertiary streets or feeder routes. These interruptions are within the recommended 150-200m (discussed above) of consecutive pedestrian crossings. This modification of access points would therefore not hinder the pedestrian movement in the area.

CROSSING WIDTH

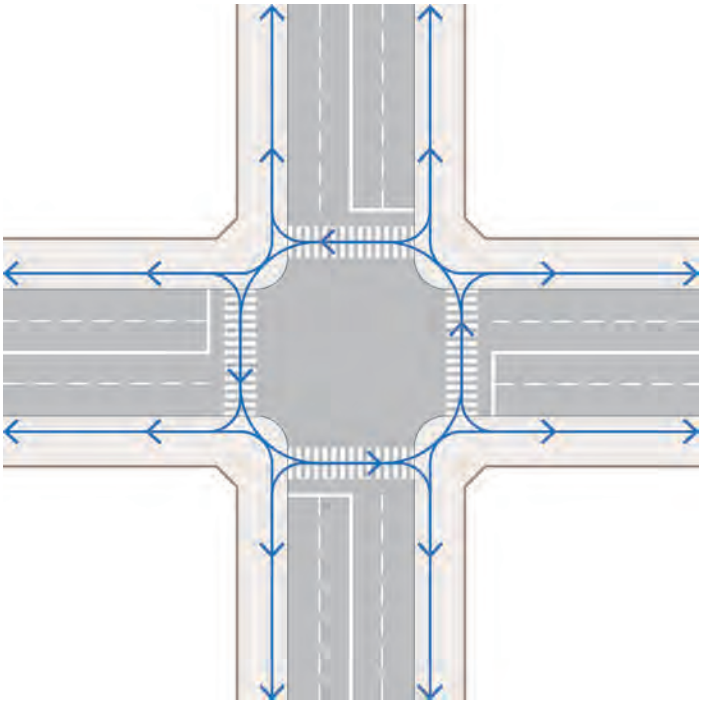
- A pedestrian crossing must be at least as wide as the footpaths that it connects.
- An even wider crossing width may be desirable, as it allows for more people to cross at the same time, which reduces delay and allows for shorter pedestrian signal cycles.
- For a wider crossing, it is recommended to have a minimum width of 3m, though a width closer to 5m may be desirable on high volume routes that connect to mass transit stations or BRT stops catering to high volume of pedestrians going towards and coming out from the stations or BRT stops.

CROSSING ALIGNMENT

Deciding on the alignment of a pedestrian crossing raises two questions:

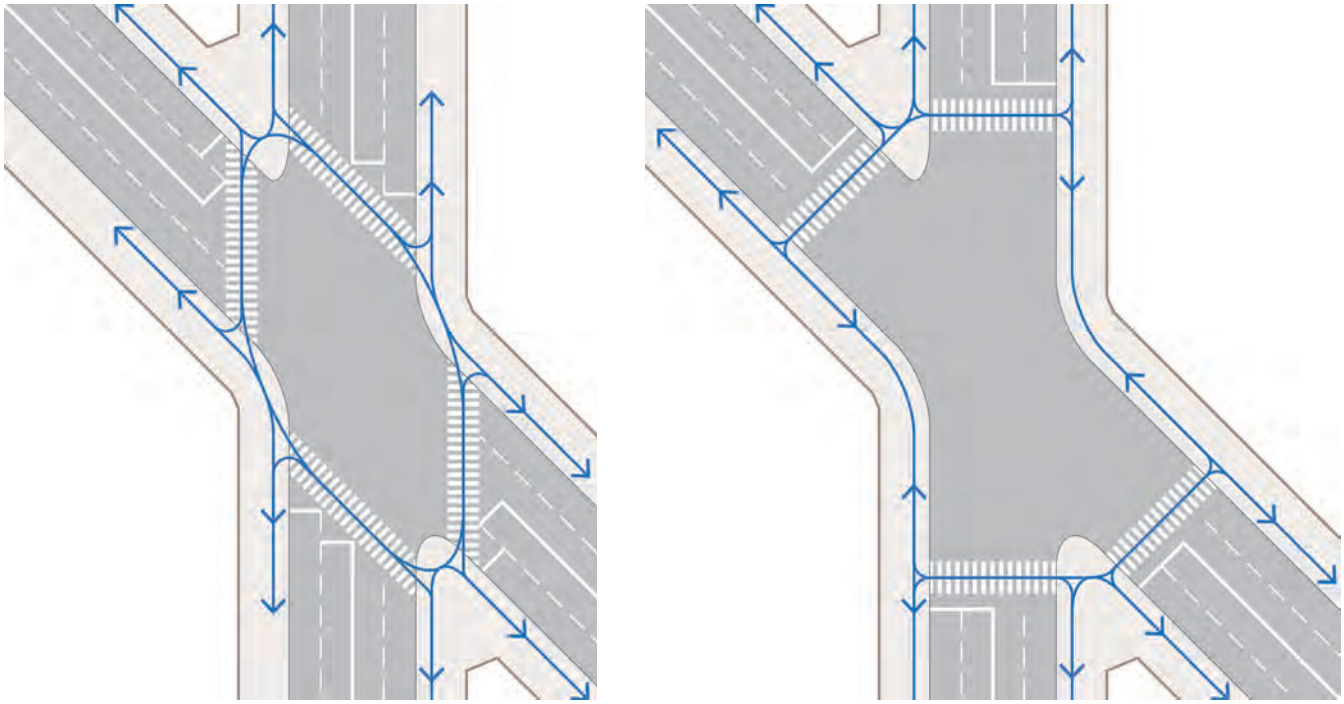
1. Should the crossings be so aligned that it continues the natural walking path between the two adjoining footpaths? Or
2. Should it be aligned perpendicular to the traffic lanes, such that crossing distance is minimized?

- The natural walking path and the shortest crossing distance will align perfectly with each other in a 4-arm intersection, where both roads are at right angles to each other.



Natural walking path and desire lines for a right-angled intersection.

- If the angle of the intersection is skewed, then there will be a deviation in the two paths. So the question becomes, which parameter should one follow.
    - For unsignalized intersections, choose the alignment that minimizes the crossing distance. This reduces the amount of time that the pedestrian is put into potential conflict with vehicular traffic. Moreover, it positions the pedestrian and traffic perpendicular to each other, which improves their visibility of each other.
    - For signalized intersections, pedestrians will want to avoid deviations to their natural walking path. It is recommended aligning the crossing as close as possible to the straight line connecting the two footpaths.



Movement patterns in a skewed intersection Crosswalks along desired lines (Left) Crosswalks along shortest distance (Right)

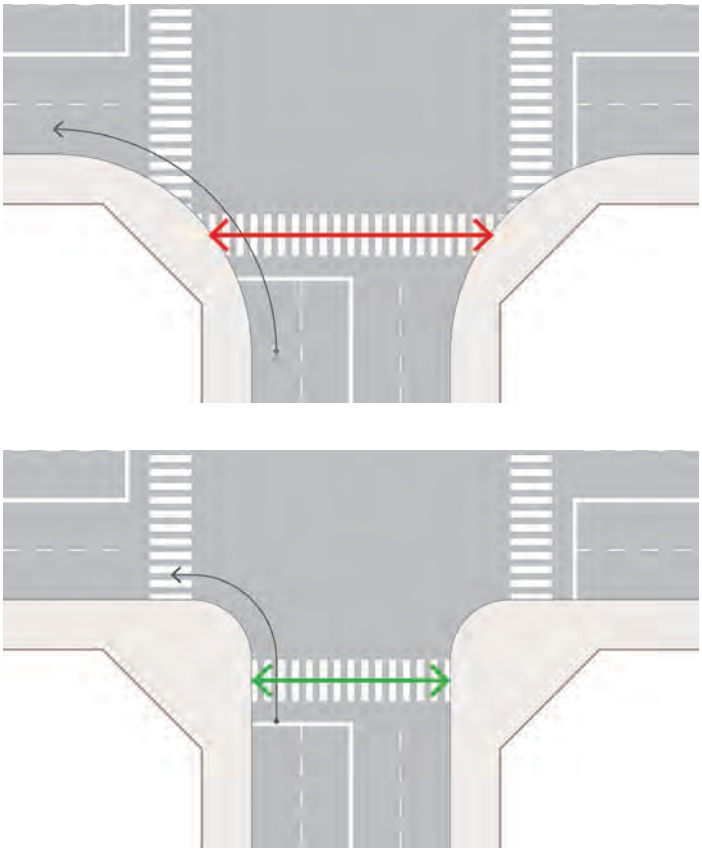
INTERSECTION DESIGN

Intersection corner curvature

The curvature of intersection corners has a significant impact on pedestrian safety.

- A generous curvature allows vehicles to make free turns at intersections at high speeds, which puts pedestrian at risks, particularly at unsignalized intersections.
- A wide curvature also increases the size of the intersection, which increased the area of undefined road space where conflicts may arise.
- Pedestrian crossings get pushed further back and away from the natural crossings path.
- A wide intersection curvature reduces the availability of space to accommodate pedestrians waiting to cross the road.

It is recommended to have intersection corner curvature radius approximately 4-6m, which allows for most vehicles to make a safe turn at a slow speed.

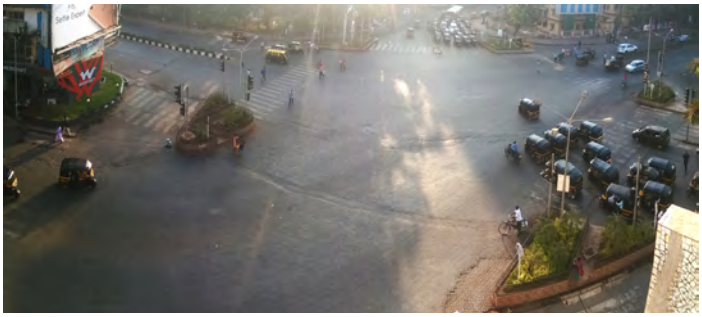


Reducing intersection corner curvature increases pedestrian safety as it enables drivers to turn at significantly slower speeds and also reduce pedestrian crossing time.

Slip lanes

- Slip lanes may be provided to give turning vehicles an exclusive lane. This is not desirable in most urban contexts, from the perspective of pedestrian safety.
- If the removal of the slip lane is not possible, it is recommended to ensure that traffic speeds are brought down close to zero, through traffic calming measures and signage like “Yield to Pedestrians” for vehicular traffic.
- The traffic islands created due to provision of slip lane infrastructure must be accessible to pedestrians and should be utilized to accommodate pedestrian waiting areas and accessibility ramps.

BEFORE



TACTICAL INTERVENTION

AFTER

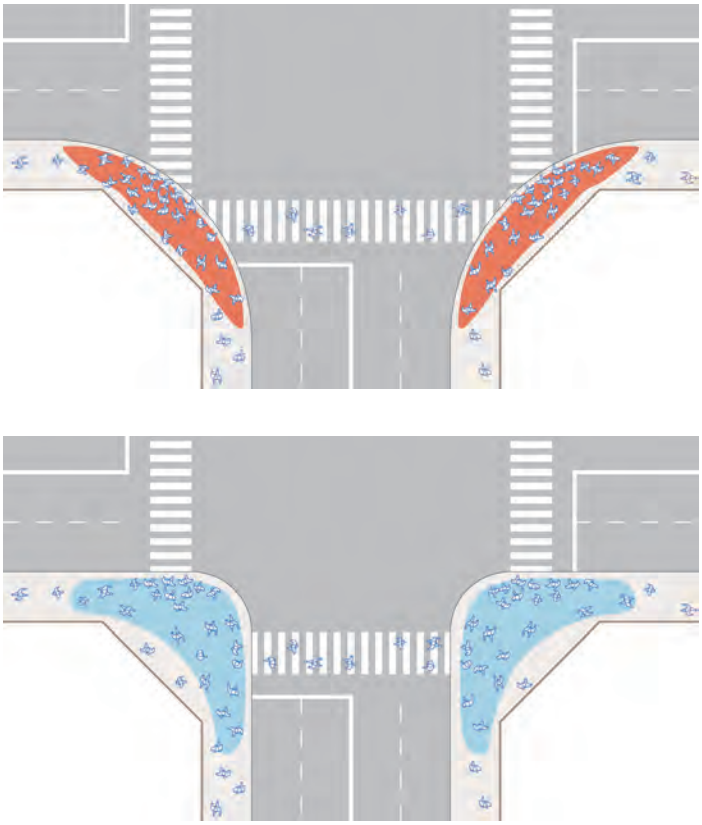
Slip lanes provided as part of HP Intersection redesign in Mumbai, India

(Source: WRI India)

Pedestrian waiting area

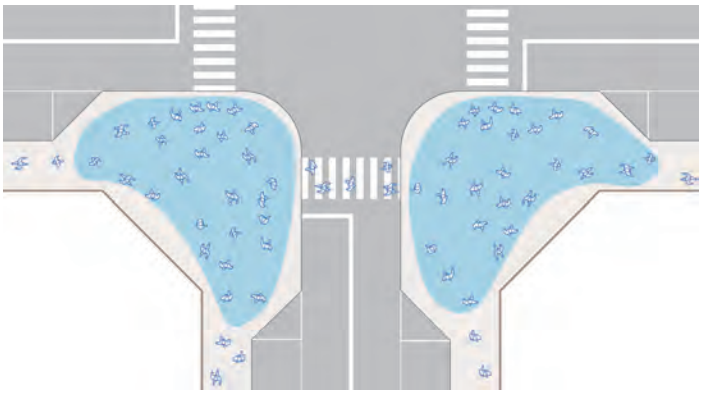
The pedestrian waiting area is an important component of a crossing. This space is especially important for signalized intersections to accumulate the build-up of pedestrians waiting for their light to turn green.

- The space requirement of the pedestrian waiting area is likely to be very high on the trunk walking lines in a station area, and if adequate space is not provided, pedestrians may spill onto the traffic lane.
- The pedestrian waiting area must be kept distinct from the walking area, otherwise waiting pedestrians will hold up walkers who just want to pass through.
- The best way to ensure a large waiting space, is to keep the intersection corner curvature as tight as possible.



Tighter intersection corner curvature provides more waiting area for pedestrians.

- Another measure is to eliminate the parking lane, if present, at the intersection, and create a curb extension to accommodate the waiting area.



Curb extensions created by removing travel lanes. These further reduce crossing times for pedestrians

Accessibility ramps

The provision of ramps is an absolutely critical aspect to ensure that street infrastructure is accessible to all roads users, including wheelchair-bound pedestrians. Ramps not only benefit mobility-challenged road users, but are also useful for pedestrians pushing baby strollers, shopping carts, hand carts, luggage, trolleys, etc.

- A well-designed ramps consists of flared portions on either side of the ramp, (maximum slope of 1:12), that allow the wheeled unit to enter or cross the ramp from any side.
- Preferably, a landing portion (flat horizontal space) should be present at the end of the ramp to accommodate waiting commuters. However, if the footpath is not wide enough to allow for a landing, then the presence of side flares in the ramp, allow for a wheeled unit to traverse the ramp with ease.
- It is recommended to avoid the use of interlocking paver-blocks for ramps, as it is difficult to fit them to the complex slope geometry required for the different components of ramps. Cement concrete is a preferred material.
- It is preferable to maintain two separate ramps for each crossings at an intersection corner. However, if the footpath area is insufficient to have two ramps, then one can consider using a combined ramp.
- Care should be taken to design it such that the pedestrian doesn't enter the intersection along the diagonal, but does so in line with the crossing.

Traffic signals

All major intersections in the station areas must be equipped with traffic signals, which incorporate pedestrian signal cycles:

- Any crossing that has more than two lanes, without the presence of a median, must have a pedestrian signal.
- The pedestrian green phase must be long enough to allow for most pedestrians to cross the road in one phase. The pedestrian green times may have to be even longer on the main walking routes within the immediate station areas which may be synchronized with the timings of transit services to accommodate the higher volume of pedestrians going towards and coming out from the mass transit stations or BRT stops. These time synchronization are critical where interchanges between one mode to another takes place, and the connections aren't direct and require crossing a road to access the stations.
- Signal priority and signal synchronization for pedestrians allows for pedestrians to face a "green wave" (uninterrupted green phases as soon as they reach the intersection); which aids in the safe and convenient access to the station.
- Additional Intelligent Transportation System (ITS) technologies can be incorporated which include use of AE cameras to detect over speeding of vehicles and turning the signal red to ensure speeds under safety limits are maintained within the station area.
- Saw cut loop detectors can be buried at intersections to detect traffic presence and accordingly phase the signal cycles to avoid traffic jams that may impede movement of shared modes and feeder services.

Traffic calming elements

Traffic signals are generally not recommended for minor intersections, with 1 or 2 lanes. In these situations, other traffic calming measures may be adopted to ensure that pedestrians can cross the intersection safely.

Curb extensions can be utilized to reduce the crossing distance at the intersection. Speed humps and tables aid in slowing down vehicular traffic. For very minor side streets, one can consider continuing the footpath across the length of the intersection, using ramps to allow for vehicles to cross the footpath.

Mid-block crossing

- A mid-block crossing may be necessary if the block-size is very large.
- Traffic signals are recommended if the pedestrian has to cross more than 2 lanes without the presence of a median, or if there is a very high volume of traffic.
- It is recommended that mid-block crossings be accompanied by traffic calming infrastructure, such as speed humps or speed tables. Curb extensions may be provided by discontinuing parking lanes close to the mid-block crossing.

Off-road pedestrian path design

Off-road pedestrian paths may also be augmented with the utilization of grade-separated infrastructure. There are broadly two categories for such infrastructure:

- Infrastructure only meant to cross a single road, such as a Foot-over Bridges (FoBs) or an underpass.
- Grade-separated infrastructure of a much longer length that provides direct connectivity to multiple locations the transit station and may comprise of a network of interconnected sections. Such infrastructure is normally elevated, and commonly referred to as skywalks, though there are cases of sub-terrain pedestrian networks as well.

Foot-over-bridges (FoBs) or Underpasses

- FoBs and underpasses are not recommended as crossing substitutes as they are very expensive, and impractical to implement at each location.
- Pedestrians also do not prefer them, because of the physical exertion and time delay involved, in comparison to crossing at street level.
- This infrastructure is unfriendly to the needs of vulnerable users.
- The access points of such infrastructure tends to impede the free movement of the footpath, because of the presence of stairwells and elevator shafts.

Foot-over-bridge restricting pedestrian movement on the sidewalk near ITO metro station in New Delhi, India
(Source: © The World Bank)

Grade separated infrastructure

A grade-separated pedestrian networks may be useful to augment at-grade pedestrian infrastructure.

- They may also provide direct connectivity of major establishments to the transit station, which can be have a positive impact both for walking and for transit patronage.
- While there are contexts where the provision of such infrastructure has benefits, their provision must only be considered as addition to at-grade infrastructure.

Foot-over-bridge connecting to the mixed development at the Novena MRT Station, Singapore
(Source: © The World Bank)

B CYCLING INFRASTRUCTURE

Cycling is a healthy and sustainable mode of commute that can play an important role in enhancing connectivity to transit. It has a higher reach than walking, which greatly increases the commutable distance to the transit station.

The most crucial aspect for cycling safety is the design of street infrastructure. The cycling network for the station area will comprise of the judicious use of dedicated cycle lanes where viable, in combination with traffic-calmed, shared streets. This section covers best-practices for the provision of cycle lanes, with respect to the station areas. This includes aspects related to the provision, typology and design.

Cycle Lane Design

CYCLE LANE PROVISIONS

It is recommended to use dedicated cycle lanes on trunk routes of the cycling network, leading to the station. Normally, the trunk cycling corridors will also contain the trunk transit and motor-vehicular routes, and hence will have a high volume of large vehicles and fast-moving traffic. Thus, the provision of dedicated cycle lanes can have a significant positive outcome on cyclist safety.

It should be noted that the cycle lane is not only for bicyclists, but for all wheeled, active modes of transport, which includes wider vehicles, such as tricycles or cycle-rickshaws.

There are, broadly, two kinds of cycle lanes:

1. Physically segregated from vehicular traffic, either, by curbs, medians, railings or landscaping.
2. Marked cycle lanes provided on the main carriageway itself, normally delineated through the use of road-marking and roadside signage.

Physically segregated versus marked cycle lanes

- Segregated infrastructure reduce the possibility of a motor-vehicle entering the cycle lane and colliding with a cyclist.
- It is recommended to avoid use of railings to segregate, because it effectively reduces the usable width of the cycle lane, as cyclists don't tend to ride closer to the railings. Medians or landscape strips should be used instead.
- The use of lane-marked cycle lanes are often more practical as they cost less. The maintenance, cleanliness and drainage of lane-marked cycle lanes are a lot easier as compared to segregated infrastructure.

Directionality

- Typically, lane-marked cycle lanes are uni-directional, and cyclists are expected to ride in the same direction as traffic on their side of the road. In this case, cycle lanes are expected to be provided on both sides of a two-way road.
- It is recommended to avoid use of contraflow cycle lanes, where cyclists travel in the opposite direction of adjacent traffic as it puts them at risk of head-on collisions in case a motor-vehicle enters the cycle lane.
- Segregated cycle lanes can be uni-directional or bi-directional. When designed to be bi-directional, the cycle lane acts much like a footpath, and cycle crossings can be designed in sync with pedestrian crossings.
- The advantage of a bi-directional cycle lane is that it can be provided one side of the road. This helps with planning the cycling network in station areas, as it may allow for the provision of dedicated trunk route connectivity on roads with constrained space availability.

Width

- Uni-directional cycle lane must be at-least 1.5m wide and it will depend on whether there is parking space or a bus lane on the adjacent space. This allows for some buffer from traffic moving in the adjacent lane.
- It however does not provide enough width for a faster cyclist to overtake a slower one. For long block lengths, it is recommended to provide pull-out zones to allow for cyclists to safely overtake.

Uni-directional marked cycle lane

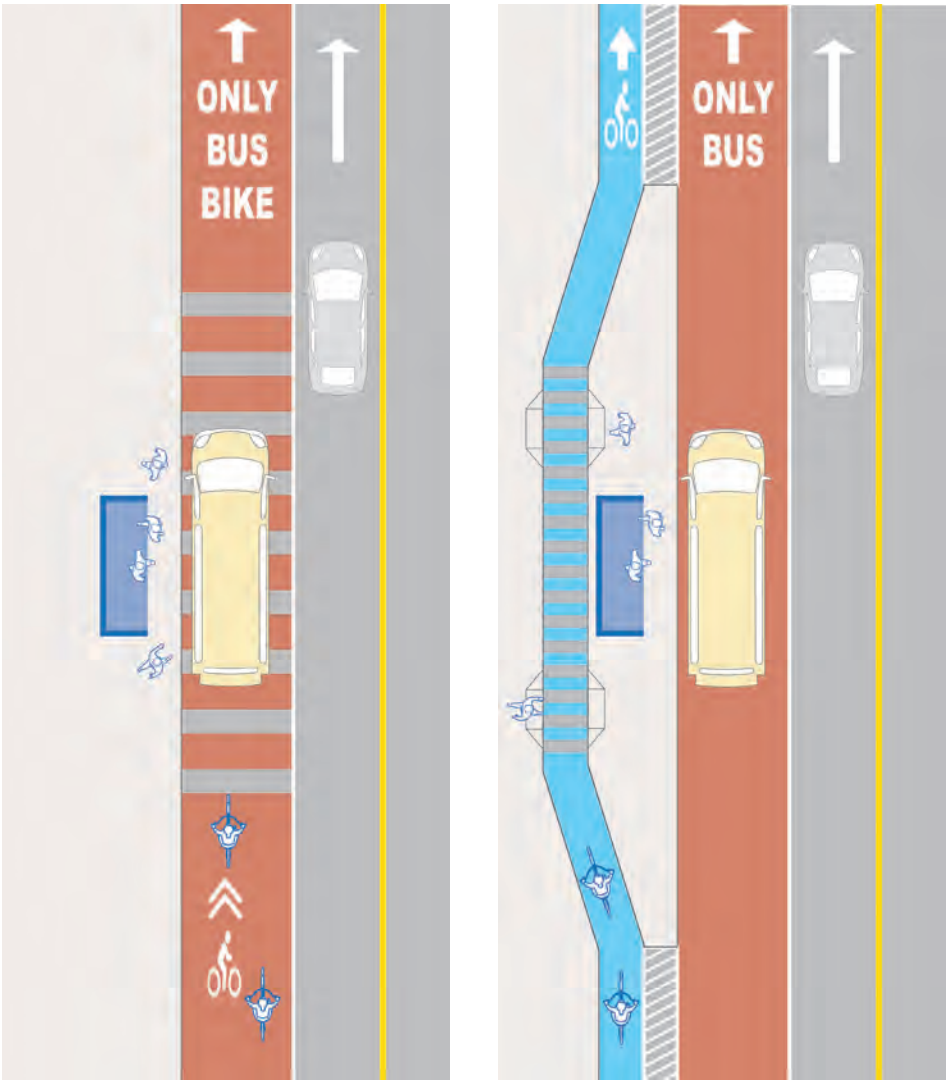
- `A bi-directional cycle lane must be at least 2.5m to allow for cycling units to pass each other.

Bi-directional marked cycle lane

Cycle lanes positioning across bus stops

The overlap of cycling routes and feeder bus routes can create potential safety conflicts. Buses need to stop next to the footpath to pick-up and drop-off commuters. This may mean that the bus has to cut into the cycle lane to access the bus stop. This is a potential safety risk, given the mass and speed of the bus in relation to the cyclist. This risk is further heightened by the fact that the bus driver has to change lanes behind the line of sight of the cyclist.

- It is recommended that cycling routes and bus-feeder routes be kept separate.
- Where sharing the route is unavoidable, the cycle lane be continued behind the bus stop, Here, the bus stop area is separated from the footpath, and commuters will have to cross the cycle lane to access the bus stop.

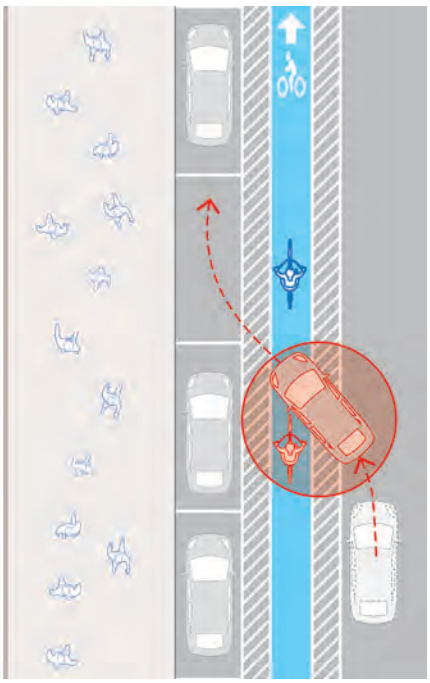


A shared bus and bike lane (Left) versus Separate bus and cycle lanes, with cycle lane going behind the bus stop (Right)

A bus station bypass in Rio de Janeiro, Brazil that raises the bicycle lane to the sidewalk level while bypassing the bus waiting area.
(Source: © WRI)

Cycle lanes and on-street parking

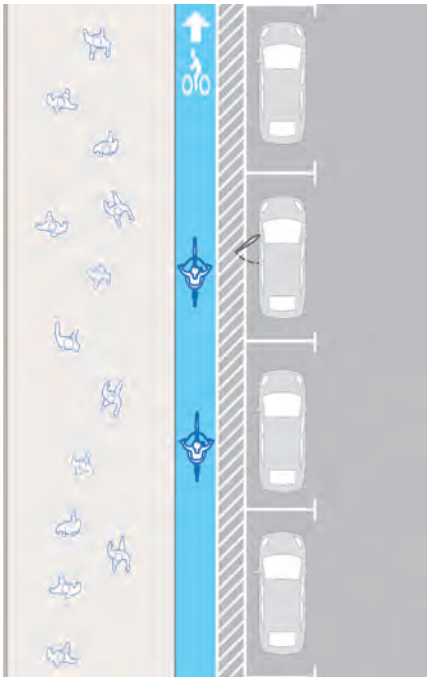
- On-street parking creates potential safety conflicts for cyclists.
- Vehicles benefit from being parked as close to the footpath as possible. This requires them to cut across the cycle lane creating safety concerns for cyclists.
- Moreover, when the door of a parked car is suddenly opened on the side of the cycle lane, it creates a safety hazard for the cyclist.



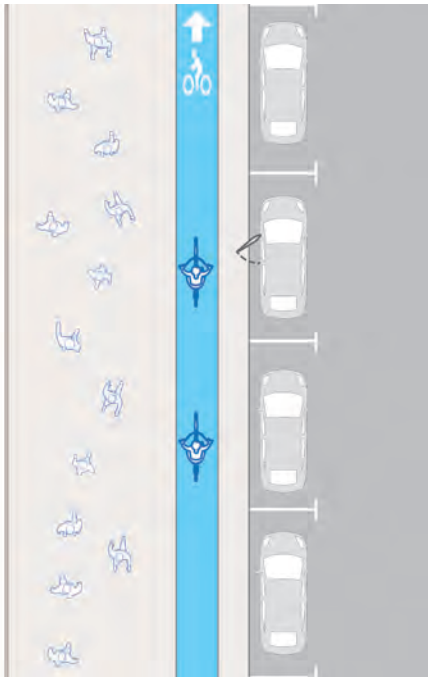
Vehicles cutting across cycle lanes to access on street parking adjacent to footpath create safety hazards for cyclists

Cycle lane designed closer to the footpath. Doors of cars opening on the side of cycle lane without adequate buffer may conflict with cyclists

- It is recommended that on-street parking be provided on streets with cycle lanes, only where there is a possibility to separate the parked vehicles from the cycle lane by a median.
- This median should be at least half a meter wide, to contain the width of an opened car door, and also allow people to enter and exit their car safely, without standing on the cycle lane.



Adequate buffer between cycle lane and parking lane allow for easy movement without hindrances.



Protected bike lanes with median as buffers are desirable.

Cycle lanes and driveways

- The trunk cycling routes to the transit station must have a smaller number of interruptions.
- Frequent property driveways along the route impact the mobility and safety of the cyclists on the trunk route. It is recommended that vehicular driveways on the main cycling route be closed, with access provided from an adjacent street.
- Where driveways are unavoidable, the continuity and priority of the cycle lane be clearly defined and maintained.
- If there is a height difference between the cycle lane and the main carriageway / driveway, then the vehicle access should be brought up to the level of the cycle lane.
- The lane markings across the driveway should be continued to reinforce the priority of cyclists over the space.

Intersections and cyclist movement

The design of intersections is a crucial aspect for the overall safety of the cycling network. Several design alternatives have been developed, which have different benefits and disadvantages with respect to the mobility and safety of cyclists.

It must be noted that whenever there is a cycle lane at an intersection, the traffic lights should include a traffic signal for cyclists as well. These may be synchronized with pedestrian lights. In larger intersections with multiple lanes, an advance phase cycle signal may also be provided.

A bicycle signal is provided along a protected bicycle lane in Istanbul, Turkey
(Source: © WRI)

REGULAR TRAFFIC-CALMED INTERSECTION

It is important to note that not every intersection in the cycling network of a station area requires definitive cycling infrastructure. Often, the safest and most appropriate measure is simply to design the intersection with adequate traffic-calming elements, such that it is safe for all road users, including cyclists.

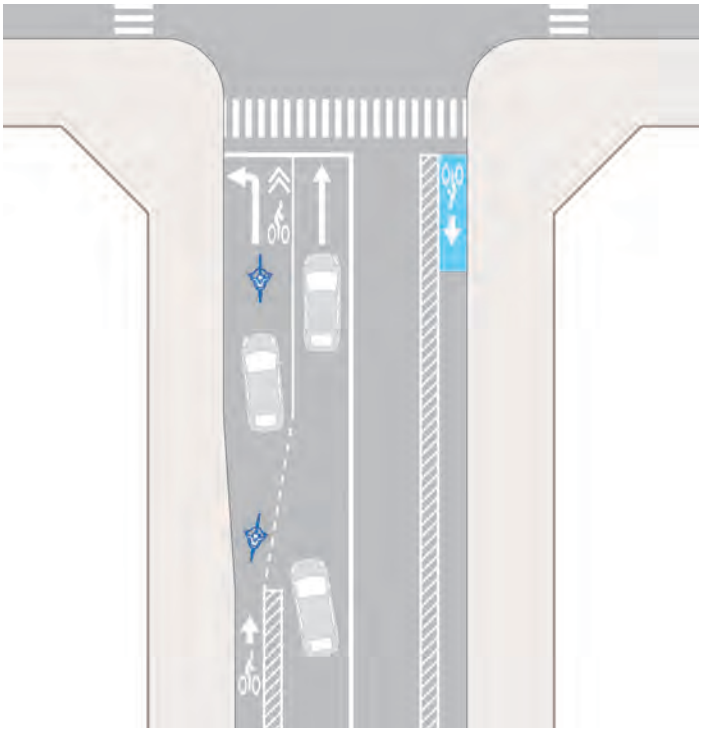
- These design-appropriate measures include, tighter intersection corner curb radius, speed-tables and speed humps, mini-roundabouts, etc.
  Refer 'Intersection design measures' section in D TRAFFIC CALMING MEASURES FOR SHARED STREETS
- Regular traffic-calmed intersections are most appropriate on the internal feeder routes of the cycling network, that typically run along neighborhood-level streets. They are expected to carry a lower volume of cycling and motor-vehicular traffic.

ADVANCED TERMINATION OF THE CYCLE LANE

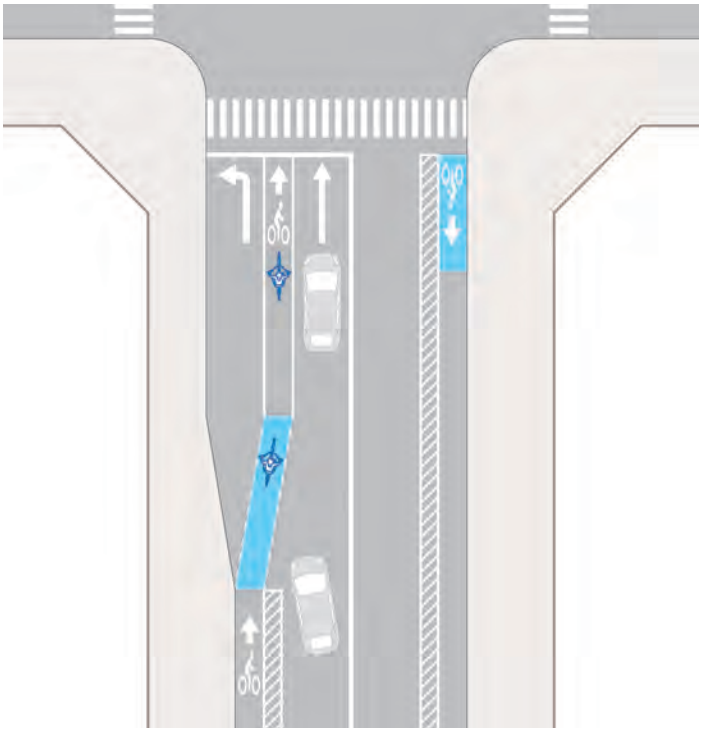
- A commonly applied measure is to terminate the dedicated cycle lane a few meters before the intersection.
- This allows cyclists who want to make a left turn, (in countries where traffic drives on the right), or right turn (in countries where traffic drives on the left) to leave the cycle lane and occupy the general traffic lane closest to the center of the road.
- Vehicular traffic that wants to make a free turn move in the lane closest to the footpath edge, in line with where the cycle would be if it wasn't terminated.
- This design is not recommended as it eliminates the dedicated cycle lane at the intersection. Intersections are the highest locations of potential crash conflict, which is where the benefits of dedicated infrastructure are likely to be the highest.
- The lateral cross movement of lane-changing cyclists and motor-vehicles put them into direct conflict with each other.

TURNING LANE BETWEEN CYCLE LANE AND FOOTPATH

- A modification of the previous design involves the continuation of the cycle lane till the intersection, with the provision of a turning lane between cycle lane and footpath.
- This design allows turning vehicles to avoid a conflict with cyclists wishing to continue straight through at the intersection; and provides the latter with a dedicated lane up to the intersection.
- However, this design also does not resolve the potential safety issues concerning the lateral movements of cyclists and vehicles, to access their respective turning lanes, creates potential crash conflict risks.



Advanced termination of bike lane as it nears an intersection.



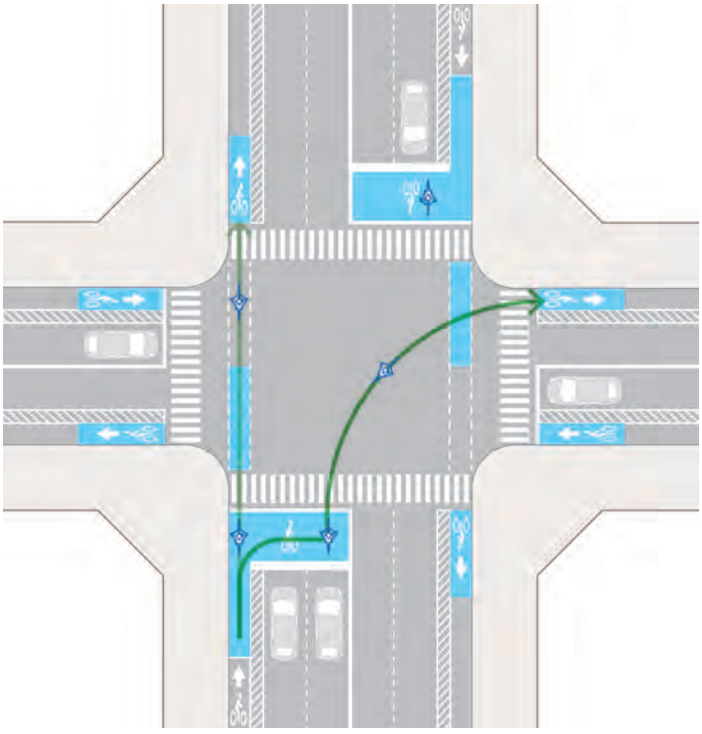
Turning lane inserted between cycle lane and footpath

CYCLE BOXES WITH 1-PHASE TURN

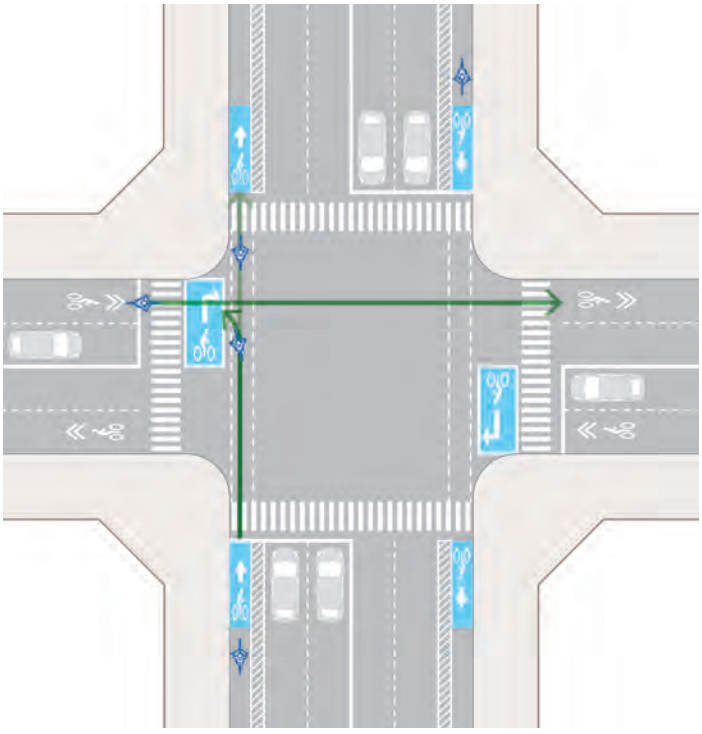
- Cycle boxes are dedicated waiting areas provided between the pedestrian crossing and an advanced stop line for general traffic.
- During a red signal phase, cyclists enter the cycle box and align themselves according to the direction they intend to go. The general traffic is not permitted to enter the cycle box during the red signal phase and waits behind the stop line.
- Normally, an advance green phase of a few seconds is provided to cyclists to allow them to clear the intersection area, before the light turns green for vehicular traffic.
- This design provides cyclists with a dedicated lane right up till the intersection. It also minimizes the possibility of conflict with turning vehicles.
- This design creates some ambiguity about where cyclists should wait when they reach the intersection during a green phase for vehicular traffic as they are expected to enter the cycle box only during a red signal phase for vehicular traffic.

CYCLE BOXES WITH 2-PHASE TURNS

- In a two phase turn, the cycle lane continues through the intersection till the mouth, closest to the footpath.
- If cyclists wants to turn opposite to the side of drive, they are expected to continue straight across the intersection, during the first green signal phase and wait in the cycle box, which is the demarcated space between the stop line and the pedestrian crossing of the perpendicular street.
- The cyclists adjust their orientation to point in the direction they intend to turn. Then, when the light turns green on this street, the cyclist continues straight, thus completing the right turn in two signal phases.
- The advantage of this design is that it allows for the provision of a dedicated cycle lane right till the mouth of the intersection and reduces ambiguity about where the cyclist has to wait during a green signal phase on their street.
- The disadvantage of this solution is that cyclists need two signal phases to make a right turn at the intersection.



Advanced stop lines with cycle boxes for cyclists to align in direction of turn



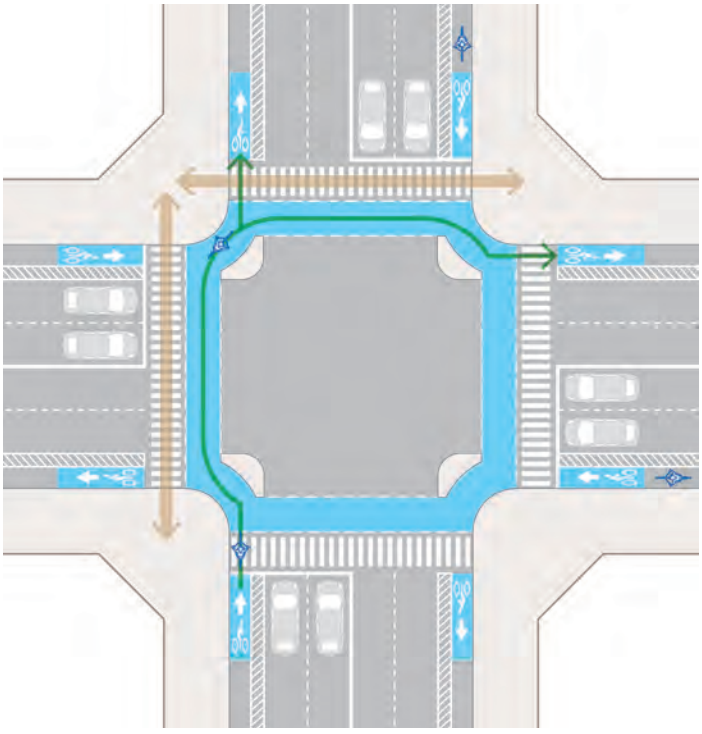
Two-phase cycle turn boxes

HOOKED CYCLE LANES

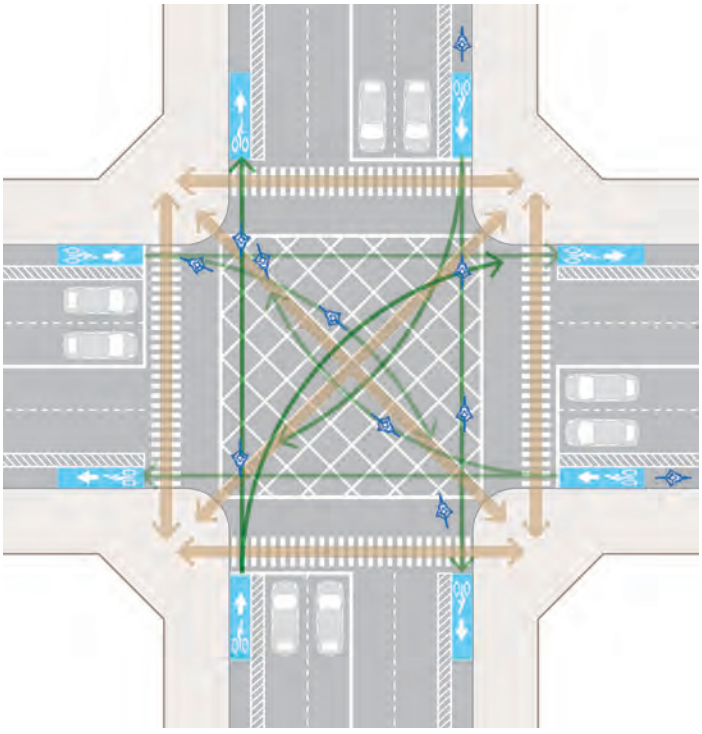
- A slight deviation in the cycle lane path is provided, to put cycle crossing adjacent to the pedestrian crossing, and functions in the same way.
- At a signalized intersection, they may share the same phase which makes the design clearer to all the different road users.
- This prevents cyclists from rushing into the intersection at high speeds and it aligns the cyclist perpendicular to traffic at the crossing, which allows for better visibility to the motorist and cyclist of each other.
- This design is also more conducive for bi-directional cycle lanes, as the cycle crossings behave similar to bi-directional pedestrian crossings.
- The disadvantage of this design is that it requires a longer maneuver to make a right turn (for traffic that drives on the left). Also, this design requires more intersection area than the cycle box design.

SCRAMBLE SIGNAL PHASE

- In a scramble signal phase, one phase in the signal cycle is dedicated exclusively for the movement of cyclists in all directions, while it is red light phase for vehicular traffic from all directions,
- Cyclists need to take precaution to avoid collision with one another. However, as cycles move much slower than motor-vehicular traffic, this is not much of a safety risk.
- The scramble signal phase for cyclists may be combined with a pedestrian scramble phase, if the numbers for both modes are conducive for such grouping.
- The advantage of a scramble signal phase is that it provides a dedicated crossing phase for cyclist, without potential for conflict with vehicular traffic and allows them to choose the shortest crossing distance across the intersection.
- On the other hand, the disadvantage of this design is that it adds one additional phase to each signal cycle, which may increase the delays for all other traffic at this intersection.



Cycle lanes hooked with pedestrian crossing

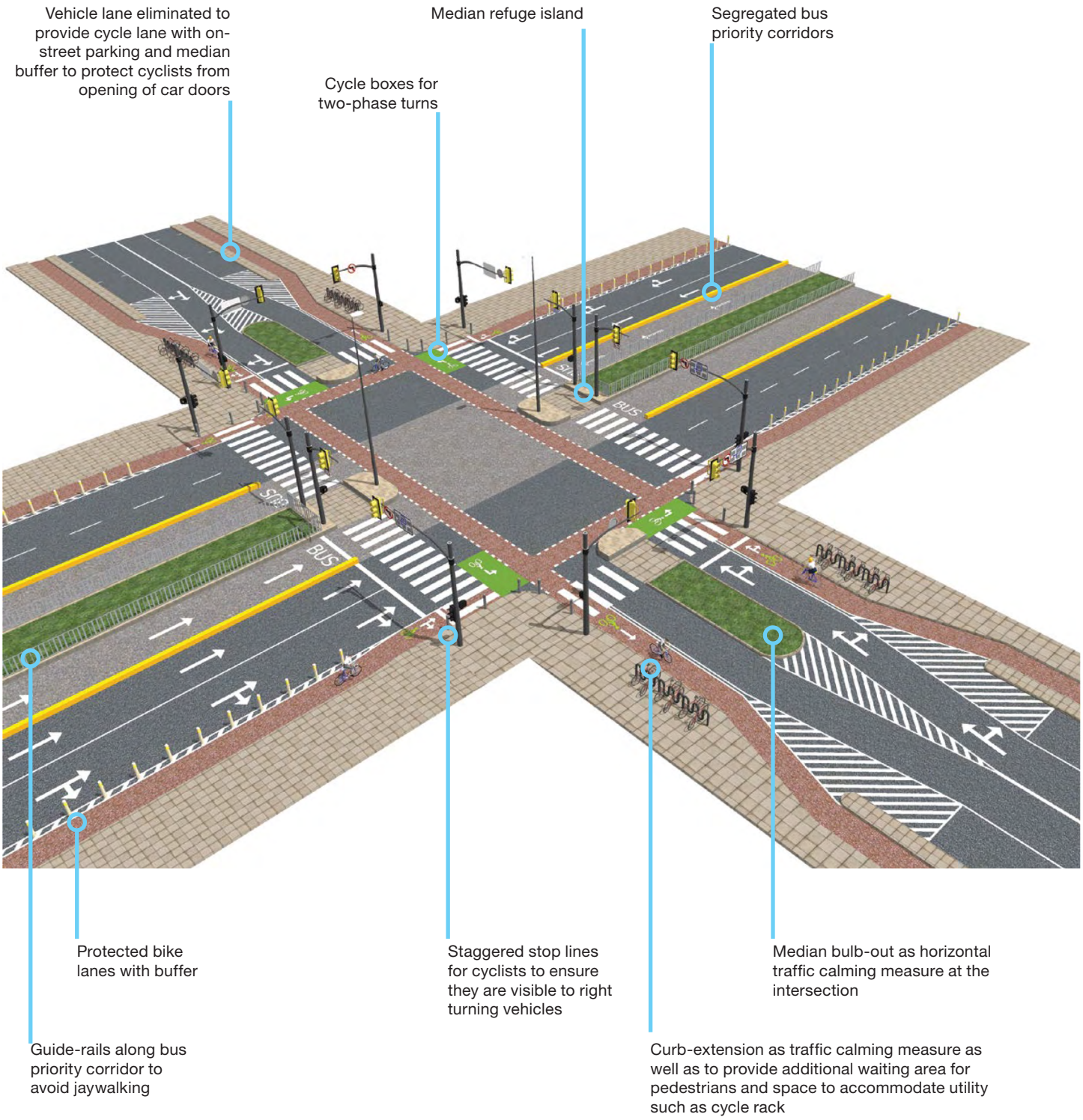


Single phase for cycle movement in all directions. Also, can be combined with pedestrian movement in all directions

Comparison of Suitability of different intersection typologies for cycling infrastructure

Type	Description	Advantage	Disadvantage	Suitability
Regular, traffic calmed intersection	No definitive cycling infrastructure is provided; but intersection is designed with speed control standards of a shared street.	Easy to implement. Doesn't require much street area.	It is not appropriate for high speed intersections, with high traffic volumes and/or high number of large vehicles.	Suitable for neighborhood, traffic calmed streets, that are normally unsignalized.
Advanced termination of the cycle lane	The cycle lane is terminated a few meters before the mouth of the intersection.	It allows motor-vehicles and cyclists to align themselves in the correct position at the intersection, depending upon the direction they intend to go.	No dedicated infrastructure for cyclists, where it's need the most. There is a risk of collision be-tween vehicles & cyclists, while they're changing lanes.	Should be used very sparingly, only after all other options are considered.
Provision of a turning lane between the cycle lane & footpath	A left turning lane* for general traffic is provided between the footpath and the cycle lane.	It allows cyclists to continue straight through the intersection, without conflict with left-turning motor-vehicles.	There is a risk of collision at the place where the cycle lane and the motor-vehicular lane cross each other.	Should be used very sparingly, only after all other options are considered.
Cycle boxes with 1-phase right turn*	Cyclists align themselves in a cycle box, (provided between the pedestrian crossing & the stop line)	It provides dedicated infrastructure right up to the intersection mouth. It allows cyclists to complete a turn in one signal phase.	It creates some ambiguity on where the cyclist should wait if it reaches the intersection during the green signal phase for vehicular traffic on the same arm of the intersection	Suitable for trunk cycling routes with a high volume of cyclists. It is especially useful when the majority of cyclist movement makes a right* at the intersection
Cycle boxes with 2-phase right turns*	During the green signal phase, cyclists intending to turn right enter the intersection and align themselves in the cycle box of the perpendicular street.	It provides dedicated infrastructure right up to the intersection mouth. The design is more intuitive to both cyclists and motorists.	It needs 2 signal phases for cyclists to complete a right turn.	Suitable for trunk cycling routes with a high volume of cyclists. An appropriate universal design principle, as it is likely to fit most contexts.
Hooked cycle lanes	The cycle lane is slightly deviated at the intersection to align it with adjacent street pedestrian crossing.	It slows down cyclists as they enter the intersection area. It provides better visibility for cyclists and motorists of each other.	It creates some deviation from the shortest path across the intersection for cyclists. It requires a larger intersection area to be implemented.	Appropriate and safe option wherever there is adequate inter-section area. It can be used for both signalized and unsignalized intersections.
Scramble signal phase	A separate signal phase is provided for cyclists to move to and from all arms of the intersection; all motor-vehicular traffic has a red light.	An intuitive design that allows for the free movement of cyclists in any direction.	The addition of a signal phase may affect intersection through-put which may result in longer delays for both motorists and cyclists.	Appropriate when there is a high volume of cyclist, with no single dominant direction of movement. Suitable for intersections with more than 4 arms

* Description is written on the context of countries where traffic drives on the left side of the road.



Two-phase cycle turn at intersection with Bus priority lanes
(Source: © WRI)

C FEEDER TRANSIT AND PARATRANSIT INFRASTRUCTURE

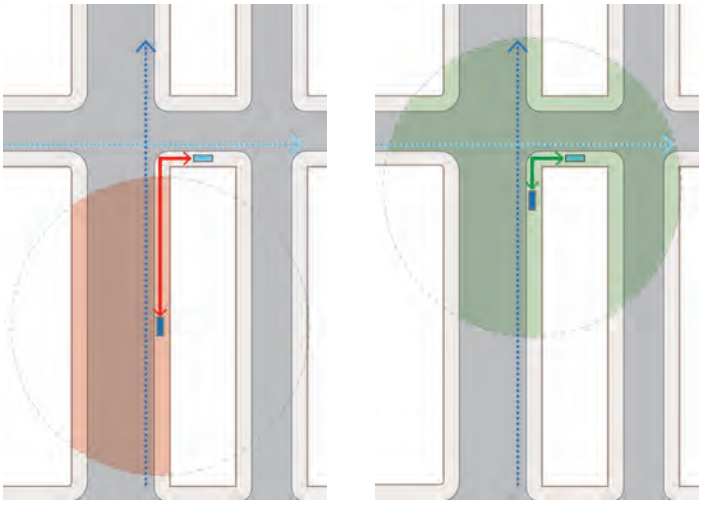
Feeder transit (generally in the form of buses) and paratransit (in the form of vans, taxicabs or auto-rickshaws) provide a valuable service in enhancing the commutable distance for transit users. This is particularly important for station areas in lower density area, where distances from the station may be too long for walking and cycling to be the only feeder alternatives.

In most cases, feeder transit and paratransit services will share the same road infrastructure as general motor-vehicular infrastructure.

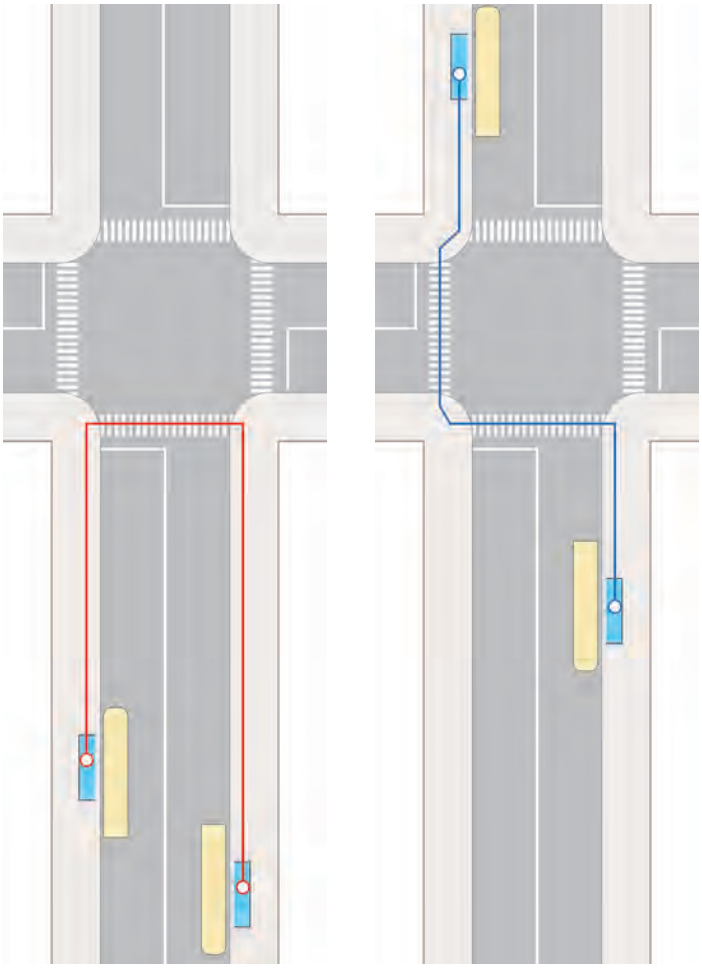
Bus stops near intersections

The intersection is an optimal location for a bus stop for two important reasons mentioned below:

1. A bus stop located at an intersection is likely to have a larger area within walking distance as compared to a mid-block stop, because of the intersection of streets moving in different directions.
2. It reduces the walking distance to transfer between two intersecting bus routes, if their respective bus stops are located at, (or near) the same intersection.



Comparing bus stop location at mid-block, having a limited reach and longer interchange distance (Left) versus a bus stop located near an intersection that increases the connectivity and reduces the interchange distance.



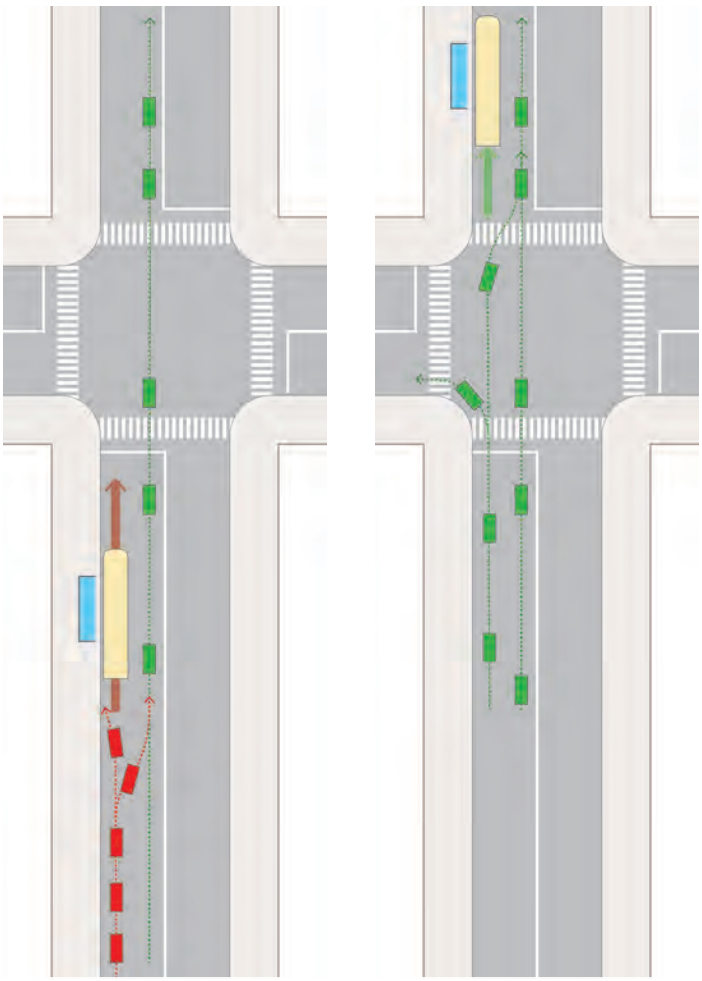
Comparing transfer distances of two stops that are positioned at mid-blocks (Left) versus two stops near the intersection (Right).

The presence of a bus stop in close proximity to an intersection can create certain challenges for traffic mobility and for safety.

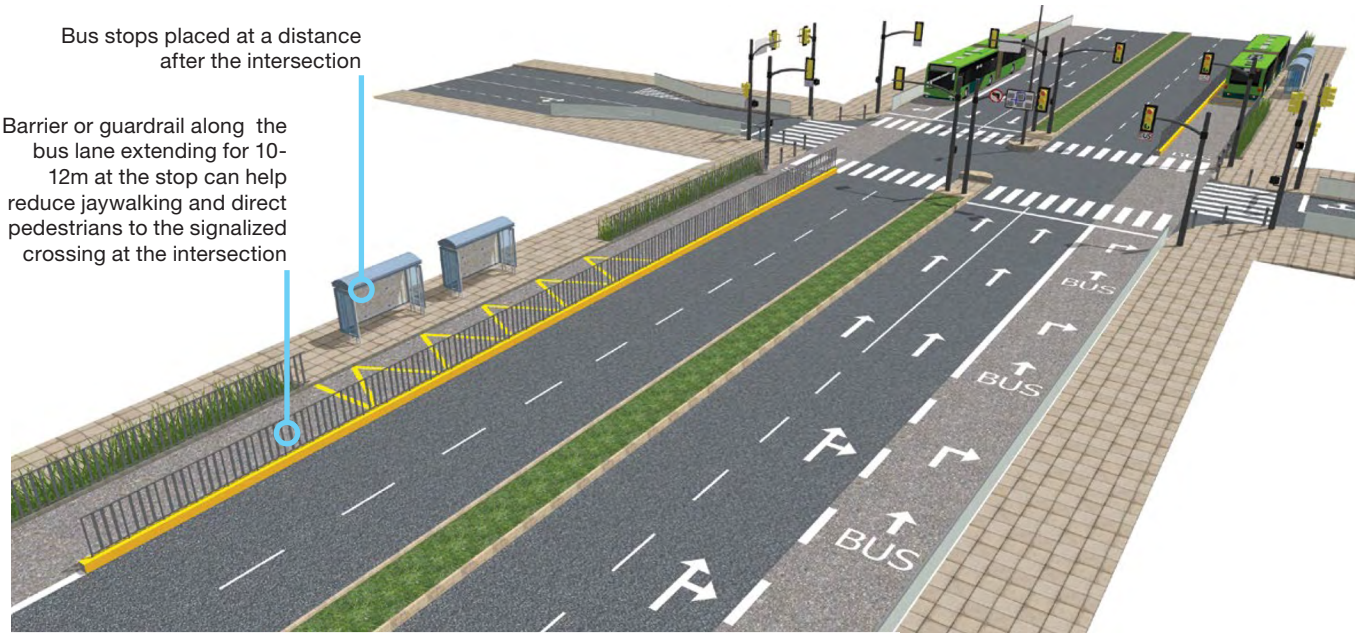
- A bus waiting at its stop may hold up traffic trying to clear the intersection, which affects intersection throughput capacity.
- Furthermore, the waiting bus may act as a visual impediment for motorists and crossing pedestrians, which can have a negative impact on safety.

These issues raise some crucial concerns with respect to the design and positioning of bus stops at intersections.

If the bus stop were to be located just before the intersection, it may unnecessarily hold-up traffic behind it if the light is green as the motorists cannot overtake the bus and they would end up queuing behind the waiting bus.



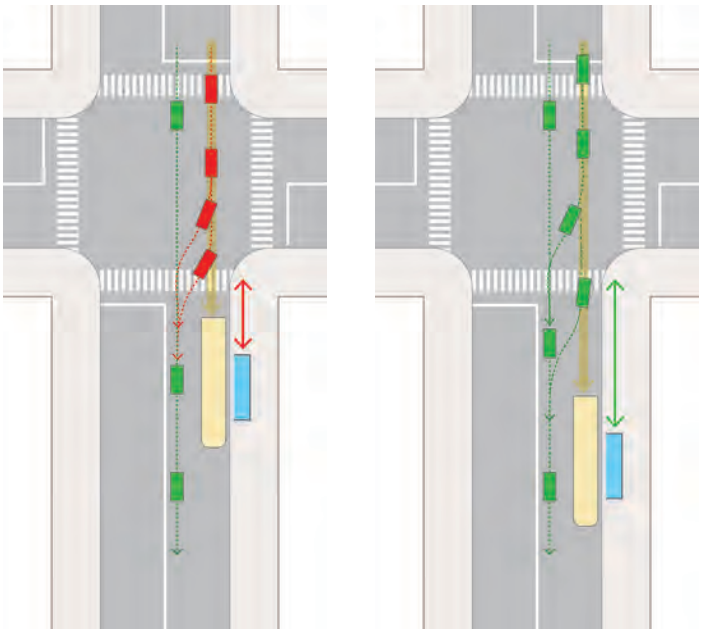
Comparing impact on moving traffic due to positioning of bus stops before an intersection (Left) and after the intersection (Right).



Curbside bus stops with marked bus lanes and barriers to avoid jaywalking
(Source: © WRI)

A bus stop is best positioned a few meters after the intersection as the bus would have to cross the intersection before reaching the stop. The bus stop should be located some distance away from the intersection to allow for vehicles entering this arm of the road to move out of the lane occupied by the bus in order to overtake the waiting bus. The advantage of this positioning is:

- It allows all traffic, (including the bus) to queue up in the correct lane, depending on which direction they intend to move.
- It does not hold up traffic that wants to go through or make a turn at the intersection. This is especially important for signalized intersections.
- The pedestrian crossing for this intersection (which will also service the bus stop) will be located behind the bus.
- It ensures that most bus commuters will walk back to the intersection in order to cross the road, putting them out of the blind spot created by the bus.



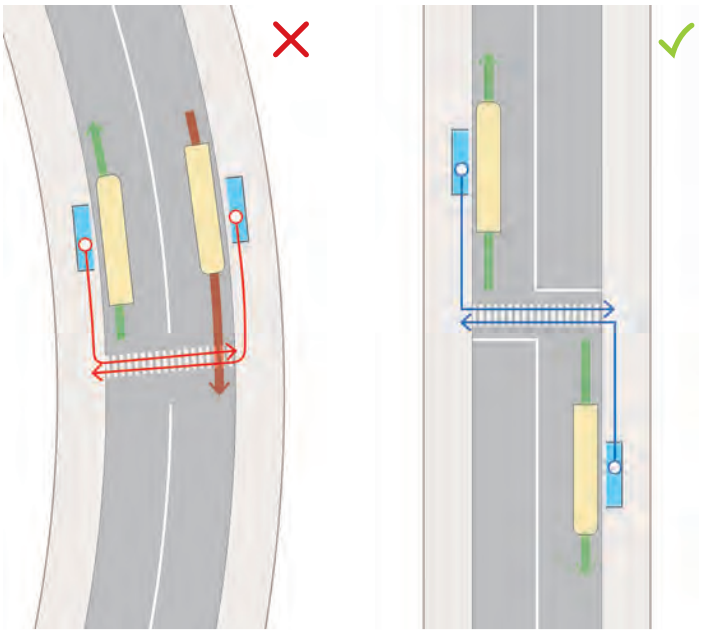
Comparing impact on moving traffic due to positioning of bus stops closer to the intersection (Left) and after a short distance from the intersection (Right).

Mid-block bus stops

In some cases, the distance between successive intersections may be very far, warranting the need for a mid-block stop. In other cases, adjacent land-use conditions may dictate the location of the stop If a prominent node, such as an educational institution or a hospital, is located at the mid-block, then it may warrant the positioning of the stop as close to this node as possible.

There are certain aspects to be kept in mind regarding the provision of mid-block stops.

- Avoid locating the bus stops along curves or slopes in the roadway, as this effects visibility of crossing pedestrians.
- As a general principle, try to locate the bus stops on opposite sides of the road, such that they share a common pedestrian crossing that is located behind both stops.



Positioning of bus stops at mid-blocks.
Locating mid-block stops along curved roads should be avoided and should be positioned in a way so that they share common crosswalk behind both the stops.

Paratransit nodes

Paratransit normally operates along the general traffic roadway in mixed traffic conditions. Typically, pick-up and drop-off happens all along the roadway, except where there are legal restrictions against stopping. As such, paratransit commuters do not normally require specific street infrastructure elements.

Places where there is a high demand for paratransit services such as shopping malls, educational institutes, office complexes, etc. there tends to be a concentration of paratransit vehicles waiting to pick-up passengers which affects both traffic throughout and safety of pedestrians

- It is recommended to provide dedicated pick-up and drop-off infrastructure at all such nodes, to facilitate the orderly alignment of paratransit vehicles, which allow for passengers to embark and disembark these vehicles safely.
- The pick-up and drop-off zones function best when they are physically separated from each other, in a manner that allows for a paratransit vehicle to quickly move from the drop-off zone to the pick-up zone, (in order to pick-up new passengers). The length of each

D TRAFFIC-CALMING MEASURES FOR SHARED STREETS

A shared street is one where the infrastructure is designed to meet the mobility and safety standards of all road users. These standards are very different for motor-vehicle traffic than for non-motorized traffic. Thus, if a street is to be designed for all road users, it is essential that it meets the safety standards of the most vulnerable road users among them, namely pedestrians and cyclists.

The implementation of traffic-calming measures is an essential component of creating safe, shared streets. The provision of traffic-calmed, shared streets allows for the completion of the feeder networks, which is an essential principle of TOD access planning.

The most important aspects of developing safe, shared streets are:

1. Slow down traffic speed to decrease the probability of conflicts between road users, while also reducing the severity of a crash when it happens.
2. Reduction of traffic volume achieved mainly through the diversion of non-local traffic.

Shared street in Guatemala with different material, bollards and planters to reduce speeds of moving vehicles, creating safer space for other road users.
(Source: © The World Bank)

General design measures

This section considers some of the general traffic-calming design measures to make streets safe for all road users.

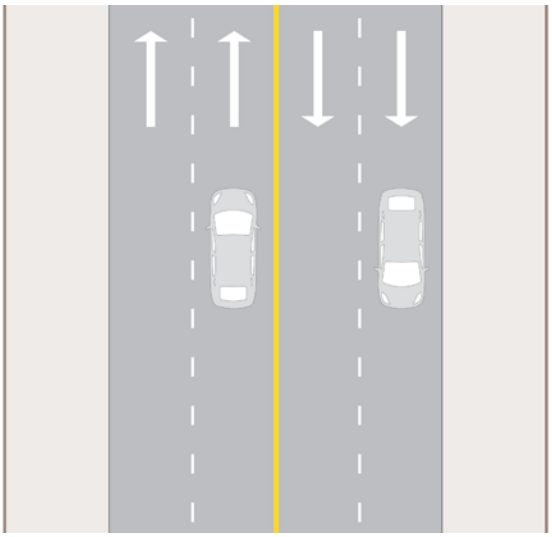
LANE DIET

The total width of the section of the road reserved for vehicular movement is often referred to as the carriageway. The width of this carriageway is a crucial factor in influencing traffic speed.

There are two aspects to be considered here:

1. The traffic lane width- Wider traffic lanes allow motorists to drive faster, because of perceived lower conflict risk with traffic in other lanes.
2. Number of traffic lanes- Greater number of traffic lanes result in increased carrying capacity, which improves traffic free-flow conditions, which further allows for faster travel.

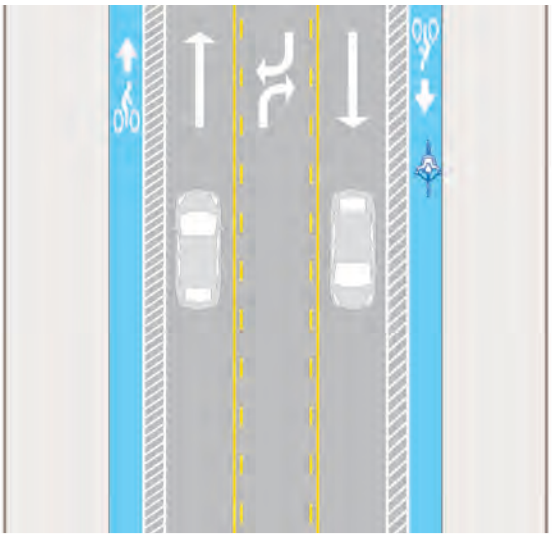
- Streets in many urban areas are designed with lane width of 3.5m and more which allows for a design speed in excess of 50km/h, which is an extremely unsafe speed for urban conditions. The design speed should be ideally closer to 30km/h. And for local, neighborhood streets, an even lower design speed is desirable.
- A traffic lane width of 3m (upper limit) is recommended for all shared streets. An exception may be made for roads that are part of the transit bus network, where the lane utilized by the bus, (in most cases adjacent to the footpath), may be as wide as 3.5m.
- For neighborhood streets, and even narrower lane width than 3m is desired.
- Generally, a shared street must not have more than 2 traffic lanes in either direction. Anything more than 2 lanes makes it difficult to implement a design speed close to 30km/h. In most cases, 1 lane in each direction is adequate for local, neighborhood streets.



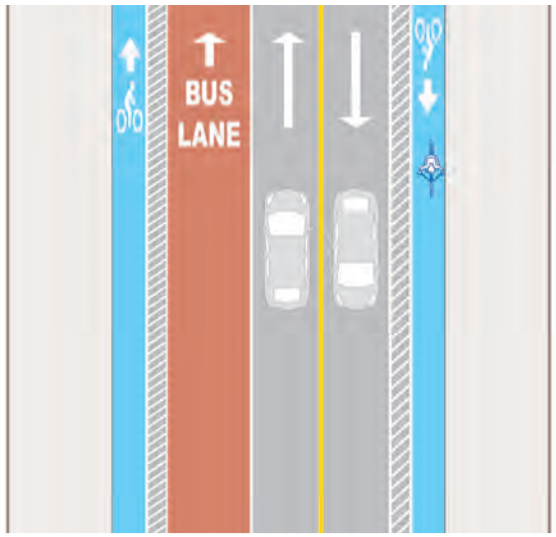
Existing distribution of ROW with wide travel lanes

If an existing bi-directional road with two lanes in each direction is to be redesigned along shared street principles, then consider converting the additional lanes into a parking lane; or utilizing the additional road width to increase space for other street elements, such as footpaths.

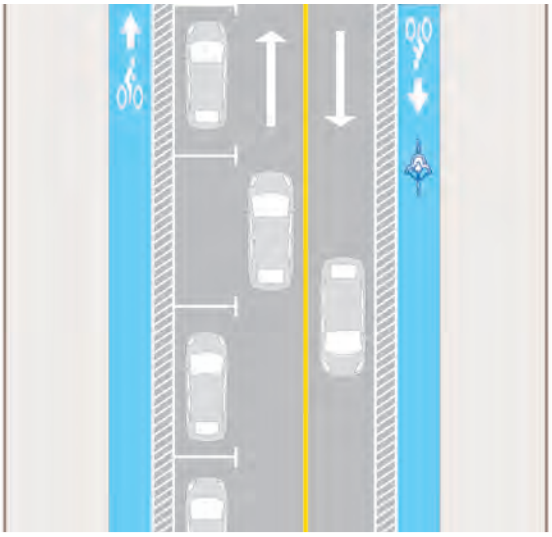
Here, it must be noted that it is a common traffic calming practice to convert a unidirectional road with two lanes into bi-directional road with a single lane in each along with other horizontal and vertical measures (discussed later in this section). It may also be redesigned to accommodate a buffered cycle lane or shared bus lane (in the same direction) to improve capacity of the street and segregate the modes – as discussed earlier in PD-H07 (sub-section Capacity).



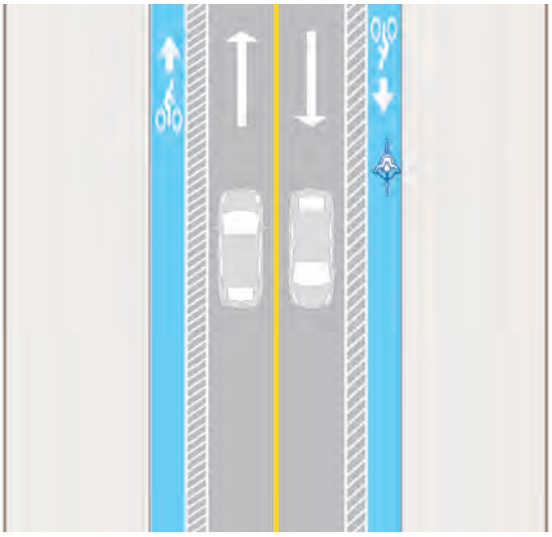
Redistributed ROW with narrower travel lanes, cycle lanes, and center turn lane



Redistributed ROW with narrower travel lanes, cycle lanes, and bus lane



Redistributed ROW with narrower travel lanes, cycle lanes, and on street parking



Redistributed ROW with narrower travel lanes, cycle lanes, and wider footpaths

FREQUENCY OF INTERRUPTIONS

The design principles for a shared street are counterintuitive to the design principles of trunk routes.

Trunk Routes

It is desirable to minimize interruptions along the trunk route by restricting median cuts, eliminating intersections and discouraging property accesses.

However, on certain kinds of shared streets, the high frequency of such interruptions may actually be desirable, as it increases conditions that disrupt through flow movement; which results in slowing down traffic.

Non-Trunk Routes

The central median may be removed to allow vehicles to cut across the center line to make turns into driveways. However, if it cannot be entirely removed, then the number of median breaks may be increased to achieve similar results

It is recommended to have fewer restrictions on property driveway accesses, as the frequency of the same, contribute to slowing down traffic.

URBAN DESIGN MEASURES

Traffic-calming measures include several engineering interventions to slow down of traffic. In addition, there are many urban design measures that act as visual cues, encouraging motorists to select the appropriate speed for this zone.

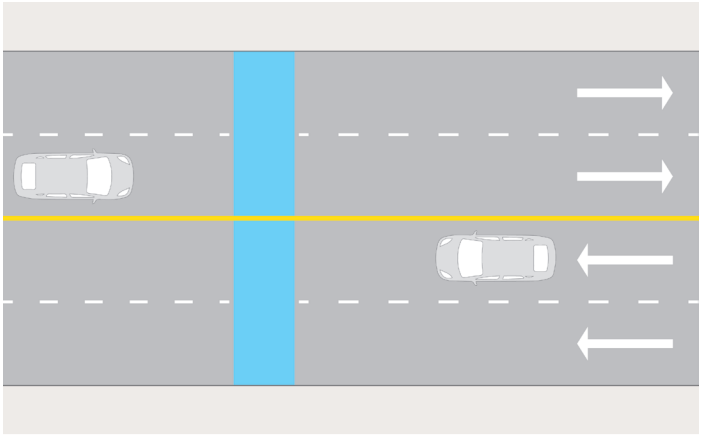
- The presence of setbacks along the road front have a psychological impact on speed selection.
    - A street where buildings are set nearer the road edge are perceived to be narrower than streets of similar widths, but where the buildings are further apart. This induces motorists to driver slower on the former kind of street, due to the narrower visibility range.
    - From a station area's planning perspective, regulations can be implemented to relax frontage setback norms, (where appropriate), to encourage more compact development.
- Trees planted close to the carriageway edge have a similar impact on speed selection.
- Softer streetscape elements may also be considered to signal to the motorists that they have entered a traffic-calmed street. This include measures such as change of carriageway surface material and color, as well as the increased use of landscaping and other street furniture.
- Another measure is to include more diverse road users, such as on-street parking and street-vending. These uses increase the perceived disruptions to the motorist, which encourages them to slow down.
- If there are definitive entry points into a neighborhood from a main street, it is a good practice to install a gateway feature across the entry point, which informs motorists that they're about to enter a different kind of right-of-way. This encourages them to slow down and choose the appropriate speed for this zone.

Mid-block design measures

SPEED HUMPS, SPEED TABLES AND SPEED BUMPS

There are three kinds of vertical deflectors, that are effective in controlling vehicular speed. They have slightly different design features which also impacts their functionality and applicability.

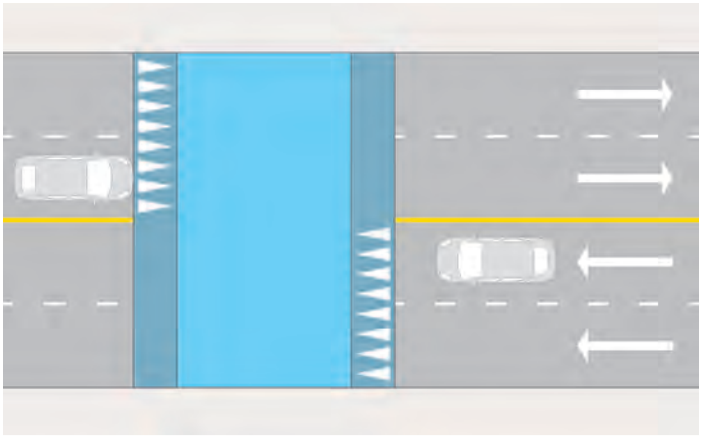
1. Speed humps: A speed hump refers to the curved, raised area, along the width of the carriageway, which causes a vertical deflection for vehicles as they traverse it, which induces motorists to slow down in order to cross the hump comfortably.



Speed hump

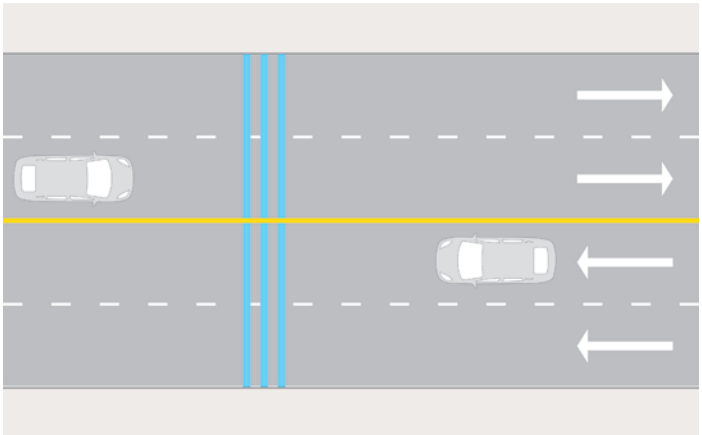
2. Speed tables: A speed table refers to an elongated speed hump, with a flattish section between the up and down slopes of the hump. A pedestrian crossing may be included along the flat section of a speed table.

   Speed humps or tables are recommended for local, neighborhood streets as a traffic-calming device. Speed bumps are normally not recommended for public streets, because of their abrupt impact on vehicles. They are more suitable for driveway or parkway entries.



Speed table

3. Speed bumps: A speed bump is significantly narrower in cross-sectional width than a speed hump, which causes a more striking vertical deflection for a traversing vehicle. A vehicle, normally, has to come to a near stop, in order to cross the hump comfortably.

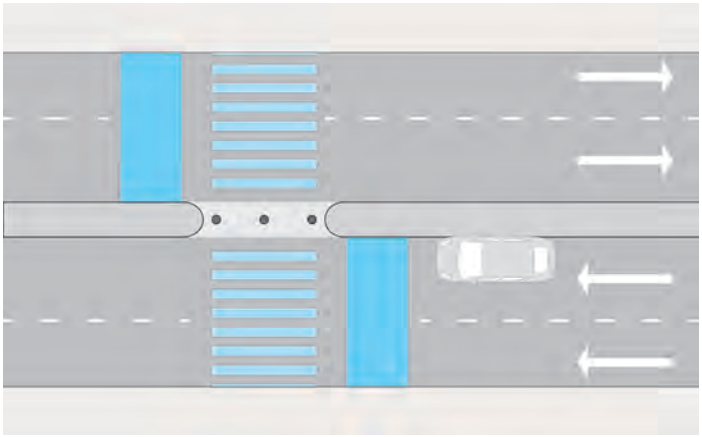


Speed bump

The frequency of speed humps along a stretch of road should be such that it discourages speeding in-between two humps. It is a good idea to provide speed humps before pedestrian crossings, especially in cities where motorists are unlikely to slow down for a crossing pedestrian. If there is no median barrier on the roadway, it is better to locate the pedestrian crossing on top of the speed table.

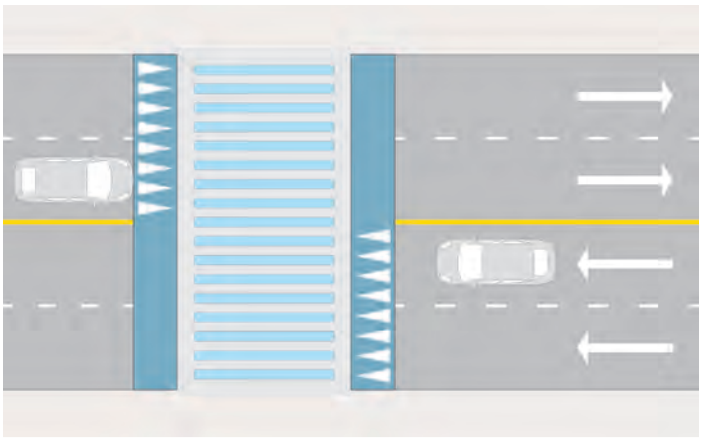
If such vertical speed controls are needed near to an intersection, it is recommended to use a speed hump instead of a speed table so that pedestrians don´t confuse it with a pedestrian crossing.

Speed humps must be avoided along curved sections of the road, or in sections where forward visibility of the roadway is low. Speed humps should also be avoided on sloping sections of the road. Normally, a speed hump should not be installed just before a traffic signal, as it affects the green phase traffic throughput for this signal.



Speed humps before pedestrian crossing

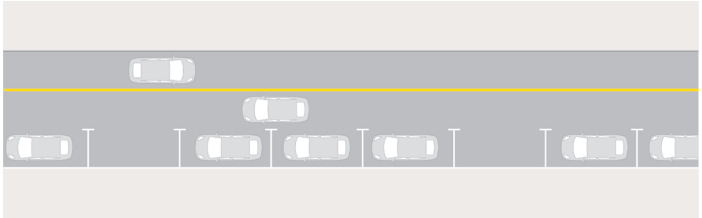
Speed table doubling up as a mid-block crossing with safety bollards in New Delhi, India
(Source: © The World Bank)



Pedestrian crossing on top of speed table

CHICANES, CURB-EXTENSIONS, BULB-OUTS AND STAGGERED ON-STREET PARKING

Speed humps, tables and bumps were examples of vertical traffic-calming deflectors. In addition, there are various horizontal traffic-calming deflectors that achieve a similar effect. The following types of horizontal traffic calming measures are applicable for both two-way and one-way streets.



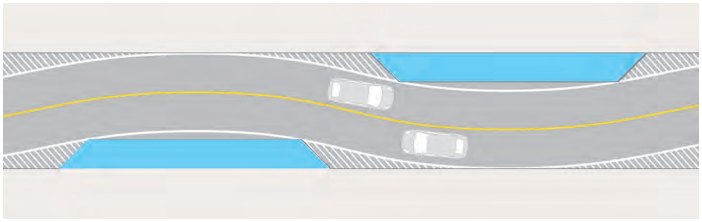
Typical existing street conditions with on-street parking

1. **Chicanes:** These refer to the series of physical deflectors that are installed along alternating sides of the road, which result in the creation of a serpentine-like roadway. This forces motorists to slow down as they steer left and right through the successive chicanes. Chicanes are a useful retrofit for long, neighborhood streets, though consideration should be given to their impact on cyclists and emergency vehicle movement.

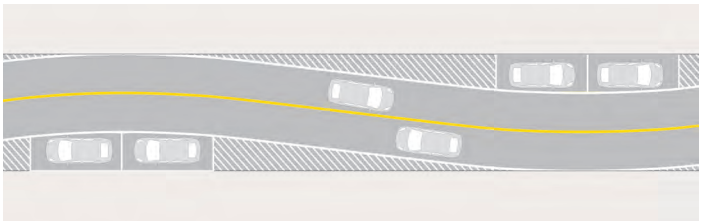
2. **Staggered on street parking:** A similar traffic-calming impact that chicanes provide can be achieved by staggering the provision of on-street parking. The presence of on-street parking has the added advantage of increasing perceived traffic disruptions, which induces motorists to drive slower.

3. **Curb Extensions:** This refers to the physical extension of the curb, (normally the footpath curb) into the carriageway, partly or fully cutting out a traffic lane. Curb extensions are also referred to as **Chokers,** because, they, in effect create a physical bottleneck, with the intention of choking traffic. This induces motorists to slow down while driving through the curb-extension area.

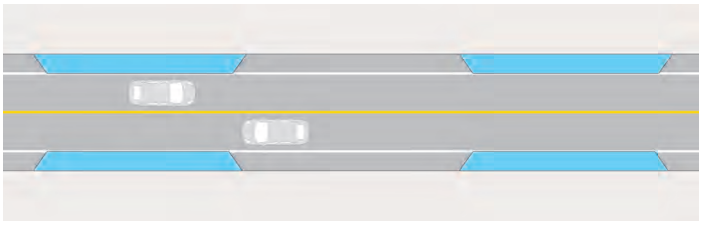
4. **Median Bulb-Out:** Curb-extensions may also be provided along a curbed median, which then creates, what is called a bulb-out in the center of the road. The advantage of such a bulb-out is that is allows for the inclusion of a pedestrian refuge area between the crossing, where pedestrians can stop and wait while crossing the road.



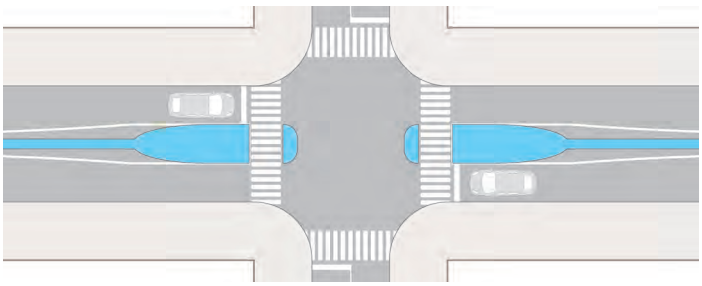
Chicanes



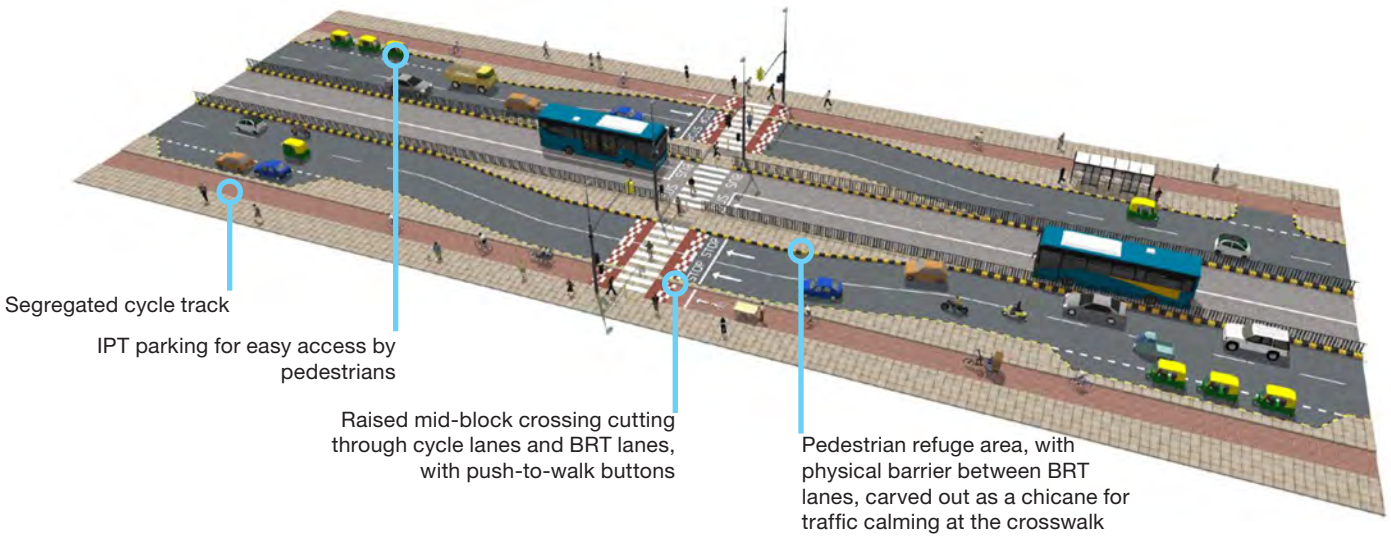
Staggered on-street parking



Curb extensions or chokers



Median bulb-out



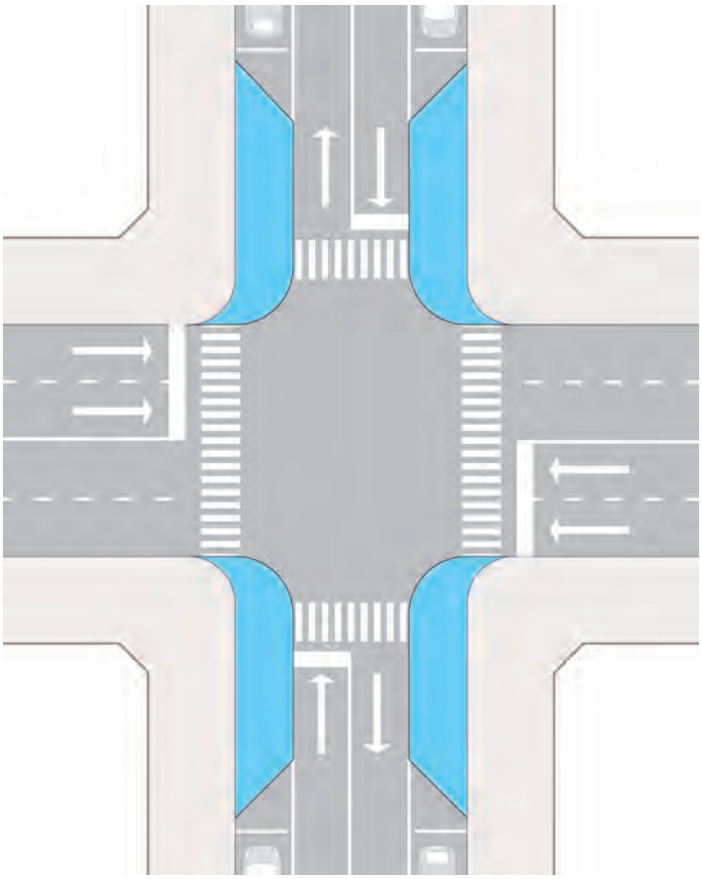
Mid-block crossings in BRT lane as a combination of horizontal and vertical traffic calming measures
(Source: © WRI India)

Intersection design measures

There are many physical design measures to slow down traffic crossing intersections that have been discussed in this sub-section.

TIGHTENING AND/OR EXTENDING CURB CORNERS

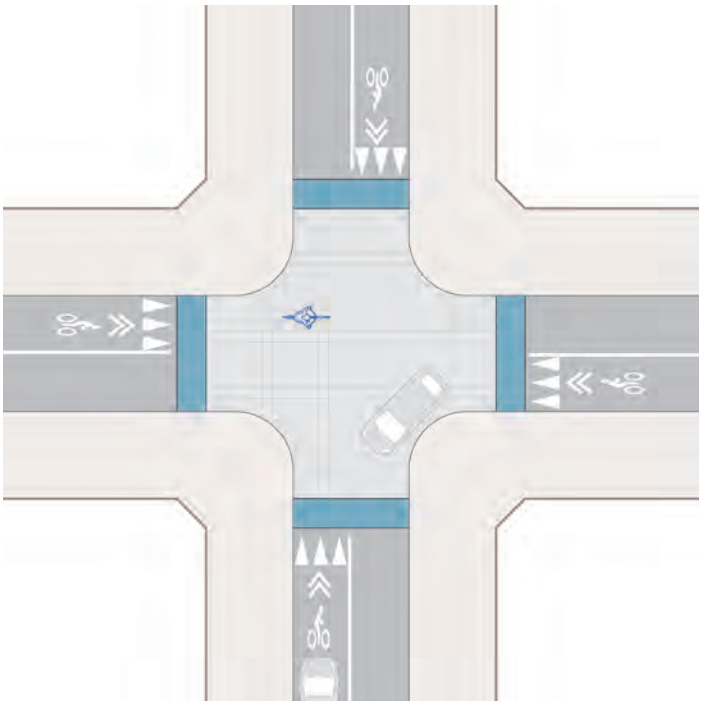
- The most important measure to reduce traffic speed at intersection is to minimize the radius of curb corners at intersections. A tighter corner induces motorists to slow down to make a turn, which adds to safety.
- It also increases the available footpath area at the intersection, which allows for safer crossing
- When designing intersections, a common mistake is to provide an intersection corner radius big enough to accommodate the turning path standards of the design vehicle. In doing so, one neglects to consider the difference between effective turning path and curb corner radius.
- The effective turning path can be wider than what is determined by the corner radius, especially if there is a parking lane adjacent to the traffic lane.
- Furthermore, for traffic-calmed streets with low-to-mid volume, it is not essential that the vehicle completes a left turn, (in the context where traffic drives on the left), from the leftmost lane to the leftmost lane. It is acceptable for the vehicle to traverse into the adjacent lane, in which case, the effective turning width is much wider.



Extending curb corners at intersections to create gateways

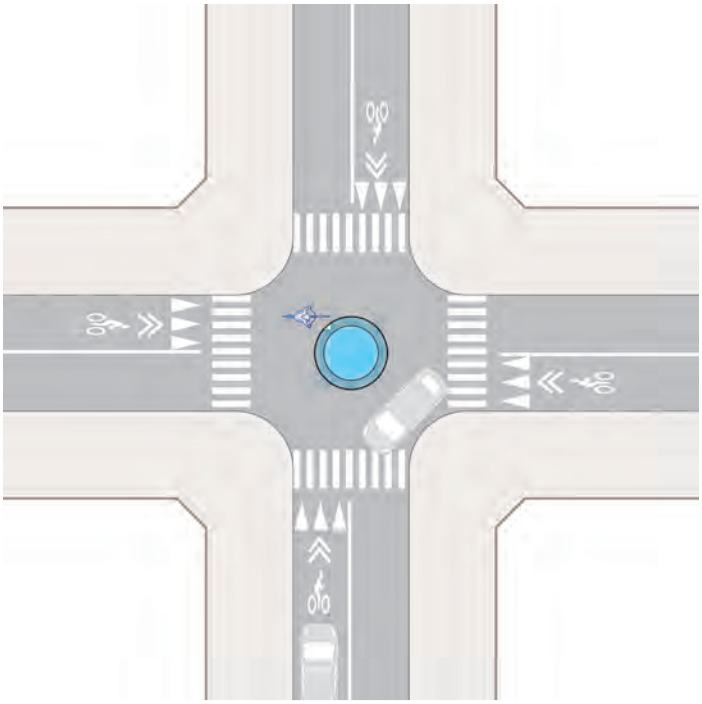
RAISED INTERSECTIONS AND MINI ROUNDABOUTS

- A raised intersection is an effective traffic-calming measure, applicable for unsignalized intersections between neighborhood streets.
- They are similar in profile to a speed table, wherein the entire intersection area is slightly raised to create a vertical displacement for traversing vehicles. This induces motorists to slow down when crossing the intersection.



Raised intersection, at the level of footpath and with a different material.

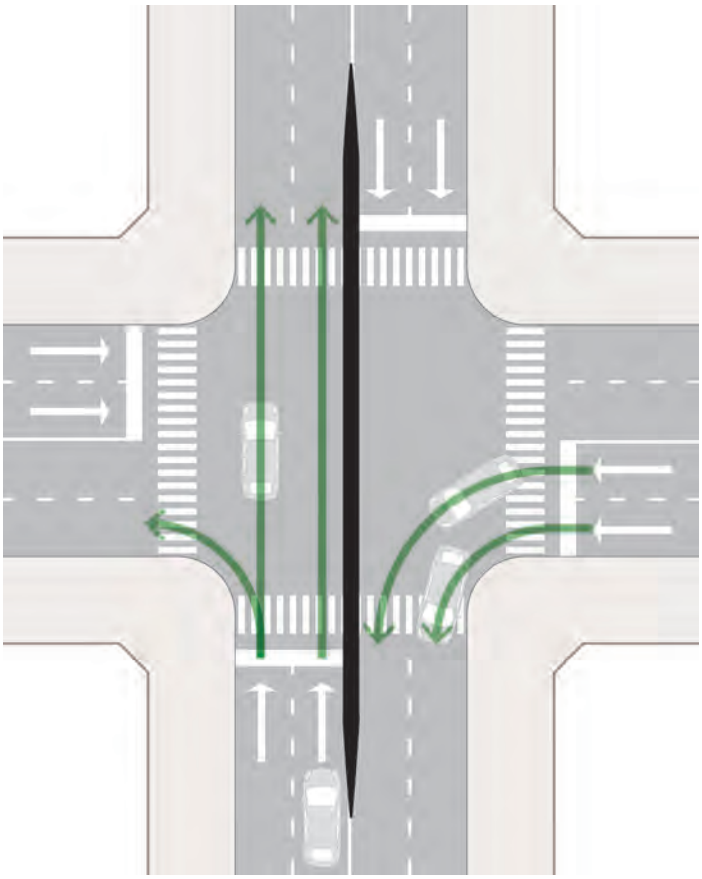
- Mini-roundabouts are another kind of useful traffic-calming intersection feature. It consists of a small circle located within the intersection area, which creates a lateral displacement for vehicles, forcing them to slow down.
- They differ in form and function from conventional roundabouts, which are much larger, and their primary function is to channelize traffic circulation, rather than slowing down traffic.
- A mini-roundabout acts a good marker of an entry point into a traffic-calmed zone, encouraging motorists to drive at the appropriate speed.



Mini roundabout

RESTRICTING MOVEMENT AT INTERSECTIONS

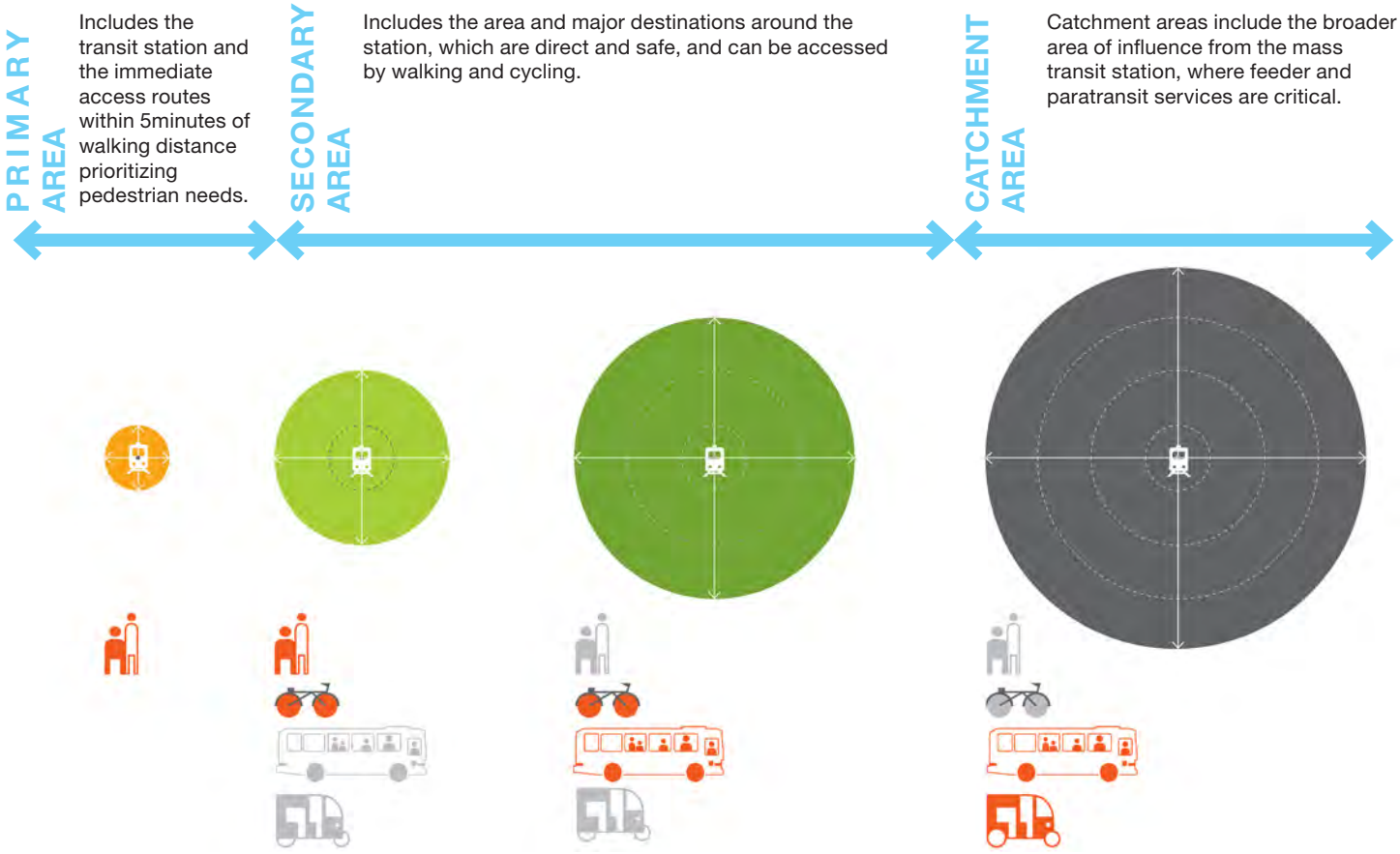
- Traffic-calming at intersections can be achieved by eliminating movements in certain direction, through the installation of physical barriers. This primarily impacts the volume of traffic using this intersection, (and the adjoining streets), by curtailing thoroughfare traffic.
- One such measure is to continue the median barrier across an intersection to prevent turning movement in one direction and prevent through movement in the other direction.
- Another measure is to install a diagonal barrier across the intersection, preventing through movement in either direction.



Restricting movement at intersections using barriers

E PRIMARY STATION AREA DESIGN

- The primary station area in the context of TOD, refers to the area immediately surrounding the transit station i.e. within 0 – 400m or 5 minutes walking, where the transfer of commuters between feeder modes and the main transit line takes place.
- This is the meeting point for the trunk routes of all feeder modes. Hence, safety and mobility challenges are the most crucial at the station area, given the high concentration of commuters and traffic into a relatively small space. To ensure maximum safety, this area must be kept car free, with only designated routes for IPT and feeder services.
- Infrastructure for the transfer of pedestrian commuters should be provided nearest to the station gates, followed by infrastructure for cyclists and feeder buses, then paratransit, and finally, for personal motor-vehicles. It is important to ensure that transit infrastructure, including station structures, do not impede the movement of any mode. It is commonly observed in many cities that the pillars of elevated transit stations completely block the sidewalks below them. In other cases, elevator shafts and stairways to the stations are placed across the sidewalk, forcing pedestrians to walk on the roadway.

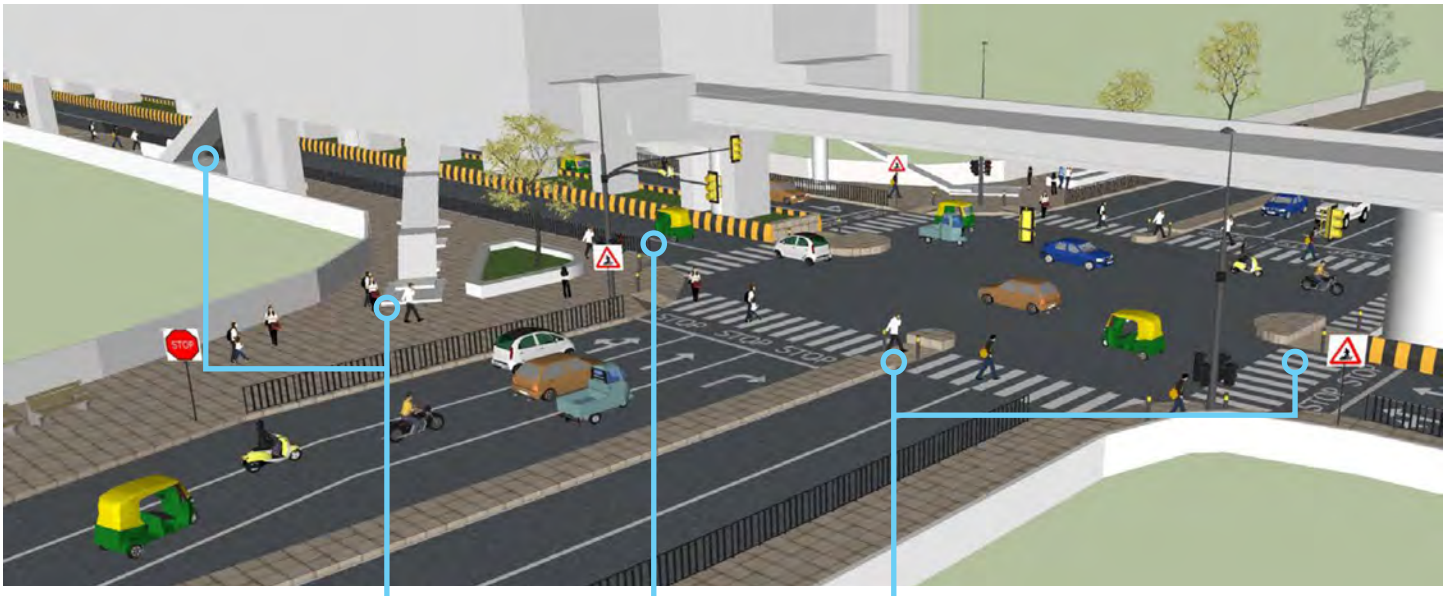


Cycle parking facility and pedestrian only area at the entrance of Transmilenio in Bogota, Colombia
(Source: © The World Bank)

Station access points

A transit station with one access point can become a potential bottleneck for commuter movement, especially during the peak commuting hours of the day.

- For a high-volume station, it is recommended to provide multiple entries and exits to the station, ideally connecting to different roads and different directions of the station area.
- Station access points can also be separated according to the transfer mode. For instance, a direct access link may be provided, connecting the station to the feeder bus routes - separating the movement of bus commuters from other commuters.
- Often local access needs are combined with station access points. Access to underground mass transit stations also double up as underpasses to cross major roads. Similarly, BRT stops are often in the middle of a highway and hence is not safe to provide at-grade access. FOBs with ramps or elevators to access the stops are provided. However, if these stations are not functioning during some hours or closed, then the local access can get impeded due to closing of the access facility as well. It is advisable to have these FOBs or underpasses to remain functional all day long and have a connection made from these off-road connectors to the transit facility.
- Grade separated infrastructure can be utilized in conjunction with sidewalks, to increase access points to the stations from important nearby land-uses that are likely to generate a high footfall of commuters. Care should be taken to see that the pillars and related civil infrastructure for such structures do not impede the movement of pedestrians on the sidewalks below.
- BRT services requiring dedicated lanes must be protected using railings and median barriers to avoid jay walking, with access to stops provided at intersections with wider crosswalks or at mid-block crossings. Additional button-activated mid-block crossings must be provided in the station area where the blocks are large or a high volume of pedestrian movement is expected.



Designed access to DN Nagar Metro Station Mumbai near an intersection
(Source: © WRI India)

Pedestrians crossing along the median, especially with longer BRT Green phase.

(Many Latin American BRT Systems have such design including Macrobus in Guadalajara)

Wide at-grade refuge island in the median to accommodate passengers entering and exiting the BRT Station using a protected ramp.

Pedestrian access to a raised BRT station in the center of the ROW
(Source: © WRI)

Cycle rack on sidewalk along the road perpendicular to the BRT lane, allowing riders to lock the cycles and transfer to BRT system.

Facilities for cyclists to access the BRT station along with pedestrians
(Source: © WRI)

NMT ACCESS STREET AT NAVANAGAR BRT STATION, HUBLI-DHARWAD, INDIA

The street leading to the Navanagar BRT station in Hubli-Dharwad in India, is designed as an NMT street. A cycle track and a pedestrian pathway are placed on either side of the street, and activity areas are carved out in the central area for multiple uses. These include a play area for children, a park for seniors, a community gathering space for the neighborhood etc.

Proposed NMT Street connecting from the school to the BRT station Plaza

Schematic section indicating range of activities along the length of the NMT Street

Visualization through a cross section of the NMT Street showing a shared use community gathering space
(Source: © WRI)

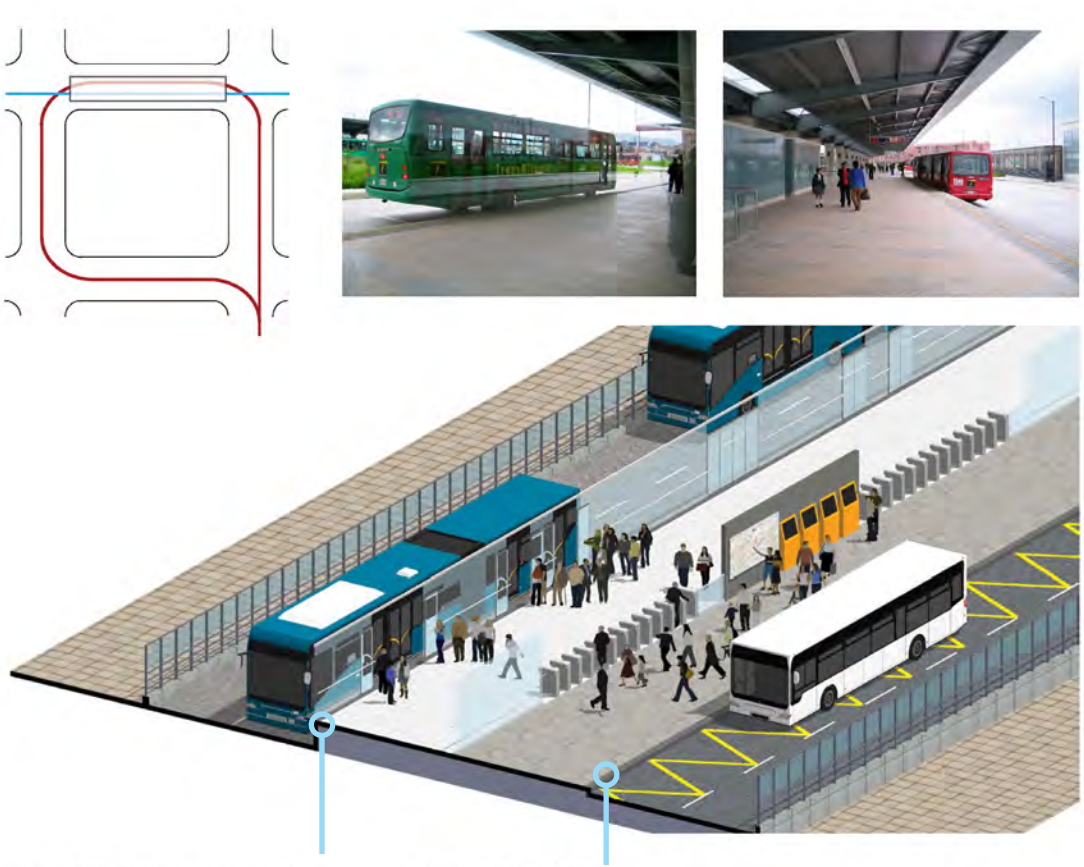
Transfer facility design

- Transfer zones should be provided in the vicinity of the transit station such that crossing requirements are eliminated or reduced.
- For instance, if a feeder bus-loop / terminal is located near the transit station, it is a good idea to ensure that there is no road in between the feeder bus-facility and the station access point.

TRANSMILENIO TERMINALS, BOGOTOA, COLOMBIA

A typical transfer station along Bogota, Colombia's TransMilenio BRT corridor includes an integrated transfer facility between the trunk BRT route and the feeder service. These terminals are designed to have a common central platform where both the services can dock on either side of the platform. This allows the passengers to transfer by simply crossing across the platform.

It is important to have proper integration between the two types of services to avoid overcrowding of the platform. The platform must be designed with adequate space to accommodate the expected volumes of passengers. Due to overcrowding of platforms in these transfer stations, passengers very often walk and wait in the bus lanes. Another challenge that these transfer facilities face is at the access point of the station which may lead to bottlenecks and even collision of the two types of buses. The diagram below along with photographs explain the transfer facility.



Platform height: Same as bus floor height

On this side of the terminal, the platform is 1 meter above street level, which would allow a typical high-floor, left-door bus to dock.

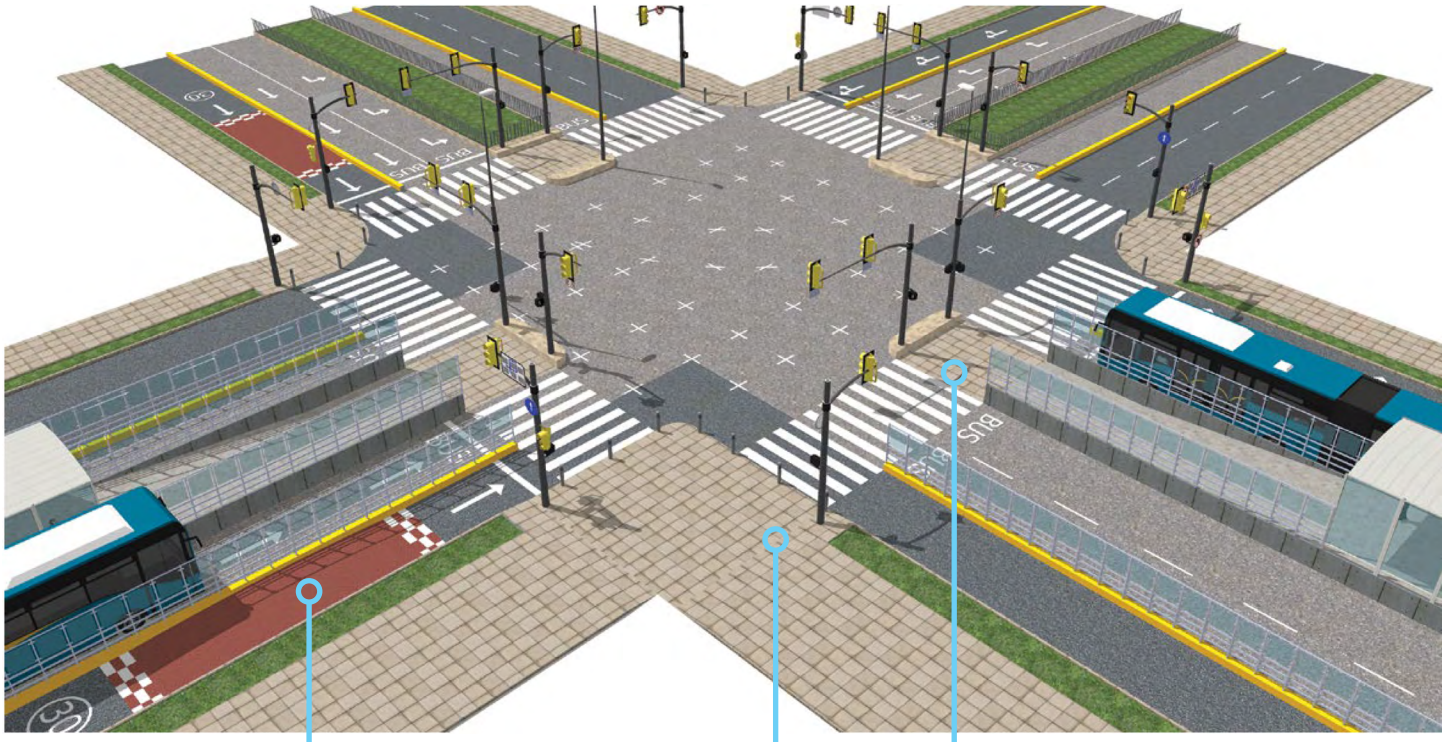
This side of the terminal should be used by high-floor BRT vehicles, It will likely be closed and feature offboard fare collection.

Platform height: 30 cm
The bus lanes on this side of the terminal are raised 70 cm above street level, so that the central platform can service low-floor buses on this side.

This side of the terminal should be used by conventional right-door buses. It can be open and feature onboard fare collection, but there must be guardrails on the outside of the terminal, to prevent pedestrians from crossing the bus lanes.

It is important to size the platform correctly so that it does not get overcrowded. Otherwise, there is a serious risk that some passengers will walk in the bus lanes.

- It may not always be possible to locate all transfer facilities on the same side of the transfer station. In such contexts, it is essential that safe crossing infrastructure is provided to access the station and a signalized crossing may be needed due to the high transfer volumes.



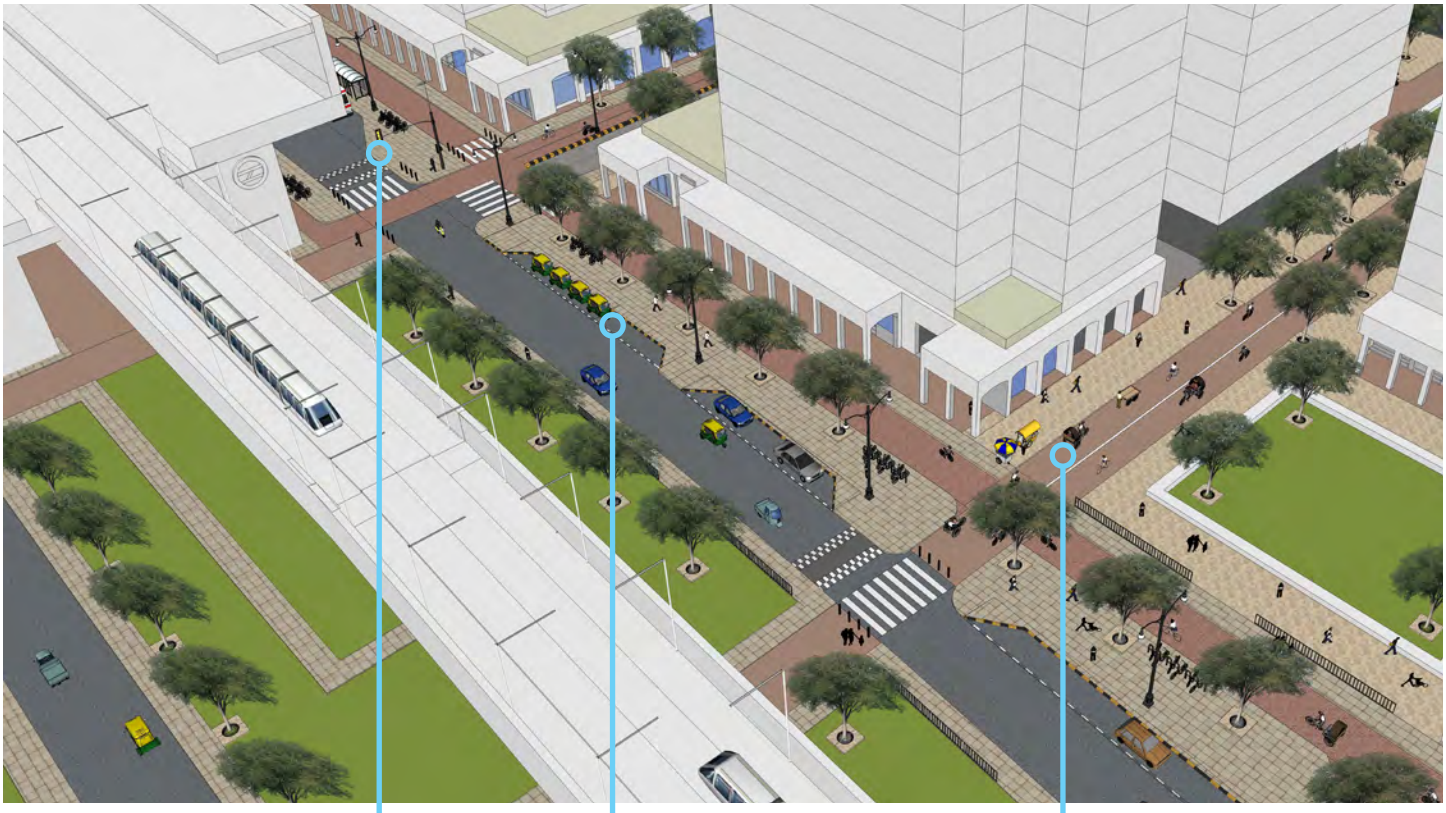
Transfer facility between two intersecting BRT Lines
(Source: © WRI)

- If the transit station is located at a different level than the road, the grade-separated connector may be extended across the width of this road.
- Grade-separated structures are not recommended for crossing the road. However, they are acceptable if they provide direct connectivity to the grade-separated station.
- It is important to separate the para-transit drop-off zones from the pick-up zone, to allow for the smooth functioning of such facilities.
- The drop-off zone should be located before the pick-up zone, which allows the driver to enter the pick-up zone after dropping off passengers. There should also be a provision for the vehicle to leave the drop-off zone, in case the driver does not want to pick up new passengers.
- Physical segregation of respective zones can ensure that the movement of paratransit vehicles does not impede the movement of feeder bus services.

GRADE SEPARATED TRANSFERS AT THANE STATION AREA, THANE, INDIA

The Mumbai Metropolitan Region Development Authority and Thane Municipal Corporation implemented traffic management infrastructure projects around the Thane suburban railway station in the Mumbai metropolitan region. Public bus services and IPT infrastructure are grade-separated. An elevated deck is constructed for public and state transport buses. It connects to the suburban railway ticketing booths through sky-walks and foot over bridges. There are at-grade auto-rickshaw pick up and drop off points with waiting and queuing areas for passengers. A lane has also been reserved for private motorized vehicles.

Thane Suburban station in India with lower level for auto-rickshaws and upper levels for bus bays. It connects to the road level via elevated walkways
(Source: © WRI India)



Para-transit access and transfers to transit station and connections for vehicular traffic and through motor-vehicle free shared streets
(Source: © WRI)

Bhubaneswar, India