TOD K P

PD-H07

HOW TO PLAN SAFE ACCESS FOR TOD

Type: Reference Guide

INTRODUCTION

An easily understood notion of TOD planning relates to the intensification of development around the transit station. This is achieved through two strategies; increasing built-up density and diversifying permissible land-uses. With such dense urban environments, the number of users in the public realm also increases significantly, posing safety concerns for all users. This also requires the provision of networks safe access to transit stations and efficient connections between these developments and transit stations – which is often neglected. If these networks are not adequately provided, then it discourages the use of transit to access these developments, resulting in a much lower transit patronage than should be expected.

In order to achieve safe networks within a TOD area, the "Sustainable Safety" principles of functionality, homogeneity and predictability will need to be looked more comprehensively for planning and designing of roads, so that they align with the TOD principles and can be integrated with the local context, to develop implementable on-ground design strategies. These three Sustainable Safety principles tailored for TOD requirements have been briefly explained below:

1. **Functionality of roads in TOD area:** While assessing road safety it is critical to understand the mixed function of the road network – whether it is an arterial road that includes a mix of transit or a connector that caters to traffic accessing the developments in the TOD or feeders that focus on accessing the transit stations as well as distributing traffic within the station area. The planning and design considerations are therefore made keeping in mind the mixed function in the street. The functions of the road in a TOD are also related to the mix of land use along it and may vary through the time of the day impacting the volume of users on it.

2. **Homogeneity of road design in TOD area:** Homogeneity of road design refers to the prevention of large differences in speed, mass and direction. The road network in a TOD area caters to all kinds of speeds and volume of vehicles within its ROW – slow moving pedestrians and persons with needs, cyclists, faster moving cars and other motor vehicles, feeder services such as IPT and public buses, and high speed mass transit vehicles such as BRT or metro rails. It is crucial to ascertain the capacity of these network based on the function they serve and segregate the users and different modes by using protective measures or adequate buffers between the modes to ensure maximum safety. It is supported by orienting streets towards the station, determining directionality of these streets to enable ease of traffic flow within the station areas, and maintaining speeds based on the immediate context – nature of land use and function of the streets. These principles are detailed out on PD-H07 subsection Capacity, Orientation and Safety; as well as in safety design guidelines provided in PD-R02.

3. **Predictability of road network in TOD area:** This refers to the usability of the road space – "are the road users familiar with the behavior demanded by different road types, and what they may expect from them and others". The design of road infrastructure and amenities are such that the users can recognize the type of road and are aware of its function. Within a TOD, higher mix of users, reinforces the need for predictability to achieve safety. Prioritization of road users, distribution of lanes within a ROW, stops and utilities, markings on the roads, signage, visibility, movement lines at intersections (especially for pedestrians, cyclists and other vulnerable users) gets highlighted.

5 PRINCIPLES OF TOD ZONE NETWORK PLANNING

The most critical aspect for the creation of a strong interlinkage between the transit station and the developments within station area is network planning. In our assessment, there are five key principles of network planning for TOD zones, which are presented below.

COVERAGE

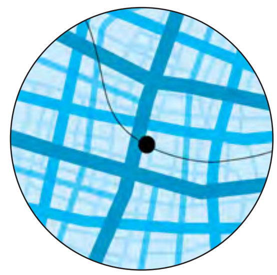
The network should have an extensive reach, such that every property within the TOD zone is connected to the network.

CONTINUITY

There should not be missing links (gaps) in the network.

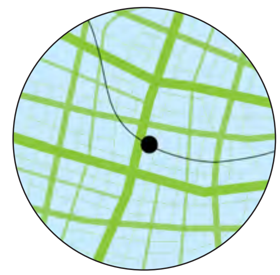
ORIENTATION

The network should be oriented towards the transit station, providing as direct connectivity as possible.



CAPACITY

The capacity of the network should be adequate to meet the high volumes of transit commuters, particularly along the trunk routes leading to the station.



SAFETY

Achieving a high standard of safety should be the guiding principle behind each and every decision on network planning; especially for the safety of vulnerable road users.

“Coverage” helps define the extent of street network and accessibility for different road users and hence provide for suitable solutions to ensure safe access. “Continuity” refers to the connectivity within the network and its density, ensures equitable access to the transit without congesting any area, and channelize traffic flow within the TOD zone. “Orientation” is facilitating the directed movement to and from transit stations and hence help in placing required infrastructure for safe movement. “Capacity” refers to the spatial quality of the network for all road users to ensure adequate space within the ROW based on the volumes of each type of user the network is catering to. Lastly “Safety” refers to creation of safer and segregated infrastructure within the network to avoid any type of crash or ensuring lower speed allowing the safe sharing of infrastructure. These as principles of network planning, help in creating framework for implementing physical safety measures.

For example, sidewalks are designed to function separate from vehicular travel lanes and cycle infrastructure. They are designed as per best practices and recommended design guidelines to accommodate the anticipated number of pedestrians using the segment of the network depending on how it connects to the transit station and any other node within the station area. However, these attributes will become redundant if the sidewalks are not part of a network that is not continuous and connect different nodes within the TOD area including the transit station.

These 5 Principles of Station area Network Planning for a TOD are thus derived from the three key road safety principles. The following sections cover these five principles in more detail, which includes guidelines and strategies on how to implement them.

*Refer **PD-R02** TOD Planning Principles for detailed guidelines for designing safe infrastructure based on road safety and network planning principles.*

PRINCIPLE 1: Coverage

The principle of Coverage, with respect to station area network planning, means that every property within the defined influence area, must connect to a network leading to the station.

- It is neither practical nor desirable, for the coverage of every network to be as extensive as another. The importance of direct access of a network will depend upon the property's location with relation to the station.
- Thus, an important step in planning the coverage of feeder networks is to first define the realms of each network within the TOD zone.

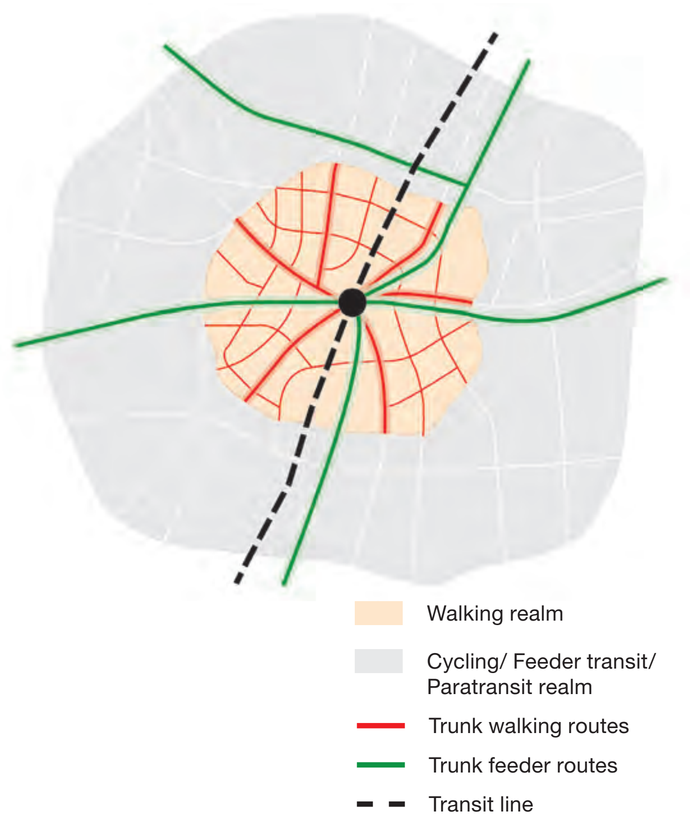
SAFETY IMPLICATIONS

If access networks do not have adequate coverage, then safety in the station area is adversely impacted. Lack of connectivity reduces the mode choices available to the commuter, which increases their dependence on personal motor-vehicles, thereby increasing traffic volume. There is clear evidence to show a strong correlation between traffic volume and road crash

DEFINING THE NETWORK REALMS

- A station area in the denser parts of the city, where transit network coverage is high, will normally only have two realms for the planning of access namely
  - The walking realm and
  - The area outside the walking realm.
- The walking realm is normally considered as what an average commuter can walk in 5-10 minutes, which is about 400 to 800m.
- In low-density, suburban areas, a higher walking reach of 10 - 15 minutes (800m - 1.2km) may be considered.

The following diagram depicts the realms of a typical station area in a medium to high density urban area.



The different realms for planning of station area

- The boundary of the walking realm will not follow a straight line radius around the station, but will take an irregular shape determined by local land-use and street networks. Typically, the higher the density of the street network, (and smaller the block sizes), the larger is the walking realm.
- The realms for cycling is much higher, typically to the order of 3 - 5 times the size of the walking realm; based on an average cycling speed of 18 to 25km/h, and an average willingness to cycle time of 10 - 15 minutes.
- Similarly, depending on context, the feeder service or paratransit realms are likely to reach up to 3 - 5km from the transit station, which typically extend up to and beyond the TOD zone boundary.
- A key component for the planning of these realms is the delineation of trunk routes leading to the station. It is not possible for every property to have direct connectivity to the station across all realms. The more practical solution is to connect properties to a few trunk routes leading to the station. This creates a strong an extensive network that offers multiple choices to the commuter. Such networks follow what is described as the hub-and-spoke model. The station is the center and trunk routes radiate outward from it. Further along, lesser capacity routes branch out of the trunk routes, forming a cohesive network.
- It is not practical to provide distinct networks for each feeder mode. The key principle to follow here is priority in network planning. This refers to a hierarchy of priority when planning for the mobility needs of different modes.
- Walking should sit on the top of this priority list, with access by personal motor-vehicles being the least priority. This is not a unique idea to TOD zone planning, but is rather a general guiding principle for creating sustainable, people-friendly cities. However, these guidelines become more relevant from the perspective of TOD, given the focus of prioritizing commute by transit.

ESTABLISHING PRIORITY IN NETWORK PLANNING

1. **Walking:**
   Walking is the most pertinent mode for first and last mile connectivity in almost any given circumstance. There is likely to be a high volume of walking commuters within the walking realm, and hence it is important that the network meets a high level of capacity and mobility. Outside the walking realm, walking infrastructure can be of lower capacity and mobility. However, it is still essential to have network coverage in this zone as well, because walking is likely to be used in combination with other feeder modes to access the station.

2. **Cycling and Feeder Transit Services:**
   Next in priority are the cycling and feeder transit services, (if applicable). As discussed earlier, the realms of the two will likely be the same in high density, urban areas, and both services can offer strong connectivity to the main transit line, depending on the context. The need for segregated infrastructure would be established based on volumes and differential speed. However, the shared network lines need to be planned and designed in a manner that offers a high level of safety and mobility for these modes.

3. **Para-transit and shared vehicles:**
   In some cases, para-transit modes, (taxis, rickshaws, etc.), may serve as feeder services to the transit station. This becomes more relevant in suburban areas, where some properties may not be within walking distance of the station or a feeder transit service. Recent innovations in mobility have also introduced the use of shared vehicles, (that can be self-driven) performing the function of first and last mile connectivity. In most cases, paratransit vehicles will share the same street networks of general vehicles. However, in the vicinity of the station, they may require special infrastructure to allow for safe and convenient transfer to and from transit. In general, paratransit services should be next in line of priority in the station area network planning.

4. **Personal motor-vehicles:**
   In some contexts, personal motor-vehicles may serve to provide first mile connectivity to transit. This may be relevant in low-density, suburban areas, that do not have access to other feeder modes. This entails the provision of adequate, long-term parking infrastructure in the vicinity of the station, which is only going to be viable in low-density areas. In most cases, personal motor vehicles should have the least priority in station area network planning.

PRIORITY 1
Walking

PRIORITY 2
Cycling & Feeder Transit Services

PRIORITY 3
Para-transit & Shared vehicles

PRIORITY 4
Personal motor vehicles

Adaptation of hierarchy of priority for mobility planning, prominent in many global cities at the forefront of sustainability. This hierarchy of priorities is all the more relevant for station areas, given the focus of moving people away from personal vehicles and onto transit.

PRINCIPLE 2: Continuity

Network continuity within the context of the station area, means that every property should be seamlessly connected to every other property, and to the transit station. This means that there should not be any gaps or missing links in the network, where a commuter is forced to use other components of the general road network that may not be designed for this mode.

- If access networks to the station are not continuous, then it forces the commuter to use other elements of the road infrastructure that do not meet its safety requirements.
- The critical importance of network continuity is often neglected in cities in developing countries, where infrastructure provision is scattered and disjointed, making it near impossible to complete a trip entirely along the network.
- When implementing a station area plan, an integral step is to implement measures to augment and complete the feeder networks. In built-up, dense urban areas, it is generally difficult to build new infrastructure to complete the network, other more practical strategies are incorporated to achieve a satisfactory result.

4 MEASURES TO BRIDGE NETWORK GAPS

1. Developing off-road connectors
2. Using development incentives to augment the network
3. Developing grade-separated infrastructure
4. Designing for shared infrastructure

DEVELOPING OFF-ROAD CONNECTORS

- When planning the feeder network, an initial step is to develop a comprehensive map of the station area. This map will have important layers, such as the street network, land-use, property ownership and building footprint.
- This map can then be analyzed to identify missing links, which is then juxtaposed against adjacent land-use and property development, in order to identify opportunities to create off-road connections. Such a spatial study will help to identify, at least, the physical possibilities for completing the network.
- Some opportunities that should be assessed are:
    - Are there any vacant/ open plots in the vicinity?
    - Is there city-owned land, which may be easier to modify?
    - Are there parks or gardens nearby that can be utilized to create walking or cycling paths?
    - Are there gaps between building footprints that may be acquired to create a link in the network?
- The next, more complex step is to develop institutional strategies that would allow for this to happen.

Refer PD-R02 *for more details on developing off-road connectors*

USING DEVELOPMENT INCENTIVES TO AUGMENT THE NETWORK

The implementation of a TOD strategy is a golden opportunity for urban transformation within the TOD influence area. An integral component of a TOD policy is to intensify development around transit, by creating development incentives. A key strategy in this regard grants landowners two boons - additional Floor Space Index (FSI) and permission to transform land-use to more lucrative uses, such as commercial development. Property owners stand to make tremendous financial gains from this transformation.

In order to ensure that the objectives of social infrastructure within the station area are also met, the city should link these incentives to different terms and conditions.

Terms and conditions for bridging network gaps:

- **Break up large land parcels:** The city can include a condition in the TOD policy or the applicable zoning regulations, that requires plot holdings beyond a given size to be divided, with a public right-of-way created in between.
- **Implement and incentivize easement rights:** Easement refers to the right to enter and cross another person's private property in order to access a public right-of-way.

Such a strategy may be implemented for large land parcels and can be linked to additional FSI in built-up urban areas. Such easement rights can be restricted to non- motorized transport only, which also stand to benefit the property in question if it is a retail-commercial establishment.

- Utilize building setbacks: Amalgamate building setbacks between adjacent buildings to create new rights-of-way. These links should be restricted to pedestrian and cycling movement ideally, because building setbacks are not likely to be wide enough to accommodate motor-vehicle traffic.
- Incentivize landowners to build missing networks: The City develops a network plan that includes the use of private land. It then works with different landowners to build the various sections of the network, ensuring seamless connectivity between the different sections. Landowners may be incentivized to build these missing sections, as a partnership model with the City. This will help provide direct, safe and convenient access to the transit station thus increasing the footfall of potential customers and improving the commercial viability of their property. The City benefits with sharing of initial capital expenditure, and subsequent maintenance of the infrastructure - typically managed by the private landowner.

Refer Finance knowledge Product FI-R01 *for more zoning incentives and other incentives that would facilitate road safety inclusion during TOD implementation.*

DEVELOPING GRADE-SEPARATED INFRASTRUCTURE

- In some extreme cases, one may consider the use of grade-separated infrastructure, either elevated or underground, to overcome a missing link in the network.
- Such measures must only be used as a last resort, when all other at-grade measures have been exhausted; because of its high capital cost, difficulty in access for mobility-impaired users, negative impact on the built-environment, and high propensity for decay due to disuse.
- Grade-separated infrastructure forces the commuter to climb up and down.
- Grade-separated infrastructure must generally be considered to augment the network and should not be used in lieu of at-grade facilities.
- Where provided, it is advantageous to directly link with the transit station, especially if the station infrastructure is at the same grade. This eliminates the need of changing grades, at-least, at one end of a transit-access trip.

Refer PD-R02 *for more details on developing grade-separated connectors*

DESIGNING FOR SHARED INFRASTRUCTURE

- In most built-up urban environments, it is not going to be practical to develop distinct networks for all feeder modes.
- There will be instances where modes will just have to share infrastructure along certain sections of the network.
- If designed appropriately, this can still ensure a high level of safety and mobility for all road users.
- The key guiding principle to follow here is, "*when infrastructure is meant to be shared, design it to meet the mobility needs of the most vulnerable road user*". For instance, if the carriageway must be shared between motor-vehicles and cyclists, then the design speed should be one that is safe for cyclists.

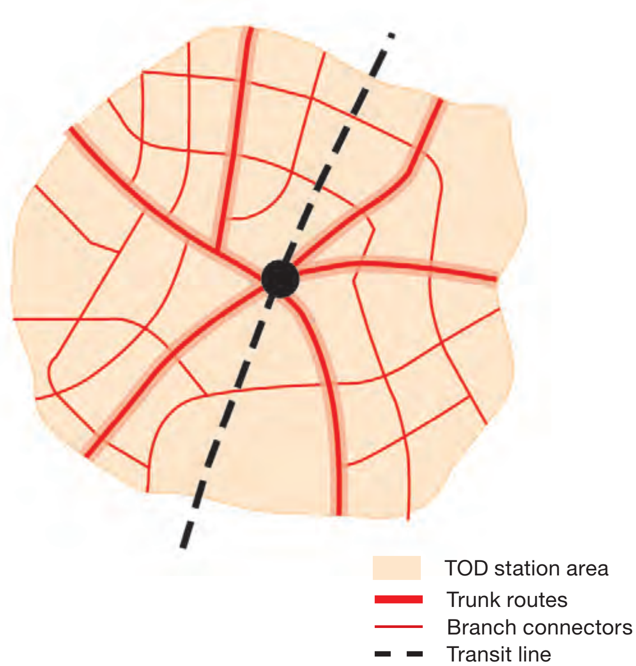
The measures to plan for a shared street are discussed in further detail under the fifth Principle of Safety.

Further, the design guides for shared streets are covered in PD-R02

PRINCIPLE 3: Orientation

This principle places the station as the anchor point of the network. The key component to ensure a network is well-oriented towards the station is to identify and develop trunk routes. This means the planning of networks that connect properties to the transit station as directly as possible.

A built-up urban environment rarely offers such a clean slate to plan the feeder network. Here, one has to work within the limitations of the existing built environment as well as the available right-of-way.



Oriented the feeder network in a greenfield station area

3 ASPECTS TO DETERMINING THE ALIGNMENT OF TRUNK ROUTES

1. Determine the main nodes
2. Assess strategies to minimize deviations
3. Assess favorability of local conditions

DETERMINING THE MAIN NODES

A key aspect of network planning in built-up areas is to first identify the main nodes in the station area, besides the station.

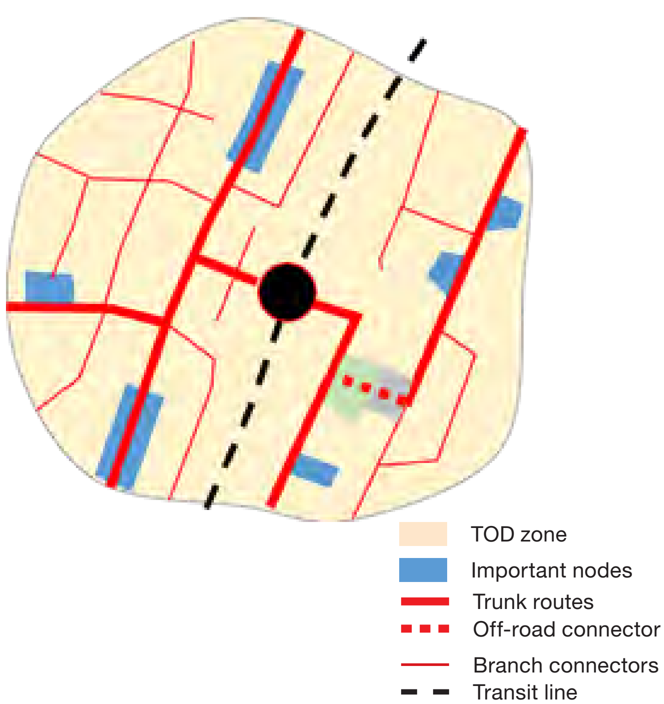
- These nodes are any location that are likely to have a high footfall, such as an office complex, a major retail street, a hospital, an educational building, etc. They may either be single points or stretches of corridor, (as in the case of a shopping street).
- Once these locations have been identified on a map, the next step is to overlay them on the road network of the station area. The objective is to determine how these nodes align with each other and transit station, and how to connect them with the least number of routes in the shortest possible distances.
- One may begin by drawing straight lines between these nodes and the transit station. If two or more lines are near one another, then consider the possibility of a single connector to these nodes.
- The next step is to trace a path along the existing right-of way, that approximates as closely as possible to the straight-line connector to the station.

ASSESSING STRATEGIES TO MINIMIZE DEVIATIONS

- Once an approximate path for a trunk route is determined, the next step is to analyze it to reduce any deviations in this route using the measures discussed earlier in Principle 2: Continuity.
- The measures under “Continuity” will have to be assessed together and analyzed for their relative cost versus benefit.
- This is likely to be an iterative process, where all options are assessed, in order to determine the optimal solution.
- It is also likely that different measures will be viable for different sections of the route, and the final solution is likely to be a combination of one or more strategy.

ASSESSING FAVORABILITY OF LOCAL CONDITIONS

- Network alignment not only includes creating a continuous linkage to the station but also must take into consideration local conditions, such as adjacent land-use, infrastructure capacity, etc.
- It is important to determine if the adjacent land-use supports the selection of this trunk route alignment, keeping in mind that this will entail higher traffic volume and/or pedestrian footfall.
- Furthermore, one has to determine if the infrastructure capacity along each section of the alignment is adequate to meet its requirement as a trunk route. There are multiple strategies that must be first assessed to augment the capacity, before a decision is made. These strategies are described in more detail under the next section, Principle 4: Capacity.
- The final feeder network plan for built-up station areas may have some imperfections but will be the best plan for the given conditions.



Feeder network planning in a built-up environment.

Here, the existing streets were not oriented towards the station to begin with as they primarily ran parallel to the transit corridor. Hence it is not possible to completely orient the feeder networks to the station. However, it is still possible to identify close to direct lines between the main nodes and the station, and adopt different strategies to minimize the deviations (Principle 2) and increase capacity (Principle 4).

PRINCIPLE 4: Capacity

Capacity deliberations are most pertinent in the planning of the trunk routes along the network. A TOD involves creating concentrated nodes of moderate-to-high density developments supporting a balanced mix of diverse land uses which are located within 5-10 minutes of walking distance or 800m-1km from mass rapid transit stations. This integration of transportation network and land use around a station area, with elements such as market demands, environmental systems etc, allows for placement of employment, entertainment, leisure and residential uses near each other around the rapid transit stations. This allows for reduced trip lengths and number of trips and prioritizes public transit use and reduces dependency on private motor vehicles.

A dense development implies higher number of users within the area, concentrating around the station, and getting distributed outwards towards the 'nodes' through the road network. However, this also poses safety issues, as different road users are interacting within the same space, raising issues of capacity. Measures to augment network capacity have to start with land use planning and transit service planning, which is supported by the following augmentation methods.

MEASURES TO AUGMENT NETWORK CAPACITY

1. Reallocate road space
2. Incorporate building setbacks
3. Eliminate on-street parking & streamline other road uses
4. Create one-way street networks
5. Reduce interruptions in flow
6. Provide more entry & exits at the station

REALLOCATING ROAD SPACE

- The most important tool to ensure adequate capacity is to reorganize the use of road space in the station areas.
- Road space is a critical and finite commodity, especially in built-up urban areas. The judicious allocation of this space plays an important role in determining the quality and safety of mobility in the station areas.
- Generally, national street design codes are inadequate for station areas, in their prescriptions on minimums for pedestrian infrastructure.
- Along major trunk routes in a station area, a minimum footpath width of 5 meters may be warranted. To determine what's appropriate, it is important to carry out pedestrian volume by capacity studies for the walking network,and reallocate road space to accommodate wider footpaths that can meet the desired Level of Service for pedestrians.
- For the cycling network, it is recommended that segregated cycle paths be provided on all trunk routes leading to the station, especially when the road way is shared with high-speed or high volume vehicular traffic. This may not always be feasible, given local constraints; but this must be the starting guiding position for cycle network planning.
- It may not be feasible to adopt dedicated transit lanes for feeder transit services. However, it would be advisable to restrict other ancillary road uses on these corridors to allow for the safe and smooth movement of transit vehicles. For instance, on-street parking could be restricted along these routes, and additional curb space provided at all bus-stops to accommodate waiting commuters.

The inadequate walking infrastructure, right outside a transit station in Mumbai, India, cannot accommodate the large volume of pedestrians commuters. This forces pedestrians onto the carriageway, resulting in a very unsafe traffic situation.
(Source: © WRI India)

- Para-transit vehicles benefit from dedicated spaces for picking up passengers. However, unlike transit services, para-transit services are not restricted to fixed routes. Hence the locations of these pick-up spaces should be determined by high demand land-uses, such as retail, office, institutional developments, etc.
- For integrating building setbacks into pedestrian networks, a TOD policy can be introduced to allow for the transformation of the ground-floor of a residential property for commercial uses along major trunk routes.
- The city can link the permissions to develop ground-floor retail activities to the condition that the road-abutting compound wall is removed, and the setback is maintained as an extension of the public footpath. The ownership of this space can remain with the property owner, but its built conditions and usage will be guided by the city TOD policy.

Refer to **FI-R01** *Development Incentives for more zoning incentives and other incentives that would facilitate road safety inclusion during TOD implementation.*

INCORPORATING BUILDING SETBACKS

Earlier in Principle 2: Continuity, "use of development incentives to incorporate building setbacks into the feeder network", was discussed in reference of creating new links in the feeder network. In this section, it will be discussed with respect to increasing the capacity along the existing network.

- Typically, residential building have a setback along the road front and building edge is recessed from the compound wall edge. A TOD policy can be introduced to allow for the transformation of the ground-floor of a residential property for commercial uses along major trunk routes.
- In this scenario, the existence of a setback and a compound wall along the road edge may not be as beneficial as when the property had exclusively residential usage.
- The city can link the permissions to develop ground-floor retail activities to the condition that the road-abutting compound wall is removed, and the setback is maintained as an extension of the public footpath. The ownership of this space can remain with the property owner, but its built conditions and usage will be guided by the city TOD policy.

Refer to **FI-R01** *Development Incentives for more zoning incentives and measures for assimilating setbacks.*

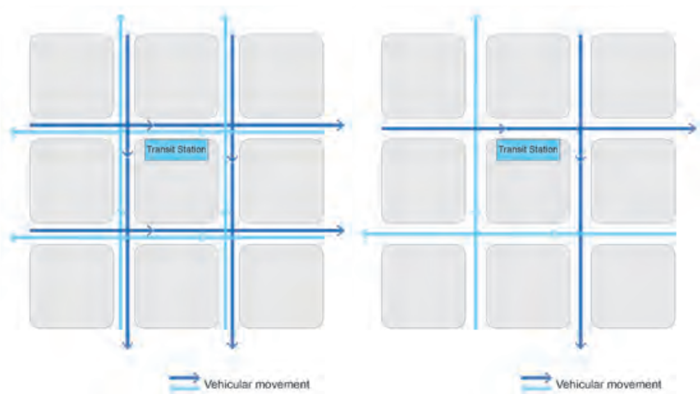
REDUCING ON-STREET PARKING AND STREAMLINING OTHER ROAD USES

- An effective way to free-up road space is to reduce the provision of on-street parking, especially along the trunk feeder routes leading to the station. This additional space can then be allocated to footpaths, cycle lanes or feeder-bus lanes.
- Within a TOD, due to the transit services there is a lesser dependence on private vehicles. Limitations on parking will encourage more commuters to use transit.
- It may also be possible to better utilize road space by streamlining other road elements, such as utility boxes, bus-stops, street-vending areas, taxi stands, freight loading/unloading areas, etc.

CREATING ONE-WAY STREET NETWORKS

- If there is a good network of parallel streets, and relatively small block sizes in the vicinity of stations, a network of one-way streets, alternatively running in opposite directions may be created.
- Typically, one-way streets require less carriageway than two-way streets, as they eliminate the need for a median or to have multiple lanes.
- One-way street networks also have the added advantage of being easier to manage at intersections, (because of lesser permissible turns); therefore, requiring fewer signal phases than a regular two-way intersection. This reduces the waiting time for feeder modes (transit, cycle or walking) to cross the intersection.
- A one-way C-shaped loop is also a great way to connect to the transit station. By making loop one-way for vehicular traffic, more road space can be allocated to other feeder network infrastructure, such as footpaths, cycle lanes and station transfer points.
- It must be noted here that converting a two-way street to one-way street is carried out to improve the carrying capacity of the street. This should not be confused with traffic calming design measures.

Refer to **PD-R02** *TOD Planning Principles & Design Guidelines for information about traffic calming measures.*

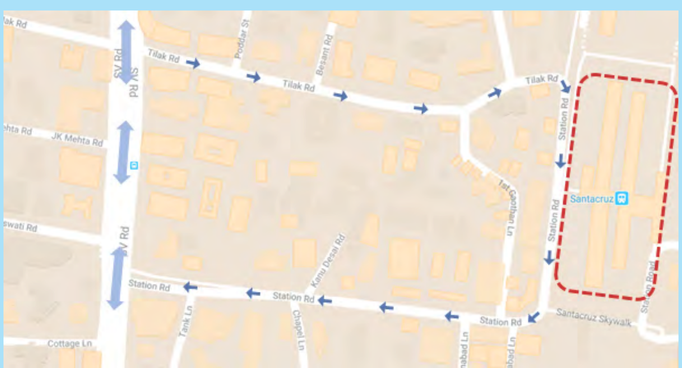


Existing conditions with two-way circulation of streets (Left), converted to one-way circulation of streets to have improved network capacity

ONE-WAY REROUTING OF STREETS

Santacruz Railway Station area - Mumbai, India:

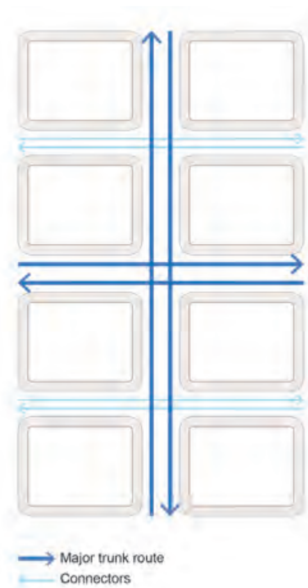
Parallel streets in the station area have been made one-way in opposite directions, creating a looped connection between the 2-way main street and the transit station. (Note: Here, traffic drives on the left)



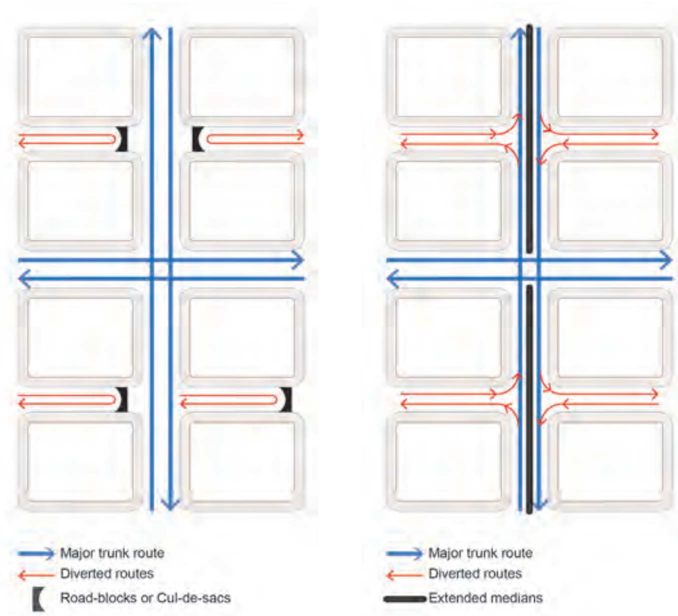
(Base map procured from Google maps.)

REDUCING INTERRUPTIONS IN FLOW

- The capacity of a trunk route on a feeder network is not only determined by the road space allocated to it, but also by the frequency of interruptions to its flow.
- The more frequent the interruptions to free-flow conditions, the greater will be the reduction in capacity.
- A crucial aspect of trunk route planning along the network is the adoption of various strategies to minimize interruptions, mainly through the diversion of conflicting traffic movements.
- Measures for reducing interruptions in flow:
  1. Eliminate traffic intersections along major trunk routes leading to the station. This can be achieved by converting intersecting streets into cul-de-sacs or by modifying the intersection to only allow vehicles to enter and exit the minor street, but not cut across the trunk route



Existing conditions with greater number of intersections along the major trunk route.



Measures for reducing interruptions to flow: Road closures creating cul-de-sacs that help reduce number intersections (Left) and, Extended medians to reduce number of intersections (Right)

2. Limit the number of driveways on the main trunk routes. This reduces the number of breaks along the sidewalk, again improving free-flow conditions.

Existing conditions with driveways to buildings from trunk route. (Left), Reducing number of driveways into developments along the trunk route and providing entrances from connectors. (Right)

- Another important measure especially pertinent to feeder transit service, is signal priority. Signal phasing can be designed to give more green time for traffic and pedestrians along the main trunk routes.

- It should be noted that for every situation with at-grade transport lines, some amount of interruptions is unavoidable. At certain points, the trunk routes will have to cross other roads. The objective, therefore, is not so much to eliminate all interruption, but to minimize them where possible, and to design them in a safe and appropriate manner where unavoidable.

PROVIDING MORE ENTRIES AND EXITS AT THE STATION

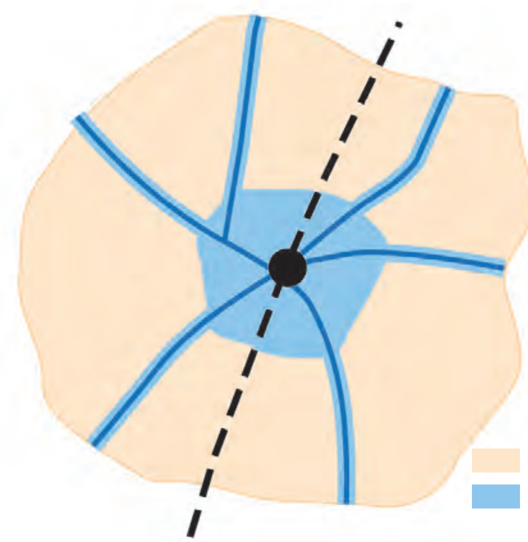
- The capacity of any network is determined by its most constrained point. In the context of feeder networks, this point is often the immediate station area, which has the highest volume of commuters utilizing the smallest amount of space.

- Measures to avoid bottleneck:

    1. Station infrastructure can be designed with multiple entries and exits, directly taking people further along on the feeder network.

    2. One can even consider different points of access for commuters on different modes, to reduce the load at one location.

PRINCIPLE 5: Safety



Determining the feeder priority area in the station area.

Planning for the safe provision of access networks in a station area, requires certain hard decisions that may lessen the mobility of other traffic in favor of the safety and mobility of the feeder network traffic.

Traffic in a station area, (both vehicular and pedestrian), can broadly be divided into two buckets:

1. Traffic destined to or originating from the station;
2. Traffic not concerned with the station in any way.

- In most instances, the priorities of these two groups will clash with each other. For instance, the loading and unloading activities of freight vehicles, servicing shops in the station area, may impede the mobility of commuters to the station. However, the principle of safety must have the highest priority.
- Balancing these conflicting priorities can be made easier by defining the boundaries within a station area, where the priorities of transit commuters are to be placed higher than those of other traffic.
- Typically, in the area closest to the station, traffic bound to the station must be given the highest priority. Similarly, traffic directed to and from the station should be of high priority along all the major trunk feeder routes leading to the station.
- Once the feeder priority areas of the station area are defined, the next step is to determine measures to ensure a high level of safety for the feeder modes in question.

MEASURES TO IMPROVE SAFETY

1. Provide dedicated infrastructure
2. Implement speed zoning & traffic-calming measures
3. Reduce vehicular traffic volume

PROVIDING DEDICATED INFRASTRUCTURE

- The safest measure, though not always the most practical, is to provide dedicated infrastructure for each feeder network which includes footpaths, pedestrian walkways, cycle lanes and bus lanes.
- Dedicated infrastructure is a good measure on wide trunk routes, especially where there is a high volume of vehicular traffic, moving at a very high speed.
- Excluding infrastructure for walking, it is not necessary, or even desirable, for the entire feeder network to be made up of dedicated infrastructure. A good network will utilize a combination of dedicated infrastructure, (where needed), and traffic-calmed shared streets for the remainder.
- Planning for safety requires the determination of where dedicated infrastructure is appropriate and is determined by the intersection of two aspects - desirability and feasibility.
- Desirability relates to the provision of dedicated infrastructure only where it is warranted from the perspective of improving safety. Whereas, feasibility relates to dedicated infrastructure provisions only where it is feasible to do so.

- Dedicated infrastructure can take two forms:
    1. **Physically segregated infrastructure:** This kind of dedicated infrastructure is physically segregated from other traffic, using curb, fence, median, landscaping etc. Generally, the segregated infrastructure doesn't continue over intersections, to allow for traffic to pass.
    2. **Lane-marked infrastructure:** It relies on lane-marking and road signage to convey the information instead of using physical infrastructure to segregate traffic,.
- From the perspective of safety, segregated infrastructure is generally safer, especially for vulnerable road users like pedestrians and cyclists.

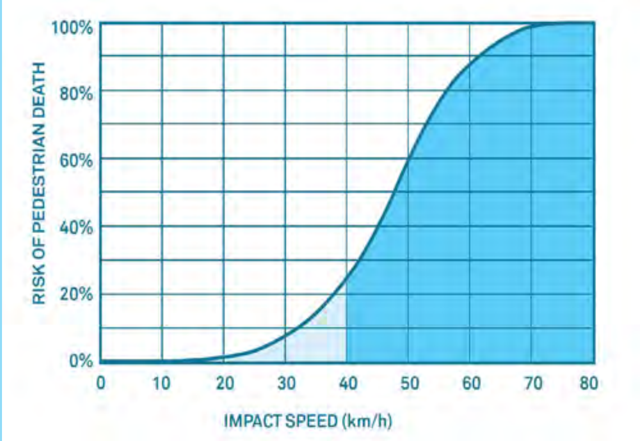
IMPLEMENTING SPEED ZONING AND TRAFFIC-CALMING MEASURES

- Speed zoning is the single most effect measure for the provision of safe mobility in the station areas. Recommended speeds for station area planning:
    - **5km/h:** Narrow streets where traffic & pedestrians share the road
    - **15-30km/h:** All streets within the station walking realm & neighborhood streets outside the walking realm
    - **30km/h:** Trunk feeder bus / cyclist routes to the station
    - **50km/h:** Maximum prescribed design speed for all other roads in the station areas

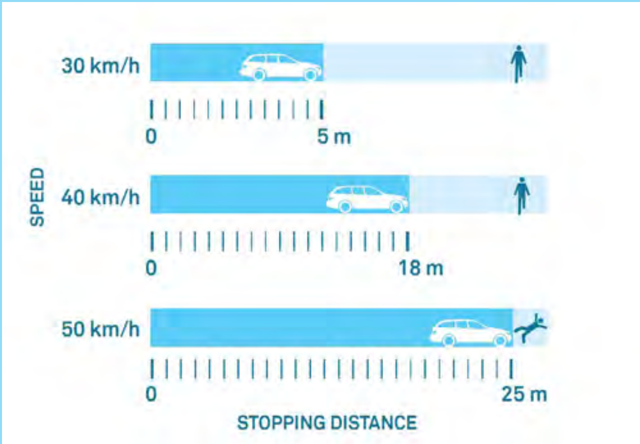
Low-speed zones in Fortaleza, Brazil, prioritize pedestrian safety
(Source: © WRI)

VEHICLE SPEED AND RISK

Vehicle speed determines the severity of crashes and injuries sustained. Researches have shown that vehicular speeds below 30km/h, drastically reduce the risk of fatalities. The fatality risk for pedestrians with vehicles traveling at 50km/h is more than twice as high as the risk at 40km/h and more than five times higher than the risk at 30km/h as can be seen in the graph below.



Additionally, vehicle speeds also affect the potential to avoid crashes. Higher speeds reduce the driver's capacity to stop in time, reduce the maneuvering ability to avoid a crash, difficult to make turns or drive along curves, and cause others to misjudge timing of approaching vehicles. The figure below shows the relationship between vehicular speeds and stopping distances.



(Source: NACTO Global Street Design Guide)

NOTE: These studies were conducted in high-income countries and there is evidence to suggest that this relationship might be even more extreme in low- and middle-income countries

- Desired speed should be achieved through a combination of enforcement and design measures.
- It is recommended to adopt a uniform speed limit for the walking realm across all station area in the city. In certain short sections, where the high pedestrian volumes, coupled with local traffic accessibility demands, a significantly lower speed limit (of 5km/h) may be desirable.
- It is prudent to note that it is not feasible for a cycling network in a station area to entirely consist of segregated cycle lanes. Such infrastructure is desirable and warranted on trunk routes with high traffic speeds and volume. However, at other locations cyclists will share the road with other traffic, and such shared streets will be an integral part of the station area cycling network.
- It is also important to note that speed zoning doesn't merely entail enforcing speed limits through regulation, but also requires the implementation of appropriate traffic-calming infrastructure to ensure that the design speed is in sync with the speed regulation.
- Automated Enforcement (AE) refers to all forms of technology which detect and record violation of any road rule without direct human involvement. Speed cameras enforcing speed limits are a common application of AE. Over speeding and other illegal behaviors, including disobeying a red light signal, mobile or cellular phone use, incorrect lane use, and non-restraint use can be detected using an automated enforcement approach. The use of technology should be considered as one part of a comprehensive speed management approach that includes road infrastructure and roadside policing as well. This technology requires adequate support of robust database of vehicle registration, high-quality camera sensitivities and calibrations, and supportive regulations and policies.

REDUCING VEHICULAR TRAFFIC VOLUME

- There are different measures that can be considered to reduce traffic volume in the station areas, particularly in the walking realm. The measures are discussed here:

    1. **Restrictive measures:** Traffic volume in the walking realm can be significantly reduced, by adopting strategies to discourage personal motor-vehicle usage. For instance, reducing parking availability, or increasing the cost of parking, in the walking realm encourages more commuters to avoid personal motor-vehicle usage.
    2. **Regulatory measures:** Another strategy is to adopt regulatory measures, such as restricting certain vehicle classes during peak commuter time periods. For instance, freight vehicles may not be allowed in the walking realm from 8:00 AM to 9:00 PM.
    3. **Alternate bypass routes:** Traffic volume in the walking realm can also be reduced through the creation of alternate routes that bypass this area. For instance, a new road may be developed to carry through traffic that does not originate, or is not destined to, a location within the walking realm.
    4. **Eliminating through traffic:** Another measure to limit traffic volume within the walking realm is to convert certain streets into dead-ends (cul-de-sacs) or loops back to the same road outside the walking realm. This discourages the use of these streets by any traffic that is not locally-bound. Loops are preferable to cul-de-sacs because often the streets in the near vicinity of the station are not wide enough to accommodate a functional cul-de-sac.
    5. **Full pedestrianization of streets:** Pedestrian-only paved streets could be created for routes in the TOD station area that connect to the transit station with developments having high footfall, or generate heavy pedestrian traffic due to commercial and recreational activities along those routes. Barring access for emergency vehicles and delivery vehicles during certain hours, no motor-vehicle is allowed in these streets.

Pedestrian only street in Sao Paulo, Brazil
Source: © WRI

- Outside the walking realm, the undue diversion of vehicular traffic is not recommended. However, along main transit feeder lines and/or cycling routes, traffic diversion may be considered to enhance safety.

Bogota, Colombia