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Development of Toolkits under the “Sustainable Urban Transport Project”

Citywide Multi-Modal Integrated Transport Plan

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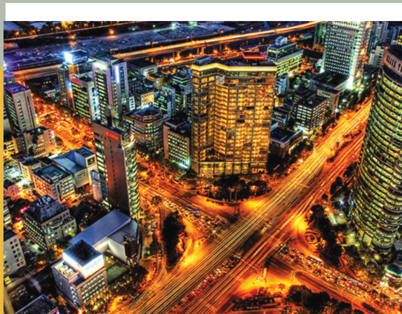

www.iutindia.org

The Institute of Urban Transport (India) is a premier professional non-profit making organization under the purview of the Ministry of Urban Development, Government of India (MoUD). The National Urban Transport Policy (NUTP), 2006 has empowered IUT to serve as a National Level Facility for continuous advice and guidance on the principles of sustainable urban transport. The objective of the Institute is to promote, encourage and coordinate the state of the art of urban transport including planning, development, operation, education, research and management at the national level.

The Institute has been nominated as the project monitoring unit for Component 1A of the SUTP. IUT is responsible for overseeing the preparation of the training modules, subject toolkits and conduct of training of 1000 city officials in urban transport.

The Ministry of Urban Development (MoUD), Government of India (GoI) has initiated the Sustainable Urban Transport Project (SUTP) with support of Global Environment Facility (GEF) and the World Bank to foster a long-term partnership between GoI and state/local governments in the implementation of a greener environment under the ambit of the NUTP. The aim of the project is to achieve a paradigm shift in India's urban transport systems in favor of sustainable development. The MoUD is the nodal agency for the implementation of the project, to be implemented over a four-year period starting from May, 2010 to 30 November 2014. Project cost is Rs. 14,161.55 Million. The project's development objective (PDO) is to promote environmentally sustainable urban transport in India and to improve the usage of environment-friendly transport modes through demonstration projects in selected cities.

Preface

Government of India has initiated the Sustainable Urban Transport Project (SUTP) with support from Global Environment Facility (GEF), World Bank and UNDP. The primary objective of SUTP is to facilitate urban transport infrastructure in a sustainable environment and under the ambit of National Urban Transport Policy (NUTP).

Component 1A of GEF-SUTP project aims at capacity building amongst practitioners in the field of sustainable urban transport. The objective of the initiative is to create an enabling institutional framework for sustainable urban transport in India. This is to be accomplished by enhancing the capacity of policymakers, planners, researchers, executive agencies, service providers, managers and other professionals involved in urban transport to plan, implement, operate and manage sustainable urban transport.

To achieve the objectives of Component 1A, as part of the program 5 sub-components have been identified which include the following:

- Sub-Component 1 – Institutional capacity development, focusing on strengthening of Institute of Urban transport (IUT)
- Sub-Component 2 – Individual capacity development
- Sub-Component 3 – Preparation of manuals and toolkits
- Sub-Component 4 – Promotion, awareness and dissemination of information to expand and enhance the impact of GEF-SUTP
- Sub-Component 5 – Technical assistance to cities to address emerging issues encountered during project implementation.

Sub-Component 3 aims at providing step by step guidance to cities and other concerned authorities to enable them to plan and implement projects related to urban transport and also facilitate public decision makers and transport planners/ engineers in overseeing urban transport projects. It will include briefly the concept behind the subject of the tool kit, applicable planning standards and norms (most up to-date version to be used) and reference to a code of practice where necessary. The toolkits are as follows:

1. Land use transport Integration
2. Urban Travel Demand Modelling
3. Transport Demand Management

4. ITS for Traffic Management System
5. Public Transport Accessibility
6. Urban Road Safety & Safety Audits
7. Planning, Design and Evaluation of Urban Traffic systems
8. Finance and Financial Analysis
9. Environmental Analysis/SEA & SIA
10. Social Impact Assessment and R&R plan
11. Revision of CMP guidelines
12. City Transport Network
13. Urban freight management
14. ITS for Public Transport & BRT

The present toolkit would deal with the subject of **"Citywide Multi-Modal Integrated Transport Plan"**. The aim of this toolkit is to suggest a methodology for planning a city wide multimodal integrated transport (which includes all modes, i.e. PT, IPT, NMT, and personal transport) with the objective of promoting enhanced urban mobility in urban areas. The objectives of this toolkit are as follows:

- Identification of various components for city-wide multi-modal integrated transport plan (CMITP).
- Defining the process to be followed for the formation of five pillars of integration, related to pre - preparation, planning and design of its various components of integration identified.

Acknowledgement

The Institute of Urban Transport (IUT), India expresses its sincere thanks to the Ministry of Urban Development (MoUD), Government of India, for awarding the work of preparation of toolkit on "Citywide Multi-Modal Integrated Transport Plan" being prepared under Sustainable Urban Transport Project (SUTP) jointly initiated with the support of Global Environment Facility (GEF), United Nations Development Programme (UNDP) and World Bank.

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Finally, IUT is thankful to all those who took out the time to give valuable inputs during the course of the preparation of these guidelines.

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List of Acronyms

- BRTS – Bus Rapid Transit System
- CMITP – City Wide Multimodal Integrated Transport Plan
- ECS – Equivalent Car Space
- FSI – Floor Space Index
- FYP – Five Year Plan
- GDP – Gross Domestic Product
- GOI – Government of India
- HSRL – High Speed Rail Link
- IPT – Intermediate Public Transport
- IRC – Indian Roads Congress
- ITS – Intelligent Transport Systems
- LRT – Light Rail Transit
- MoUD – Ministry of Urban Development
- NMSH - National Mission on Sustainable Habitats
- NMT – Non- Motorized Transport
- NUTP – National Urban Transport Policy
- PIS – Passenger Information System
- PT – Public Transport
- UMTA – Unified Metropolitan Transport Authority
- UTF – Urban Transport Fund

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Executive Summary

Commuters use several modes of transport in a city - Public, Personal and NMT. Public modes include mass rapid transport modes i.e. Metro Rail, Light Rail Transit, Monorail, BRT, buses of various sizes and IPT modes i.e. Tempos, Autos, and cycle rickshaw. Personal modes include 4-wheelers and 2-wheelers. NMT includes walk and cycle. All these modes contribute to the citywide multi-modal transport network. These must be integrated to provide seamless connectivity to the commuters. The toolkit gives a methodology to plan a CMITP for a city. This involves three main steps;

a. Elements of Integration

b. Components and Sub-Components

c. Methodology for preparing CMITP plan includes Pre-planning, Planning and Design stages

STRUCTURE OF THE TOOLKIT

The structure of the toolkit is shown in figure below:

Introduction to the Toolkit	Introduction to the Subject	CMITP	Best Practices
•Aim •Objective •Scope •Intended Users •Methodology •This section deals with the problems faced by urban transport in India and, explaining the importance of carrying out multi-modal integration for urban transport plans, programs and projects.	•Concept •Why CMITP • Benefits to various users •Recommendations from various Indian policies •This section discusses the concept of City-wide Multimodal Integrated Transport Plan, its benefits and along with brief detail about its component and sub-components	•Introduction •Importance of Five pillars of Integration •Planning of five pillars is divided into three stages •Preplanning •Planning •Design •The section also gives a step-by-step methodology for carrying out CMITP for urban transport plans/ programs/ projects.	•London •Hong Kong •Singapore •Key learning's from case studies •This section discusses some case studies on CMITP studies carried out for urban transport plans, programs, and projects in cities around the world

STEPS INVOLVED IN CITY WIDE MULTIMODAL INTEGRATED TRANSPOT PLAN

The steps involved in the process of CMITP is shown in figure below

Step 1: Five Pillars of Integration

↓

Step 2: Components and Sub Components

↓

Step 3: How to carry out Citywide Multimodal Integrated Transport Plan

Step 3a: Pre Planning Stage	Step 3b: Planning Stage	Step 3c: Design Stage

The details of each step shown in Figure above are given below:

STEP1: FIVE PILLARS OF INTEGRATION

In order to provide seamless mobility, it is necessary to have the following five pillars of integration.

Institutional

- Integration of public transport authorities- Govt. & Private

Operation

- Route rationalization- All modes complementing each other
- Coordinated operational time tables

Physical

- Integration of Public transit services- Terminal & Interchanges

Fare

- Integration of Public transit fares throguh single ticket across all modes

Information

- Passenger Information System across all modes


STEP 2: COMPONENTS AND SUB COMPONENTS OF INTEGRATION:

Based upon the recommendations of national policy documents such as NUTP – 2006, NMSH, and FYP 12, the five pillars of integration can be divided into three major components as given below

- Public transport
- Transport network
- Non-Motorized transport

Each component is further divided into sub component as given in table below:

<table>
<tr><th>Components</th><th>Institutional Integration</th><th>Operation Integration</th><th>Physical Integration</th><th>Fare Integration</th><th>Information Integration</th></tr>
<tr><td rowspan="5">Public Transport</td><td rowspan="11">Setting up of UMTA</td><td rowspan="2">Route Network Planning</td><td>Bus Stop</td><td rowspan="11">One ticket for all means of transport</td><td rowspan="11">Inter-modal real time passenger information systems</td></tr>
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<tr><td rowspan="3">Service Plan</td><td>Metro Station</td></tr>
<tr><td>Intermediate Public Transport (IPT) Stop</td></tr>
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<tr><td rowspan="3">Transport Network</td><td rowspan="3">N/A</td><td>Road Network</td></tr>
<tr><td>Intersection</td></tr>
<tr><td>Parking</td></tr>
<tr><td rowspan="3">Non- motorized transport (NMT)</td><td rowspan="3">N/A</td><td>Cycle Track</td></tr>
<tr><td>Cycle Stop</td></tr>
<tr><td>Footpath</td></tr>
</table>

STEP 3: HOW TO CARRY OUT CITYWIDE MULTIMODAL INTEGRATED TRANSPORT PLAN?

The five pillars of integration (mentioned in Step 1 above) and their components along with sub- components have been detailed in three stages as follows:

- Preplanning Stage: This details out the pre-requisites including the list of surveys required to complete the analysis of planning stage. The list of surveys required for each identified component and subcomponent is given in their respective sections and details of each survey along with its format are given in Annexure 1
- Planning Stage: This stage lays out a series of steps necessary to achieve the desired output (i.e. five pillars of integration).
- Design Stage: It details out the desired or expected output of the integration. This section provides design brief for all the five components.

- Stakeholders *Consultation: To be done at each stage of pre-planning, planning and design stage.*

The details of the Institutional, physical, Information, Fare and Operational integration with respect to pre planning, planning and design stage is given in the following sections;

STEP 3A: PRE-PLANNING STAGE:

This stage details out the pre-requisites including the list of primary surveys and secondary data collection required for components & subcomponents of five pillars of integration. The details are given in table below

Integration	Pre-Planning Stage
Institutional	Secondary Data of various concerned department to be collected are Annual Report (Admin, Financial, Legal & Human Resource), Organizational Chart & Duty, Details of operations and Earlier Study Report, if any
Operation	**1. Public Transport:** For both, Bus System andMetro System or any other mass transit system a. Secondary Data to be collected are listed below; • Fleet Usage Detail (Number of buses by type of bus < standard, mini, low floor>, fuel used and age, Fleet utilization rate, Vehicular kilometers, Average kilometers per bus per day, Percentage occupancy - peak hour and average, Total passengers per day) • Route Detail (Route inventory along with bus stops) • Cost & Fare (Operation cost per km, Tax levied, Fare structure & Mobility card (Pass), Revenue per km, Profit/loss) b. Primary survey: Route Detail (Headway on different routes, Average route speed, Service reliability) **2. Transport Network:** N/A **3. Non-Motorized Network:** N/A
Physical	**1. Public Transport:** a. Secondary Data: City Map for existing location of infrastructure, transfer points b. Primary Survey: Inventory of Bus Stop/Metro Station/IPT Stop /Bus Terminal / Multi-Modal Hub (Interchange) **2. Transport Network:** a. Secondary data: Existing road network, Intersections and other On street & off street parking locations b. Primary Survey; Road Network Inventory, Intersection Inventory, & Parking Inventory **3. Non-Motorized Network:** a. Secondary data: Existing Infrastructure details of Footpath & Cycle Track b. Primary Survey; Footpath Inventory & Access, Bicycle track Inventory & Intersection Treatment


Integration	Pre-Planning Stage
Fare	The secondary data collection will be required for fare integration as given below: • Fare Structure (For various Modes of Transport) • Financial Performance Report • Fare Policy/Revision • Earlier Study Report, if any
Information	The secondary data collection for Information integration are given below: • Existing ways of information flow to commuters, if any • Details of its Operations & Maintenance • Earlier Study Report, if any

The details of the survey along with its format are given in Annexure 1.

STEP 3B: PLANNING STAGE:

This stage lays out a series of steps necessary for planning of components & sub components of multimodal integration and achieves the desired output

Integration	Planning Stage
Institutional	The steps for this integration, are as follows: 1. Step 1 - Identification of Concerned Authorities: Identify and list out various agencies & stakeholders concerned with urban transport in the city 2. Step 2 - Role & Responsibility of concerned Authorities: understand the functioning of the listed agencies. 3. Step 3 – Gap Identification: Identify the weaknesses prevalent in the various organizations/ listed agencies 4. Step 4 - Planning for Single Authority Unified Metropolitan Transport Authority (UMTA): Based upon the gap identification and investigation of responsibilities, UMTA can be formed as an executive body governed by a Board made up of heads of various departments in the city, local elected leaders and eminent citizens and also identify its functions at various levels
Operation	For this integration; steps needed are as follows: **1. Public Transport:** a. Step 1 - Review of Existing PT Scenario: Such as public transport modes, available infrastructure, peak load, frequency etc. b. Step 2 - Demand Estimation: The steps involved in the demand estimation are as follows: • Data Processing: Processing of data collected to estimate the travel demand • Data Analysis: Calculate potential ridership, peak and off-peak frequencies, fleet size requirement, total cycle time etc. • Prepare Four Stage Model using any transport software • Validation of Demand Model: Validate the model by using base year trip ends to be distributed and assigned on the network. • Forecasting –Calculate the ridership in terms of passengers per hour per direction (PPHPD), in the estimated horizon year


Integration	Planning Stage
	c. Step 3 – Co-ordinated Routing & Scheduling: After, undertaking the four stage modelling the primary mode providing trunk and feeder service required for the city is established. For their effectiveness to cater the current and future demand of the city travel needs, the operation integration i.e. coordination of route and schedule is necessary which can be achieved through the **"Integrated Operation Plan—Public Transport",** which is authorities first step towards operation integration. (Details are given in section 3.2.2.3) **2. Transport Network:** N/A **3. Non–Motorized Transport:** N/A
Physical	**1. Public Transport:** The steps involved in this integrations are as follows: a. Step 1 - Types of Infrastructure: Identify the type of public transport infrastructure with associated facilities such as bus stop/ metro station/ IPT stop/ bus terminal/ multi-modal hub (Interchange) available in the city b. Step 2 - Location Identification: The factors that need to be considered for location identification are regional connectivity, routes, existing location of infrastructure (stops/ station/multimodal hub/terminal etc.), ridership and transfer points where many routes converge or meet, surrounding road network available, approach to the site, on-site & off – site features, Applicable development controls, building norms and / or zoning regulations such as FAR, parking, height restriction, setbacks, etc. c. Step 3 – Requirement Analysis: Based upon the selection of modes and its associated infrastructure, the requirement analysis can be established. (Details are given in section 3.3.2.1) **2. Transport Network:** a. Road Network – The steps involved in the planning of road network is as follows: ✓ Step 1 - Review of Existing Condition: Inventory of the existing road network which includes Right of way, pavement width, central reservation (median), shoulder, camber, side slopes, horizontal & vertical clearances, road pattern etc. This covers aspects such as classification of the street system, length, cross sectional dimensions, capacity, type and condition of the surface, intersection, control devices and street furniture ✓ Step 2 - Traffic Composition/Volume Study: Analysis from the Classified Traffic Volume Count (TVC) survey data will help in road planning and it includes observation of average annual flow, expressed in terms of vehicles per year, annual average daily traffic, expressed in terms of vehicles/day, hourly flow, expressed in terms of vehicles per hour. ✓ Step 3 – Requirement Analysis: Through the above analysis road need to be revamped for the designated traffic volume. The other details such as recommended design service volumes, different type of road hierarchy are also given in the section 3.3.2.2 (a).

Integration	Planning Stage
	b. Intersection – The steps involved in the planning of intersection is as follows: ✓ Step 1 - Review of existing Intersection: Study the efficiency of operation, safety, speed and capacity of the junction which is directly governed by its design. It includes road geometry, weaving length, turning radius, exit entry radius, capacity & turning volume count of the intersection. ✓ Step 2 – Requirement Analysis: Analysis of data pertaining to intersection inventory, intersection turning movement and queue length survey helps in identifying the improvement needed junctions. Intersections can be redesigned depending on the traffic condition. (Details are given in section 3.3.2.2 (b)) c. Parking – The steps involved in the planning of parking to boost the demand of the public transport through different parking options of off-street and on- street parking is as follows: ✓ Step 1 – Location Identification: Location of parking spots needs to be such that it is easily accessible and in sync with the public transport system. Factors that need to be considered for location are land use pattern, travel characteristics, future growth pattern of the targeted areas. Also, study of existing infra for the gaps. ✓ Step 2 – Requirement Analysis: It includes analysis of demand and supply. All other details such as types of parking (On Street & off Street), parking accumulation, volume, load etc. are given in section 3.3.2.2 (c).
	3. Non–Motorized Transport (NMT): It includes physical integration of Footpath and Cycle Track. The steps involved are as follows: ✓ Step 1 – Types of Infrastructure: The planning details related to NMT infrastructure is as follows: o Cycle Track: A cycle track is a way or a part of a roadway designed and constructed for the use of pedal bicycles, and over which a right-of-way exists. Cycle tracks are classified into two groups i.e. cycle tracks which run parallel to or along a main carriageway and separate cycle tracks Cycle Parking Stations: Cycles are a very desirable and affordable private feeder service to MRTS/ BRTS stations/bus stops o Footpath: It is a portion of right of way of road used for the movement of pedestrian traffic. The facilities to be provided includes Information kiosks, passenger shed and foot over bridges (if necessary), footpath surface, width, obstructions, encroachment, potential for vehicle conflicts, continuity. ✓ Step 2 – Location Identification: o Cycle Track and Parking Stations: Important criteria for location identification of cycle track and parking stations are potential demand, width, continuity & directness, safety, grade, type of pavement, areas with high automobile traffic & emissions etc. o Footpath: General principle of pedestrian facility is continuity, accessibility, conflicts zone and safety. Details are given section 3.3.2.3

Integration	Planning Stage
Fare	For this integration; steps needs to be followed are as follows: 1. Step 1 - Existing Fare Scenario: Identify the list of PT modes and their operator. Then study their existing scenario such as, fare structure, fare products, pricing, concessionary fare, kind of ticket and collection system. 2. Step 2 - Gap Identification: Issues with respect to fare integration need to be studied i.e. accessibility of point of sale, collection process, verification of correct fare, etc. 3. Step 3 – Standardization of Operation Procedures: Common operation procedure and policy need to be achieved amongst the participating public transport modes. The other details such as fare integration models i.e. distance fare, time fare, one trip fare and zone fare which covers detailed introduction, management with example are given in section 3.4.2.
Information	For this integration; steps needs to be followed are as follows: 1. Step 1 - Existing System Study: Identify and study the existing components, supporting the information integration and study the current architecture of various public/ private transport modes available in order to upgrade it. For further understanding the information integration, the data is analyzed according to the secondary surveys done in pre – planning stage. 2. Step 2 - Gap Identification: Based upon the lacking in component identified and design cavity in terms of information flow between all modes for all modes, one can identify the underlying gap in the planning process. 3. Step 3 – Component Identification: A state-of-the-art Information Integration System comprises many components that must be integrated using communications links and computer systems. A city's Intelligent Transportation System is used to manage information dissemination related to public transport and private traffic updates. The other details such as layout of Information integration, List of Component for information dissemination which includes Pre- trip information, en-route information are given in section 3.5.2 4. Step 4 – Requirement Analysis: The requirement is fulfilled by an ITS architecture, which is a useful tool for integrating different ITS component across all modes for information flow. The ITS architecture defines the comprehensive set of data that should be shared by various agencies of transportation network through the use of components.

STEP 3C: DESIGN STAGE:

It details out the desired or expected outlook of the integration. This section provides design brief for all the five components.

Integration	Design Stage
Institutional	In order to provide teeth to an UMTA, the key elements which must be addressed are ensuring the activeness of organization by carving out a dedicated secretariat and providing the UMTA with legal backing and financial powers
Operation	The design for operation integration which when planned and implemented differs from region to region because of its different need. It is governed by various factors, such as geographical location, traffic and travel characteristic, route/corridor network, socio-economic characteristics, existing public transport, transport infrastructure (roads, station, stops etc.) or other (built-up, zone characteristics/ activity) features presence. Transit services can be designed in two ways customer oriented design and technology driven design. The details are given are section 3.3.3
Physical	Design along with its standard for all the sub-components of components i.e. 1. **Public Transport:** The general design guidelines for components of public transport i.e. bus stop, bus terminal, multimodal hub etc. is as follows: ✓ Bus Stop: There are various factors which influence decision on spacing of bus stops. These includes adjacent land use and activities, Bus route, Bus signal priority (e.g. extended green suggests far side placement.), Impact on intersection operations, Pedestrian access, including accessibility for handicap / wheel chair patrons. Physical road side constraints (trees, poles, driveways, etc.), Potential patronage etc. All other details such as general acceptable standard practice criterion for selection of bus stop, sample layout of bus stop etc. are given in section 3.3.3.1.1 ✓ Bus Terminal: The factors need to be considered for design of bus terminals are traffic demand, traffic characteristics, function of terminal, segregation of vehicular and pedestrians traffic and movement, segregation of traffic by type, function and direction, coordination of different activities in terms of functional and spatial inter-relationship etc. The other details such as sample layout of terminal, planning norms for design of bus terminal, parking norms, etc. are given in section 3.3.3.1.2 ✓ Metro Station: Various factors that influence decision for metro stations design are:- entrance of building, concourse, platform, circulation pattern, bus/ parking/ IPT facility, sub-station (traction power) etc. The layout design of underground and over ground station is given in section 3.3.3.1.3 ✓ Multi-Modal Hub: the planning of Multi-Modal Hub can be done for the state-of-the-art bus terminal, rail link, metro station, IPT, personal mode (Car &2W) & NMT traffic. The design should be such that there is "no different mode interaction" i.e. easy and separate circulation should also be provided for public transport, private vehicles, & NMT therefore adequate parking/resting area should also be provided for various modes. Apart from this, the hub can be made economically viable, through inclusion of property development.

Integration	Design Stage
	2. Transport Network: ✓ Road Network: The concepts of road network design such as design of road speeds, space standards, cross sectional elements, typical cross sections wit standards are given in section 3.3.3.2.1 ✓ Intersection: The design details such as basic principles of intersection design for safe, smooth and efficient flow of traffic, parameters of intersection that needs to be undertaken, warrants of interchange with standards are given in section 3.3.3.2.2 ✓ Parking: The design parameters of parking in terms of different modes available in the city, permissible ECS for different land uses, space standards for parking are given in section 3.3.3.2.3 3. **Non - Motorized Transport (NMT):** It covers the design of Footpath and Cycle track and associated facilities. ✓ Footpath: The design standards of footpath such as clear walking zone, kerbs, continuity and consistency, tactile pavers etc. are given in section 3.3.3.3.1 (a) ✓ Pedestrian Crossing – The key guidelines to design the pedestrian crossing such as minimum width for crossing and features of crossings are given in section 3.3.3.3.1 (b) ✓ Street Furniture – The elements of street Furniture such as light post, seats, kiosks, hawker zones, bins, information panels, traffic signs, parking meters and post boxes etc., are given in section 3.3.3.3.1 (c) ✓ Pedestrian Facilities at Transit Areas – The details of facilities that needs to be provided for pedestrian in transit area are given in 3.3.3.3.1 (d) ✓ Design of Cycle Track and other facilities : the key features of cycle track design and other facilities such as standards of cycle track capacity of different lane width, horizontal curves, vertical curves, sight distances, lane width, width of pavement, cycle parking stations, long & short stay parking are given in section 3.3.3.3.2.
Fare	The design of MORE card issued by MoUD is given in section 3.4.2.1
Information	The requirement of detailed design features of ITS architecture, concept layout of control center, and ITS framework design for public transport, transport network and NMT network are given in section 3.5.3.

Background

1.1 CURRENT SCENARIO AND CHALLENGE

Cities are engines of economic growth and presently contribute about 60% of India's 'gross domestic product' (GDP). By 2030 this figure is estimated to increase to about 70%. Urban transport (UT) imparts mobility and accessibility to a city which increases its commercial and labour market efficiency and adds to the quality of life of its citizens.

Cities today face the major challenge of growing urbanization and therefore require augmentation and up-gradation of all kinds of urban infrastructure and services including urban transportation. The challenge becomes even more severe on account of the huge existing deficit in urban services especially in urban transport facilities.

The current situation in Indian cities along with major issues has been outlined below:

i. Different transport entities, in India, are planned, managed and operated by independent agencies. These agencies have no accountability to each other and are lacking the requisite coordination amongst them. None of the agencies have been assigned the role for integrating different transit services and private modes.

ii. Lack of city wide coverage by public transport system increases the automobile dependency for commuters in cities. There is also a gap in the first and last mile connectivity. The extra time and hassle that the commuters face when they are going from home to a transit station and then from the station to a final destination becomes a major deterrent for commuters to use public transport.

iii. The infrastructure built for different modes private and public is hardly in sync with each other. Stations, stops, roads, parking for different modes, footpaths, cycle tracks etc. are mostly planned in isolation without much effort at integration. Lack of physical integration amongst terminal points for different modes leads to accessibility issues and creates a mental block against usage of public transport.

iv. Lack of information regarding availability of parking slots, traffic signage, public transport scheduling also acts as a deterrent for commuters to use public transport.

Given this backdrop and within the wider context of promoting sustainable urban transportation, there has been an increased cognizance of the need to have a city wide multi modal integrated transport system for our cities. Therefore, there is a need to prepare a methodology for planning a city-wide multimodal integrated transportation system that can support seamless city-wide travel.

1.2 AIM OF TOOLKIT

The aim of this toolkit is to suggest a methodology for planning a city wide multimodal integrated transport (which includes all modes, i.e. PT, IPT, NMT, and personal transport) with the objective of promoting enhanced urban transport in urban centers.

1.3 OBJECTIVES OF THE TOOLKIT

This toolkit has two main objectives:

i. Identification of various components for city-wide multi-modal integrated transport plan (CMITP).

ii. Defining the process to be followed for the expected outcomes related to inventory preparation, planning and design of various identified components.

1.4 SCOPE OF THE TOOLKIT

The purpose of this toolkit is to equip and inform city level officials and consultants involved in planning and implementation of various components pertaining to CMITP on the:

- Concept of CMITP
- Importance of 5 levels of Integration –
  - o Institution,
  - o Operation,
  - o Physical,
  - o Fare and
  - o Information
- Methodology / Approach towards various integration components: At the strategic level, the toolkit will guide how CMITP can be planned and executed for seamless transport.

Source: http://www.discovery.org/cascadia/centralPugetSound

- It is aimed that with the help of this toolkit, the city officials will be in a position to either plan CMITP themselves or be able to appraise the CMITP carried out by the hired consultants effectively. The structure of toolkit is shown in Figure 1.1.

Introduction to the Toolkit	Introduction to the Subject	CMITP	Best Practices
•Aim •Objective •Scope •Intended Users •Methodology •This section deals with the problems faced by urban transport in India and, explaining the importance of carrying out multi-modal integration for urban transport plans, programs and projects.	•Concept •Why CMITP • Benefits to various users •Recommendations from various Indian policies •This section discusses the concept of City-wide Multimodal Integrated Transport Plan, its benefits and along with brief detail about its component and sub-components	•Introduction •Importance of Five pillars of Integration •Planning of five pillars is divided into three stages •Preplanning •Planning •Design •The section also gives a step-by-step methodology for carrying out CMITP for urban transport plans/ programs/ projects.	•London •Hong Kong •Singapore •Key learning's from case studies •This section discusses some case studies on CMITP studies carried out for urban transport plans, programs, and projects in cities around the world

Figure 1.1: Structure of the Toolkit

1.5 INTENDED USERS

This toolkit will be useful to

i. Government officials involved in policy and decision making for urban transport.

ii. Local authorities / agencies involved in planning and implementation of urban transport projects

iii. Consultants / institutions engaged in project implementation

iv. Agencies engaged in planning, operation and management of various public transport services

v. Also, may be used by researchers and academician.

The focus of the Toolkit is "Planning", and it provides "Basic Design Knowledge" with appropriate reference to "guidelines and manuals", required for the implementation of planned concept.

1.6 METHODOLOGY FOR THE TOOLKIT

The detailed methodology chart is given in the Figure 1.2 below.

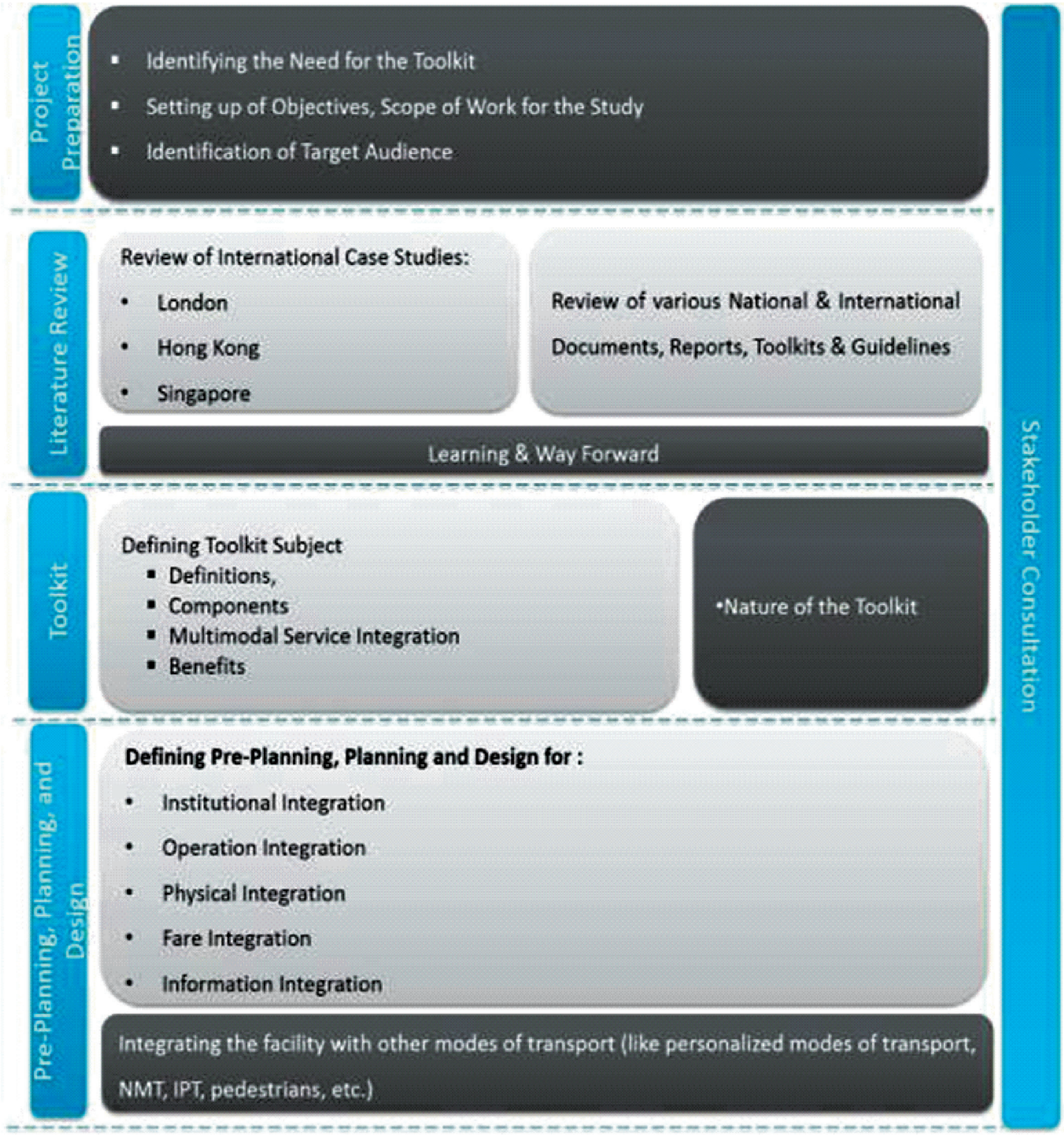


Figure 1.2: Methodology of the Toolkit

Introduction of Subject

2 INTRODUCTION TO THE SUBJECT

2.1 CONCEPT

An integrated transport system is made up of a network of interconnected infrastructure and or services. As such, no one mode can operate in isolation if it is to play a role in an integrated network. As each mode is suitable for different journey types, a combination of modes and complementary services is typically required. The concept is given in Figure 2.1 below:

The National Urban transport Policy (NUTP - 2006) and the 12th Five Year Plan, provide recommendations for the City wide multimodal integrated transport facilities as follows:

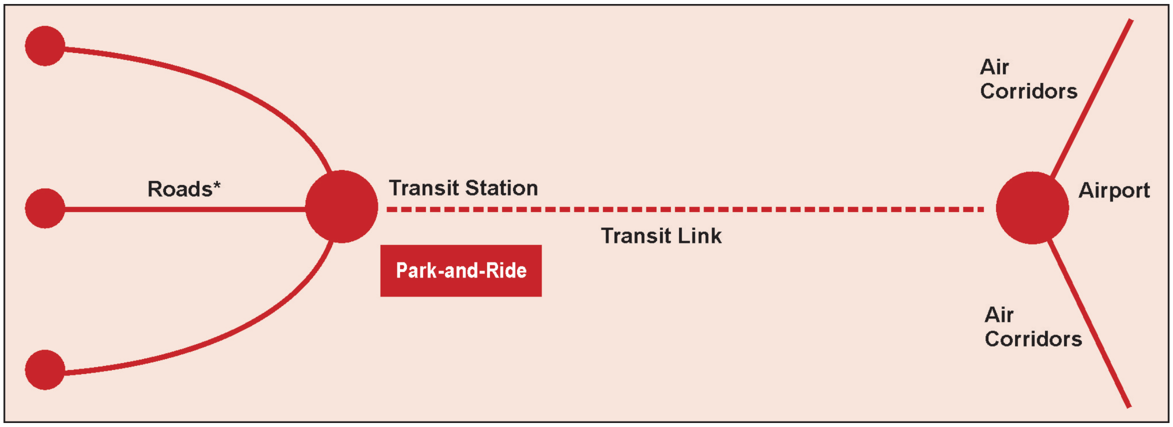


Figure 2.1: Concept Plan of Integration

2.1.1 RECOMMENDATION BY NUTP 2006:

Objectives: Enabling the establishment of quality focused multi-modal public transport systems that are well integrated, providing seamless travel across modes (Topic 5.6).

2.1.2 RECOMMENDATION BY FYP 12;

- GOALS FOR THE 12TH FYP: To use technology for multimodal integration, enforcement and traffic management. (Topic 4.2.9).
- MULTIMODAL INTEGRATION: General measures for integrating transport services include Network integration, Fare integration, information integration and Institutional integration. (Topic 10.5.1)

2.2 FIVE PILLARS OF MULTIMODAL INTEGRATION

In line with the policy documents as mentioned above, it can be suggested that, "The **City Wide Multi-Modal Integrated Transport Plan** can be defined as an approach towards the set-up of amalgamated institution, transportation & information structure for the unified transport network to provide the first mile and last mile connectivity by the use of both private & public mode in each journey made by user".

An integrated transport systems needs to be planned in a manner, so that there is coordination between various modes and their infrastructure (new and old).

Five essential pillars of Multimodal integration as depicted in Figure 2.2 would contribute seamless mobility and improve the transport plan of the city.

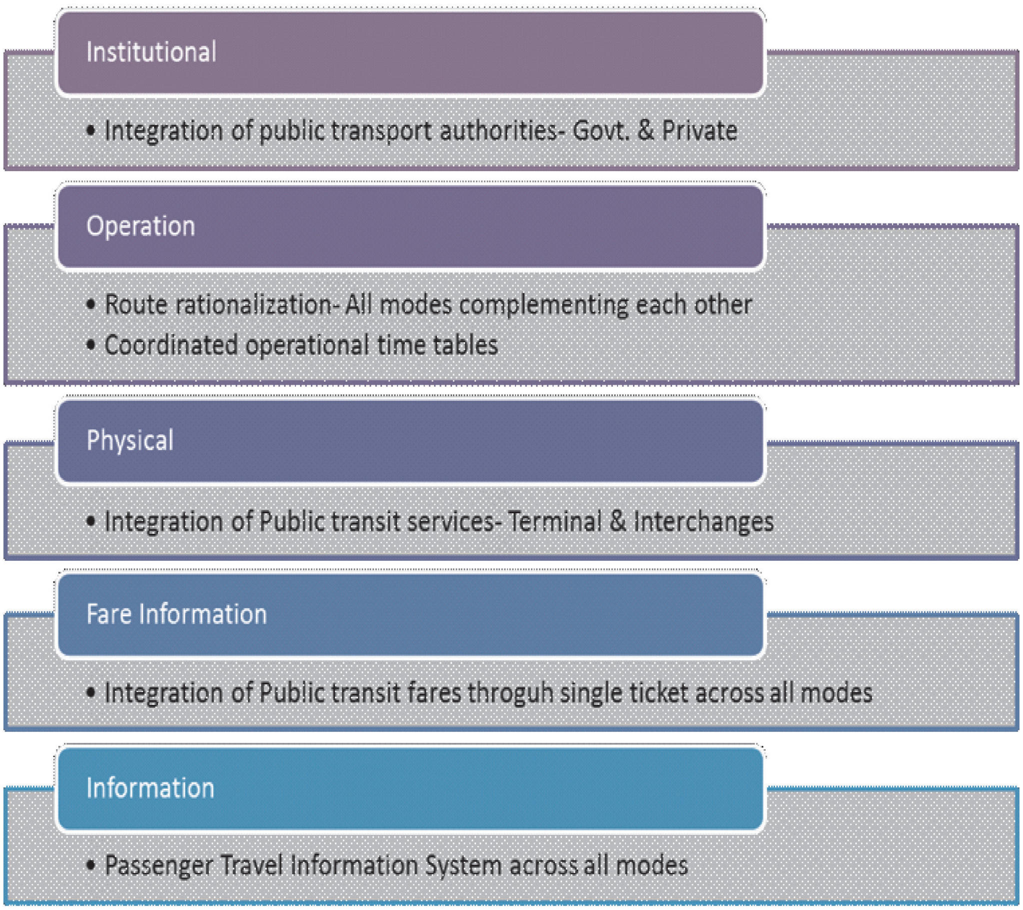


Figure 2.2: Five Pillars of Multimodal Integration

The working of an integrated multimodal transport system comprises of two levels –transportation (operation, physical & fare integration) & information (information integration), and both must operate under the umbrella of a synchronized / single institution level (institutional integration) as shown in Figure 2.3.

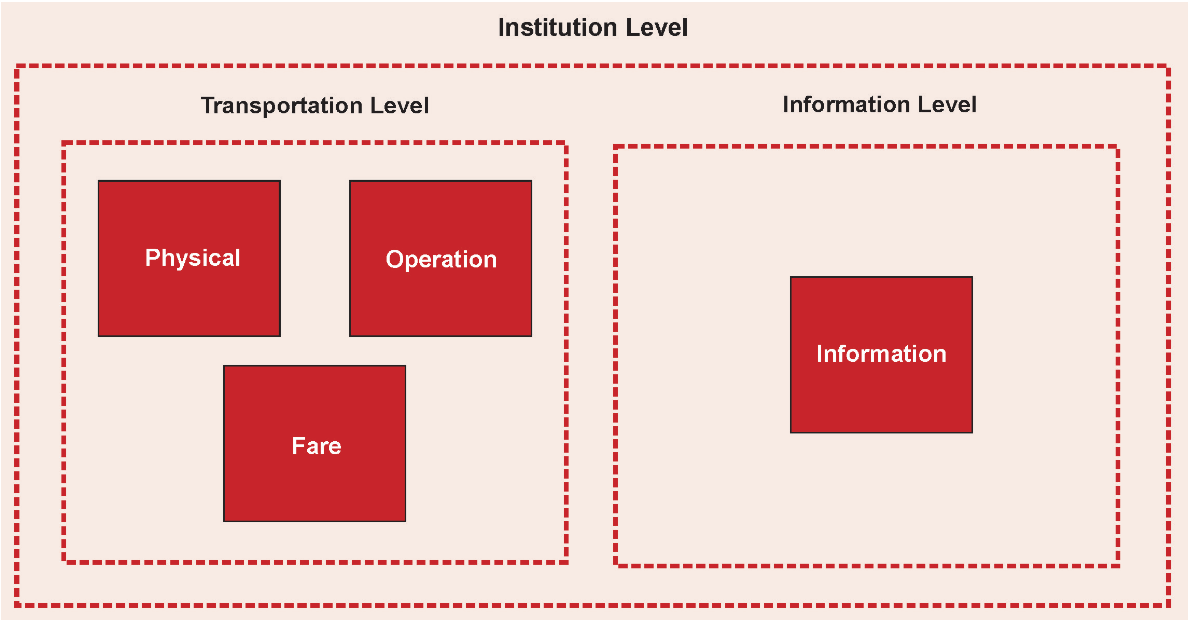


Figure 2.3: Working of Multimodal Transportation System

2.3 WHY CITY-WIDE MULTI-MODAL INTEGRATED TRANSPORT PLAN

The transport network should be citywide so that the commuter is assured that he / she can complete his / her journey all the way by the modes of their choice with minimal or no use of private vehicle. This, besides road infrastructure and public transport network, includes a continuous citywide facility for pedestrians and cyclists. Public transport whether road based or rail based cannot provide door to door service. Other ancillary modes i.e. walk, cycle, IPT and personal vehicles have to be integrated with the public transport network for the first and last mile connectivity. The network planned should be such that most commuters live and work within 500m of a public transport stop or station.

Integrating Mobility For Better Cities Planning

Source: http://www.india.uitp.org/need-integrated- mobility-planning-better-cities

2.4 BENEFITS OF MULTI MODAL INTEGRATION

A multi modal integrated transport system provides overall benefits in the following terms:

- **Integrated Public Transport:** The concept behind an integrated public transport is synchronized timetables & schedules, infrastructure, common fare collection system and traveler information for each mode across each mode.
- **Meets the needs of Customers:** Customer’s journey time is reduced and due to available of travel information, an image of dominant transport system of the city is built up. These features can boost customer’s satisfaction level.
- **Increase in Public Transport Use:** Once, the customers are satisfied with the built image of the transport system, the shift to the public transport system is easier.
- **Decrease in Private Vehicle Use:** The change of modal share towards public transport will lead to lower use of private vehicles.

The benefits of multimodal integration are shown in Figure 2.4.

Figure 2.4: Overall Benefits of the Integration

2.4.1 BENEFITS FOR COMMUTER

The daily commuter finds the “one network, one timetable, one ticket, from door to door” characteristic very attractive for a transport system and thus derives a range of benefits such as:

- Reduced travel time
- Reduced hassle of interchange
- Savings in money
- Assured door to door travel using the public transport system

All four modes: Walking, Cycling, Personal & Public transport together provides the citywide multimodal integrated transport network

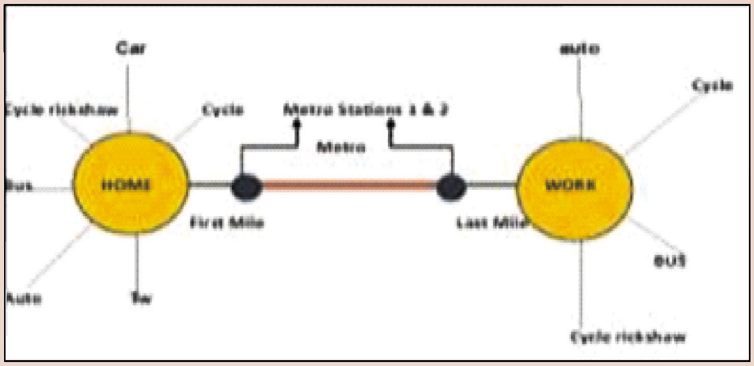
2.4.2 BENEFITS FOR OPERATOR

For operators and authorities, benefits are felt over the medium and long term. By making the transport system more attractive & reducing access barriers, benefits reflect on patronage in terms of regular usage by existing customers as well as introduction of new customers to the system. This in turn provides:

- Higher revenue
- Higher operational efficiency (through reduction of overlap in services)
- Higher cost efficiency

First and Last Mile Connectivity

The first and last mile connectivity is about delivering connectivity from home to PT and PT to home with different modes of transport (the actual distance of this leg may be considerably more than a mile). This concept is majorly used in transportation in the form of logistics, freight distribution and in access dispersal of public transport.



It can be achieved through Multi-Modal Integration

2.4.3 BENEFITS FOR CITY

The city has overall benefits in terms of reduced traffic on roads and thus reduced emissions (better air quality) along with a higher quota of public spaces that gets created as a by - product of the physical integration of transport infrastructure

2.5 COMPONENTS OF INTEGRATION

Five pillars of Integration **(Section 2.2)** needs strategic planning direction, which aims at enhancing a city “stand-alone transportation systems” into “multi-modal transportation system”.

To understand the subject as per "Indian Scenario" various dossiers issued by *Ministry of Urban Development (MoUD), GOI* were scanned. And, the conclusion drawn from these documents are presented below in the form of recommendations:

2.5.1 RECOMMENDATIONS BY NUTP - 2006

- **Priority to the use of Public Transport (Section 13):** The central government would promote investments in **public transport** as well as measures that make its use more attractive than in the past.
- **Comprehensive city wide plans** should be drawn up c**omprising of trunk and feeder corridors** as well as good integration with **personal modes, suburban traffic,** etc. High cost trunk route systems should, through appropriate hub-spoke arrangements be integrated with feeder systems that enable higher ridership on such trunk systems.
- **Integrated Public Transport Systems (Section 21):** A good **public transport** system is one that is perceived by the user as a single system and allows seamless travel between one mode and the other as also between systems managed by different operators. Such seamless interchange is possible if proper inter-change infrastructure is available and users are able to use a single ticket over all such systems. This also requires that a single agency takes responsibility for coordination so that there is a common approach to **public transport** planning and management.
- **Priority to non-motorized transport (Section 27): Non-motorized** modes are environment friendly and should be given their due share in the transport system of a city. The problems faced by them would have to be mitigated.
- **Segregated paths (Section 28):** would be useful not only along arterials, to enable full trips using **NMT** but also as a means of improving access to major **public transport** stations. Such access paths, coupled with safe **bicycle** parking places, would contribute towards increasing the use of **public transport.**

2.5.2 RECOMMENDATION BY NATIONAL MISSION OF SUSTAINABLE HABITAT (NMSH)

- 2.0 Objective (Section 6): To promote patterns of urban growth and sustainable urban development that help secure the fullest possible use of sustainable transport for moving freight, **public transport, cycle** and **walking,** thereby reducing need to travel, especially by **car**.
- Multi-Modal Integration (Section 3.6.11): To provide seamless connectivity over a widespread network of various **public transport modes**, the government should insist on setting up Unified Metropolitan Transport Authorities (UMTA) in all million plus cities. This will facilitate more coordinated planning and implementation of urban transport program and projects as well as an integrated management of urban transport system.

2.5.3 RECOMMENDATION BY 12TH FIVE YEAR PLAN

Multimodal Integration (Topic 10.5.1): The most critical requirement is the creation of multimodal interchange facilities where commuters can change modes or routes without much time penalty and in a safe manner without coming in conflict with other vehicular modes. Such locations occur at the point where two public transport services cross and at various road junctions where commuters may need to change direction or to take a feeder

service. In addition commuters will need to interchange at inter-state bus terminals, railway terminals and airport. All these interchange points will also need to cater to interchange with personal modes, from the surrounding areas, such as **car, 2-W** and **bicycle** and **public modes** i.e. para-transit, autos, taxis and **cycle rickshaw** etc., by providing 'Park and Ride' and 'Pick up and drop off" facilities.

2.5.4 CONCLUSION

Based upon the recommendation perceived from above national documents, the five pillars of integration can be divided into three major components as given below:

- Public transport
- Transport network
- Non-Motorized transport

Then each component is further divided into sub components. The details are given in Table 2-1 below:

Table 2.1: Component and Sub component of Integration

<table>
<tr><th>Components</th><th>Institutional Integration</th><th>Physical Integration</th><th>Operation Integration</th><th>Fare Integration</th><th>Information Integration</th></tr>
<tr><td rowspan="5">Public Transport</td><td rowspan="10">Setting up of UMTA</td><td>Bus Stop</td><td rowspan="2">Route Network Planning</td><td rowspan="10">One ticket for all means of transport</td><td rowspan="10">Inter-modal real time passenger information systems</td></tr>
<tr><td>Bus terminal</td></tr>
<tr><td>Metro Station</td><td rowspan="3">Service Plan</td></tr>
<tr><td>Intermediate Public Transport (IPT) Stop</td></tr>
<tr><td>Multi-Modal Hub</td></tr>
<tr><td rowspan="3">Transport Network</td><td>Road Network</td><td rowspan="3">N/A</td></tr>
<tr><td>Intersection</td></tr>
<tr><td>Parking</td></tr>
<tr><td rowspan="2">Non- motorized transport (NMT)</td><td>Cycle Track and Parking Station</td><td rowspan="2">N/A</td></tr>
<tr><td>Footpath</td></tr>
</table>

Note: Details of all the "Integration Component and their sub-component" are established in Chapter 3.

City Wide Multimodal Transport Plan

As mentioned in the Section 2.2 above that **City Wide Multi-Modal Integrated Transport Plan** have five pillars of integration i.e. institutional, operational, physical, fare and information which would be contributing seamless mobility and improve the transport plan of the city. The details of steps involved in each pillar are given in the following sections:

INSTITUTIONAL INTEGRATION

3.1 INSTITUTIONAL INTEGRATION

Urban transport consists of elements like land use plans, development plans and master plans, road network, public transport and its related infrastructure, personal vehicles, fare structure of public transport, intelligent transport system mechanism, traffic enforcement agencies and traffic law enforcing mechanisms, goods and freight movement and their operators, road safety and accident management system. All agencies in charge of governing these functions and elements generally work independently or with remote assistance. There exists no umbrella agency that monitors and integrates these multiple bodies in order to ensure smooth functioning of all aspects related to urban transport in any city.

Figure 3.1: Single Agency with End-to-End Accountability

Source:http://smartsearchmarketing.com/benefits- of-an-integrated-search-marketing-team/

Institutional integration refers to the creation of an organizational framework within which joint planning, implementation and operation

of transit services can be carried out. A single authority is able to function more effectively and with greater flexibility essentially independent public and private transit operators. The components & Sub-components of institutional integration are shown in Figure 3.2.

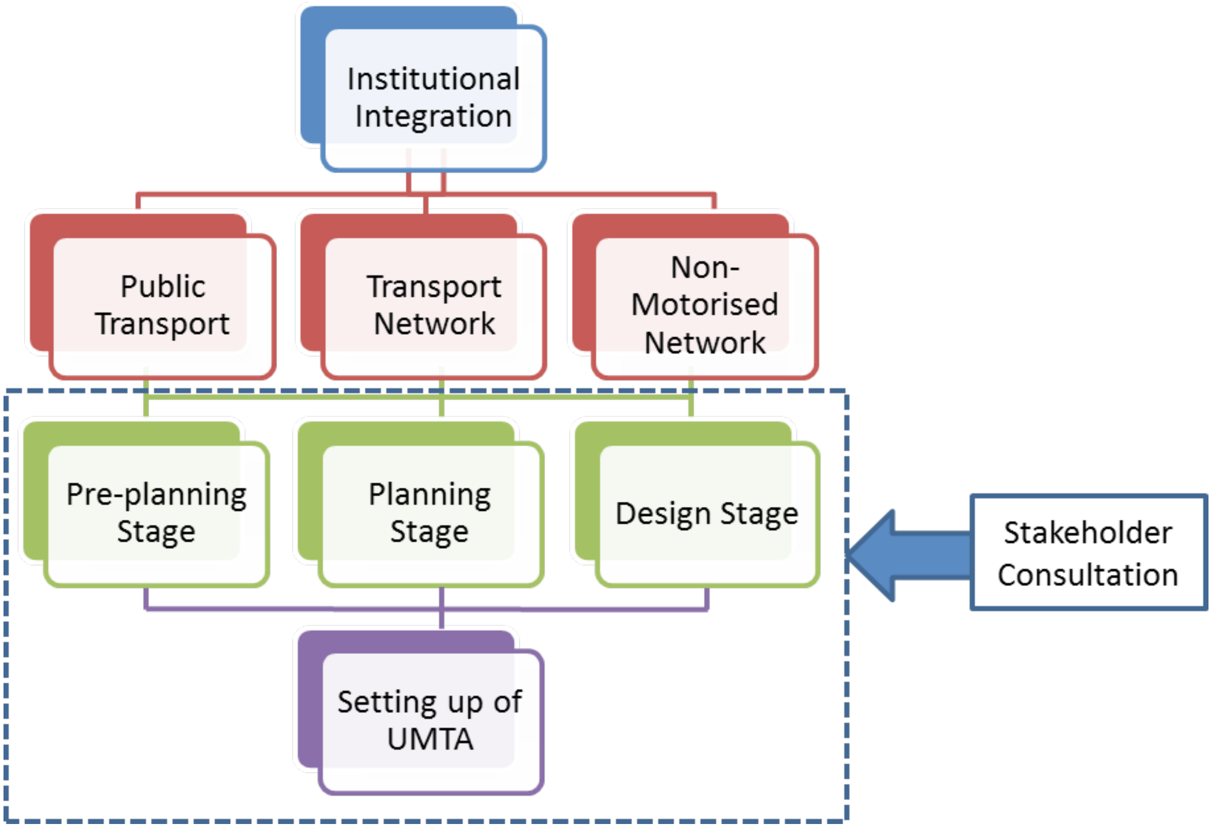


Figure 3.2: Institutional Integration "Components & Sub-Components"

Data Level	Source
City Wide	All Concerned Departments

3.1.1 PRE-PLANNING STAGE

This stage requires collection of data/ information with respect to urban transport from the concerned organizations/ departments/ agencies. Further, the data/ information collected will be analyzed to understand the various functioning of organization. The details of the **Secondary Data** to be collected are as follows:

- Annual Report (Admin, Financial, Legal & Human Resource)
- Organizational Chart & Duty list
- Details of operations
- Earlier Study Report, if any


3.1.2 PLANNING STAGE

Institutional Integration refers to integration of all authorities responsible for provision, management and operation of urban transport in a city. The steps involved are shown in Figure 3.3.

3.1.2.1 STEP 1 –IDENTIFICATION OF CONCERNED AUTHORITIES:

The first step is to identify and list out various agencies in charge of public transport, departments, institutions & stakeholders concerned with urban transport in the city.

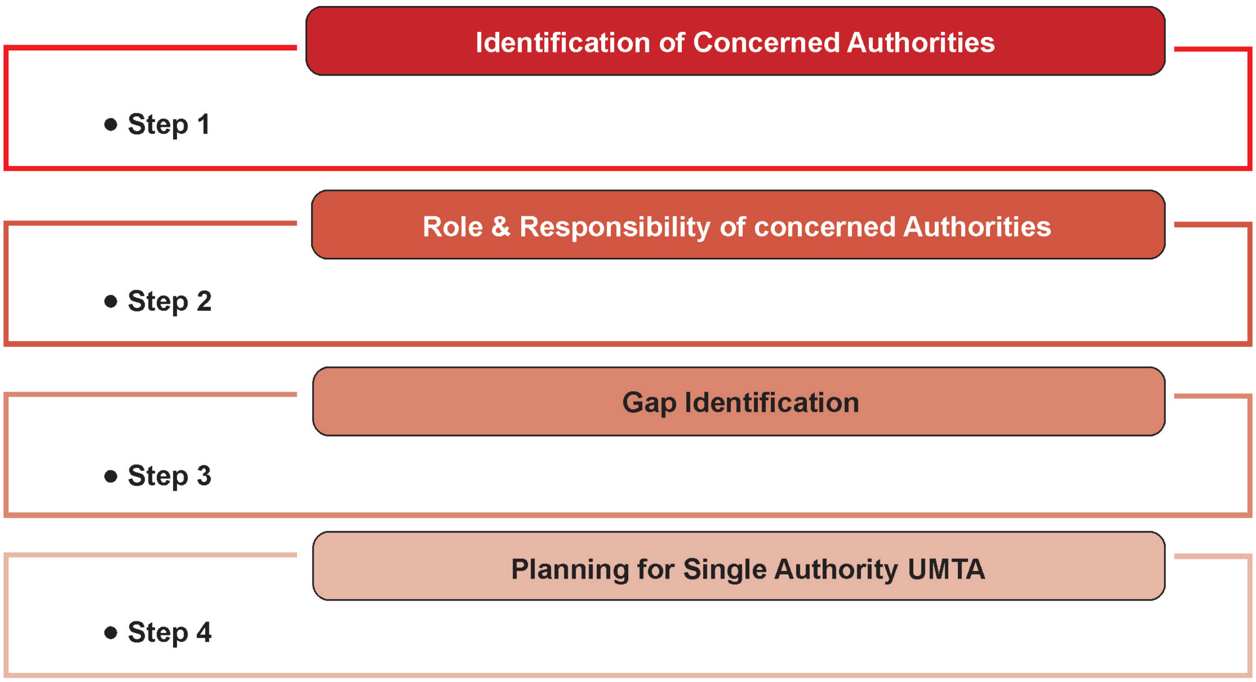


Figure 3.3: Steps for Institutional Integration

3.1.2.2 STEP 2 – ROLES & RESPONSIBILITIES OF CONCERNED AUTHORITY:

Step 2 is to understand the functioning of the listed agencies. This helps in deciding their role and monitoring them, when they come under a single umbrella. This facilitates better coordination between the authorities and improves the efficiency of the proposed single authority.

3.1.2.3 STEP 3 – GAP IDENTIFICATION:

This step studies weaknesses prevalent in various listed agencies. One of the most important weaknesses to be assessed during the planning of institutional integration is the overlapping of roles and responsibilities among multiple agencies i.e. similar tasks are carried out by two or more agencies.

Once these are duly noted, the roles and responsibility can be divided without ambiguity among listed agencies, during the formation of a "single authority", so that no confusion is caused when it comes to carrying out the task.

3.1.2.4 STEP 4 – PLANNING FOR SINGLE AUTHORITY UNIFIED METROPOLITAN TRANSPORT AUTHORITY (UMTA):

Based upon the gap identification and investigation of responsibilities, UMTA can be formed as an executive body governed by a Board made up of heads of various departments in the city, local elected leaders, regional ULB's and eminent citizens. It should be supported by a team of professionals with a Chief Executive Officer. If a city is too small to support a professional team by itself, the State Government should provide such a cell either at its HQ or at regional level, in case the State is large. The functions of the formed UMTA can be broadly classified into the following three levels as given below and depicted in Figure 3.4.

- Level I Strategic Planning Functions
- Level II Infrastructure Planning, Service Planning, Enforcement and Regulatory Functions
- Level III Public Transport Operations, Construction /Maintenance of Infrastructure and Common Services

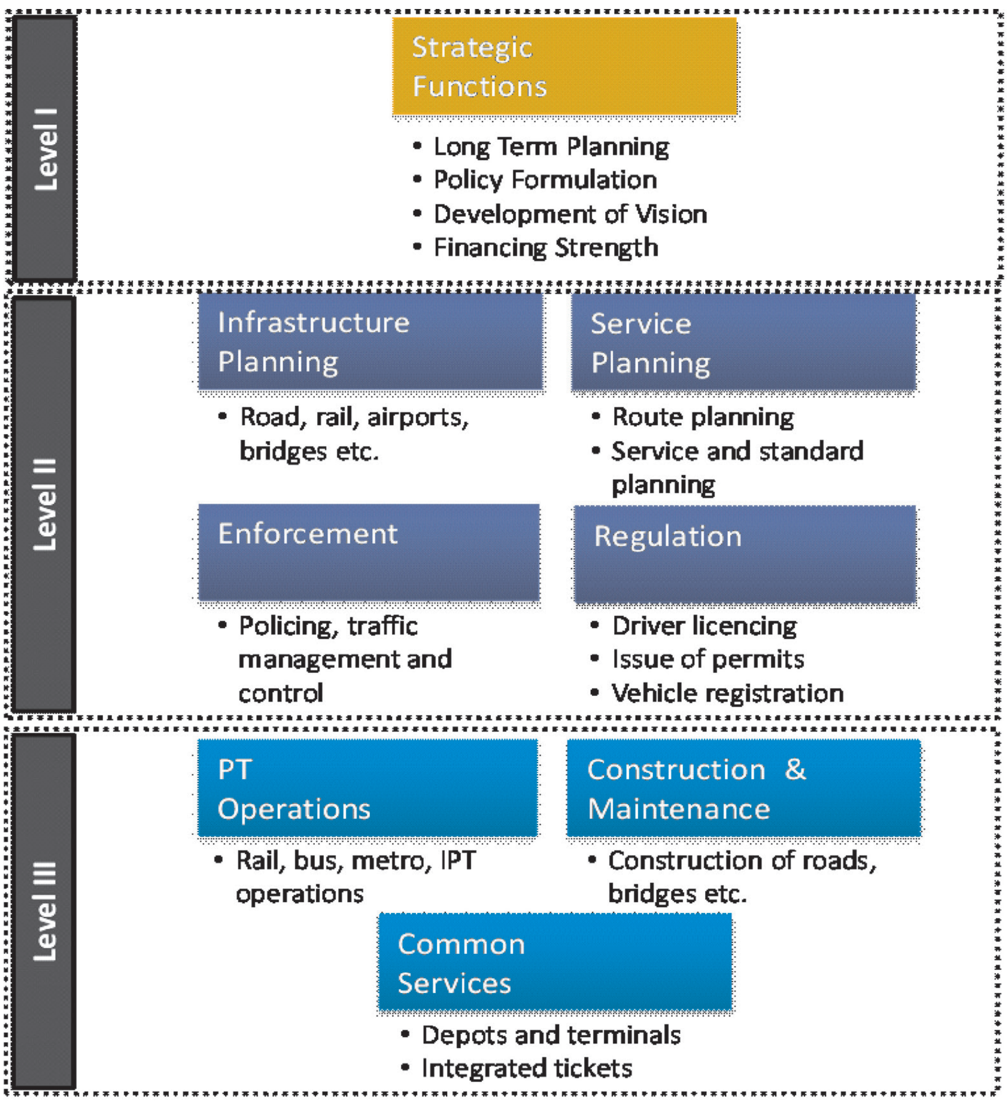


Figure 3.4: Functional Hierarchy for UMTA
Source: Evolution of Unified Metropolitan Transport Authorities (UMTAs) in India, IUT (India)

3.1.3 DESIGN

In order to provide teeth to an organization such as UMTA, the three key elements (Shown in Figure 3.5) that must be addressed are:

a) Ensuring the activeness of organization – This can be done by carving out a dedicated secretariat for the UMTA, which is appropriately staffed with a mix of urban and transport planners, engineers and economists. With the presence of such a secretariat, it is easier to organize meetings more frequently, and better control over the UMTAs focus.

b) Providing the UMTA with powers so that it has an overriding effect on all urban transport matters of the metropolitan area. Provision of a legislative backing is ideal, however, it cannot be ruled out that the status of an empowered committee if given to UMTA can also result in ensuring its influence over other departments.

Figure 3.5: Key Elements of UMTA

Source: Evolution of Unified Metropolitan Transport Authorities (UMTAs) in India, IUT (India)

c) The most important amongst all is providing financial powers to the UMTA. The authority needs to be given the status of a financing authority and approval agency for investments. The format which can be followed for the UMTA is that of a Public Investment Board (PIB). This should enable UMTA to examine the investment plans put forward by individual departments.

d) Functioning:

- ✓ *Strategic Planning* – In the current scenario, several urban transport aspects often come under multiple agencies. At the same time, there are other aspects which do not list under any existing organization's purview. It is thus felt that the UMTA apart from ensuring coordination and overseeing strategic planning; must also take up those uncovered aspects which do not feature on anyone else's mandate. Issues of integrated planning of land-use transport, multimodal integration, common ticketing, and policy decisions must ideally be immediately taken up by the UMTA.

- ✓ *Coordination* - A brief assessment of the discussion points of the UMTAs will indicate the kind of issues or agenda items that go up for the meetings. Whether the issues being discussed are

interdepartmental in nature or are merely department issues can be studied under this parameter.

- ✓ *Process Funds* – Any investment to be done in urban transport should be routed through an urban transport fund (UTF). In an ideal scenario, the UMTA should be the custodian of the UTF.
- ✓ *Approving Authority* – Urban transport projects can be undertaken by any kind of organization. It is however crucial if UMTA becomes the nodal agency for approving any form of project and keep it under its scanner. In an ideal scenario, any urban transport project with any organization should be brought under the UMTA's notice for the final approval for implementation.
- ✓ *Project Monitoring/Implementation Agency* – There may be several recommendations or advisories issued by UMTA. It is equally critical for UMTA to ensure that they are being aptly implemented and in the most suitable manner. Instead of immediate delegation of functions, it is thus needed that the UMTA must also be technically sound and have enough manpower to continuously monitor the implementation of its recommendations.
- ✓ *Regulation* – This more or less links with the UMTAs legal status. In-case UMTA has a legal backing; it automatically gets the authority to question or summon defiant organizations which fail to respond to UMTAs decisions. Very often, it also has to do with the organization structure of UMTA. A political head of state or department who is also heading the UMTA can have a similar impact as that of the body having a legal backing.

The parameters required for functional UMTA is given in Table 3.1;

Table 3.1: Functionality Required in UMTA

Parameter	Strategic Planning	Coordi-nation	Process Funds	Approving Authority	Project Monitoring/ Implementation Agency	Regulation
UMTA	✓	✓	✓	✓	✓	✓

Every UMTA formed must have all the functionality mentioned in section 3.1.3 (d) for complete Institutional Integration

3.2 OPERATION INTEGRATION

This involves application of management techniques to optimize the allocation of transit resources and coordinate the services.

The techniques / principles[1] of operation integration include:

a) **Coordinated Routing and Scheduling-** For mega cities, in which high capacity, long haul modes, such as mass rapid transit are considered as the trunk system, buses act as feeder e.g. Mumbai & Delhi. For large cities busses act as trunk system and IPT act as feeder e.g. Lucknow & Bhopal. For small and medium town, where there is no organized public transport, IPT acts as a transport service provider. The schedules of trains & buses or buses & IPT can be coordinated to minimize waiting time between the two modes.

b) **Rationalization of Redundant Services-** The wasteful duplication of transit service by competing systems is eliminated and resources are redeployed to reduce headways on existing routes and extend services into unserved and urban extension.

The details of operation Integration (Components & Sub-Components) are shown in Figure 3.6.

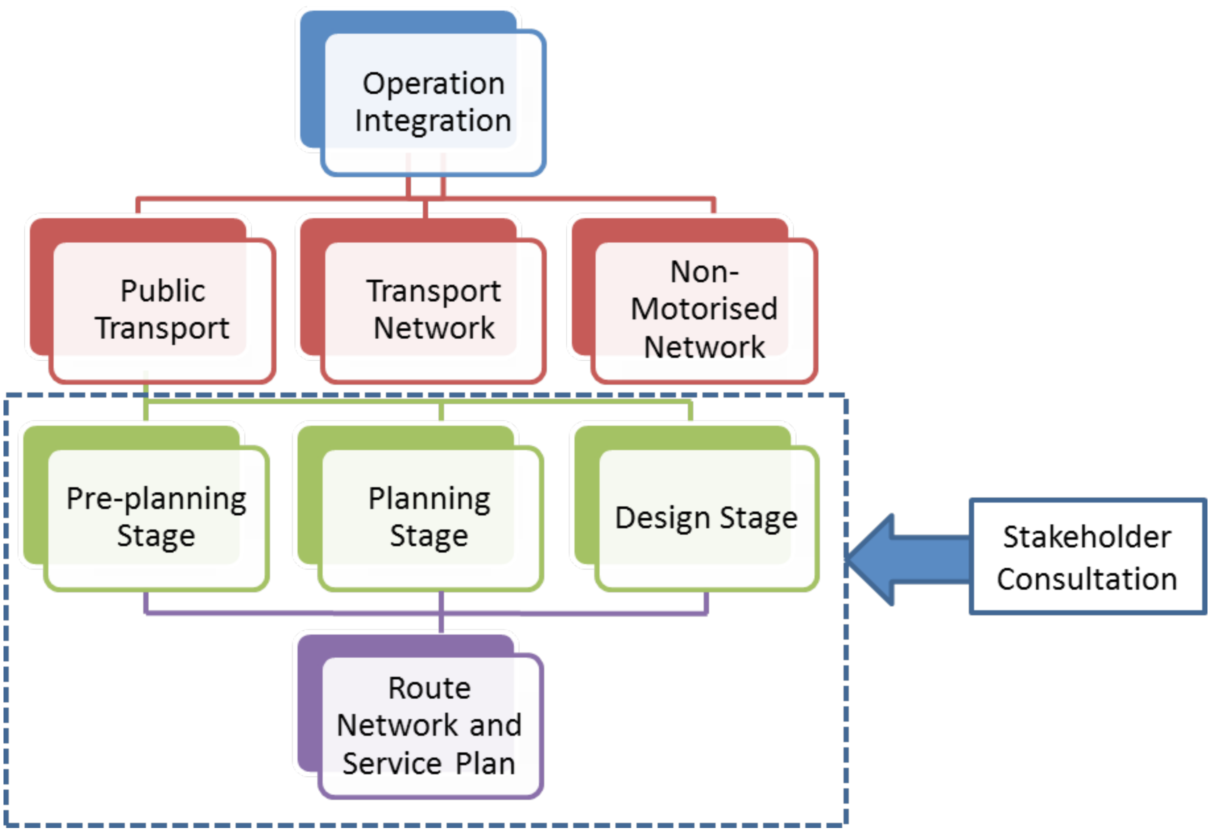


Figure 3.6: Operation Integration "Components & Sub-Components"

[1]Source: Concept adopted from Development of Training Material under Sustainable Urban Transport Project, Reference Guide Volume 2 Public Transport

3.2.1 PRE-PLANNING STAGE

The pre-planning stage of a project is the stage when organization starts to draw up ideas. In this stage, data is collected from secondary sources and primary surveys for various components and sub components as discussed below.

3.2.1.1 PUBLIC TRANSPORT

The data required for planning with respect to operation integration is given in Table 3.2:

Table 3.2: Data Requirement for Public Transport - Operation Integration

Survey	Details	Data Level	Source
a. Bus System/Metro Rail System or any other mass rapid transit system			
Fleet Usage Detail	Number of buses by type of bus (standard, mini, low floor), fuel	Citywide	ULB & RTO
	used and age		
	Fleet utilization rate		
	Vehicular kilometers		
	Average kilometers per bus per day		
	Hours of Operation		
	Percentage occupancy- peak hour and average		
	Total passengers per day		
Route Detail (*Survey 9 – Public Transport System Study)	Route inventory along with bus stops		
	Headway on different routes	Sample	Primary Survey
	Average route speed		
	Service reliability		
Cost and fare	Operation cost per km	Citywide	SRTC report & city's bus company if any
	Manpower / Bus		
	Taxes levied		
	Fare structure & Mobility card (Pass)		
	Revenue per km/Cost per km		
	Profit/loss		

Survey	Details	Data Level	Source
b. Para Transit System			
Fleet usage detail	Type of ownership	Citywide	RTO, para-transit workers' union & survey
	Number of para-transit by type (shared and personal autos), fuel used and age		
	Vehicular kilometers		
	Passenger / Vehicle		
Route detail (*Survey 10 – Para Transit Study)	Route inventory for	Citywide	RTO
	shared auto		
	Average waiting time for auto, cycle rickshaw and shared auto	Sample	Para-transit workers' union
Cost and fare	Operation cost per km	Citywide	Para-transit workers' union
	Taxes levied		
	Fare structure		
	Revenue per km		
	Rental / Day		
	Profit/loss		

Source: Concept adopted from "Preparing a Comprehensive Mobility Plan (CMP) - A Toolkit (Revised), Ministry of Urban Development, Government of India"

* - For details of surveys, refer Annexure 1: List of Survey & its Format

3.2.2 PLANNING STAGE

A step by step process for planning various components of operation integration has been explained below.

3.2.2.1 PLANNING PROCESS FOR PUBLIC TRANSPORT[2]

The first step towards planning of public transport is the selection of mode based upon the criteria mentioned below:

Operation integration of Transport Network and NMT components is not applicable because this integration only covers coordinated routing & scheduling and rationalization of redundant services with reference to public transport. Also, personal mode, walking and cycling are independent in nature, based upon users need to operate.

[2]For further details: Refer to Preparing a Comprehensive Mobility Plan (CMP) – A Toolkit (Revised), Task 5-2 for more information

3.2.2.2 SELECTION CRITERIA

The selection of public transport mode in a city may be decided based on details given in Table 3.3 below:

Table 3.3: Selection Criteria of Public Transport - Operation Integration

Mode Choice	PHPDT in 2021	Population as per 2011 census (million)	Av. trip length (kms.)
Metro	More than 15,000 in 5 Km. stretch	More than, equal to 2	More than 7-8
LRT at grade	Less than, equal to 10,000	More than 1	More than 7-8
Mono Rail	Less than, equal to 10,000	More than 2	About 5-6
BRT	4,000-20,000	More than 1	More than 5
Org. City Bus		>0.1 or 0.05 in case of hilly towns	>2 to 3

Other factors for selection of public transport modes are as follows

- Availability of the mode to meet demand
- Cost
- Right-of-way availability
- Environmental impact
- Journey time
- Safety
- Comfort
- Flexibility
- Reliability
- Fare
- Technical sophistication
- Implementation complexities
- Brand Image

3.2.2.3 PLANNING STEPS

The steps required for operation integration of public transport in a city under a planning stage is shown in Figure 3.7:

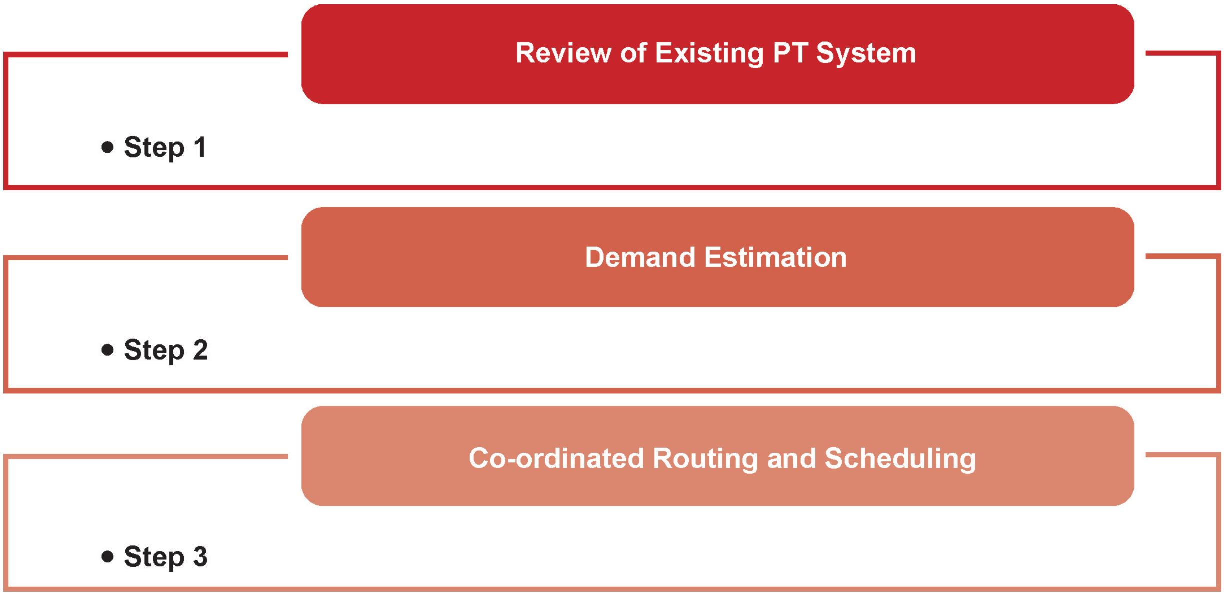


Figure 3.7: Steps Involved in Planning of Public Transport in Operation Integration

STEP 1 – Review of Existing Public Transport (PT) Scenario:

The first step is to review the existing scenario in the city. The details are given in Figure 3.8 below.

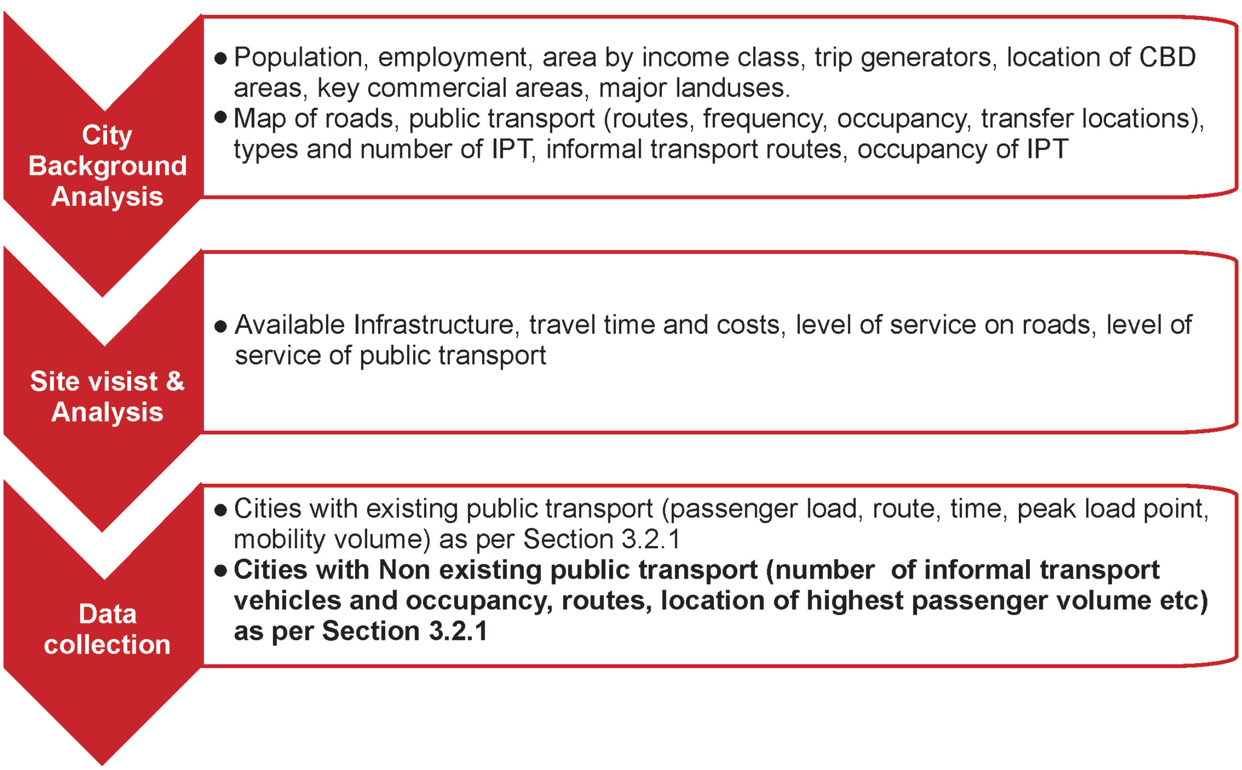


Figure 3.8: Review Existing Scenario of Public Transport System in City

The city with a Public Transport System or none can follow the same procedure towards development of operation integration.

STEP 2 – Demand Estimation[3]

Following steps need to be followed for demand estimation

A. Data Processing:

- **Cities with Existing Public Transport:** Once you have identified the public transport routes in the city for further analysis, "**START**" the quick assessment of key data by gathering the following information:

S	**Survey** bus passenger loads. These surveys are to be conducted in conjunction with vehicular counts for other modes. Hourly counts of boarding, alighting and through passengers (BAT) should be recorded while riding the bus for at least one entire day of the route. In cases where there is no time and budget for on-board surveys, bus occupancy surveys can be conducted where a surveyor stands at a particular stop and notes the time, route number and estimated occupancy of each bus that passes by.
T	**Time** the length of the route from start to finish.
A	**Articulate** the peak load point along the route by analyzing the boarding, alighting and PT occupancy survey data.
R	**Review** on-board through survey of volume over a 12-16 hour period at peak locations and loads on Public Transport to determine where the highest passenger volume occurs.
T	**Tabulate** mobility volume to determine what time of day has the highest overall mobility volume, including traffic + pedestrians + bicyclists + IPT (if present as different modes – shared auto rickshaw, minivans, minibuses – classify them while counting) based on 12-16 hour counts survey.

- Cities with no Existing Public Transport: Data collection for cities without public transport follows a similar process. While there are no pre-existing routes upon which to ride and measure passengers, for strategic corridors identified above, follow this "**SMART**" procedure for predicting formal transport demand.

S	**Survey** strategic locations (through Reconnaissance Survey) to count number of informal transport vehicles and occupancy by hour. These riders are usually the first people to shift to the bus if the service is reliable and good, therefore it is important to count them as well.
M	**Measure** occupancy of vehicles by observing passenger levels in broad terms such as: Empty, ¼ Full, ½ Full, ¾ Full and Full. This will give an idea of total vehicles and people using the corridor.
A	**Ask** the informal transport drivers about the most frequently travelled routes. Some cities have done surveys where the surveyor drives in the shared auto / taxi for an entire day recording travel patterns.
R	**Review** roadside conditions at each location over a 12-16 hour period to determine where the highest passenger volume on IPT occurs.
T	**Tabulate** your counts of pedestrians, bicycle riders, and informal transit vehicles to allow for fleet size and bus frequency calculations as in the next section.

[3]For details, please refer 'Preparing a Comprehensive Mobility Plan (CMP)- A Toolkit (Revised)', Ministry of Urban Development, Government of India

B. Four Stage Modelling[4] : Travel demand modelling is a tool which helps to understand existing travel pattern of the city. Also it is pre requisite for introducing a public transport system as it frames the need and justification for it. The steps involved in demand modelling for public transport service are given in Figure 3.9 below:

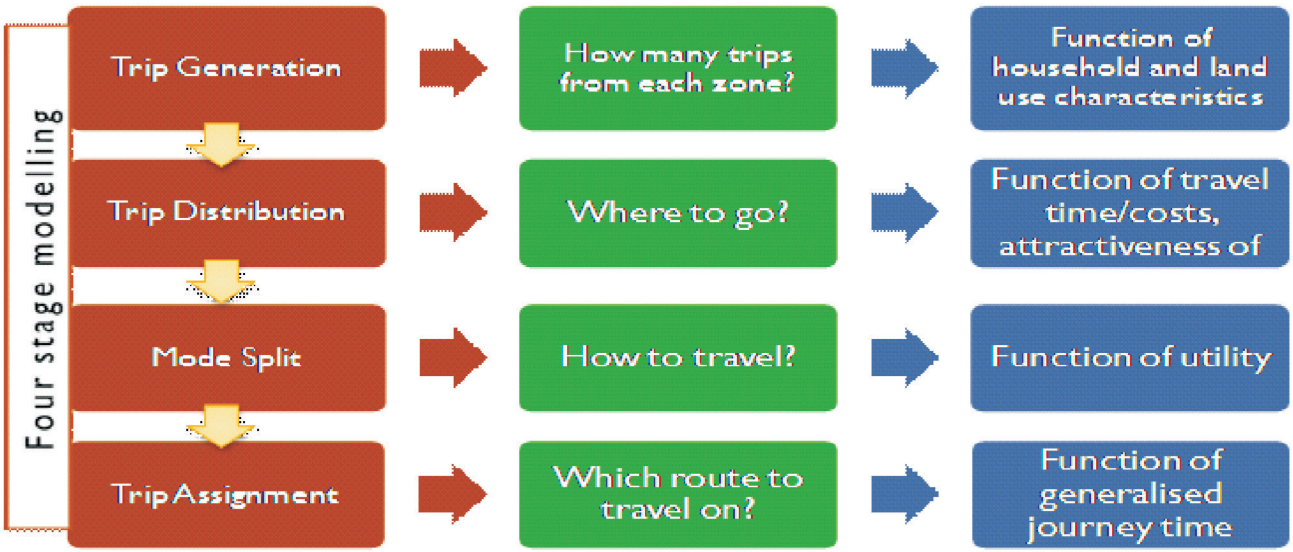


Figure 3.9: Four Stage Modelling

C. Forecasting[5] : Planning variables such as population and employment are projected for the horizon years. These projected planning variables are then applied to calibrate the demand model, to calculate the ridership for corridor in terms of Passengers per Hour per Direction (PPHPD), in the estimated horizon year.

Step 3 – Coordinated Routing and Scheduling:

After, undertaking the four stage modelling the primary mode providing trunk and feeder service required for the city is established. For their effectiveness to cater the current and future demand of the city travel needs, the operation integration i.e. coordination of route and schedule is necessary which can be achieved through the "**Integrated Operation Plan—Public Transport**", which is authorities first step towards operation integration. This plan should establish a basis for planning and development of the city's PT network to meet upcoming demands, including designing the services to maximize opportunities for seamless travel.

The plan should establish a multi-modal coordination service framework to guide service elements such as scheduling and network development planning. Key features to include are:

- Service coordination hierarchy consisting of feeder services which are scheduled to meet trunk services.
- Defined connection types for all intersecting services—i.e. 'turn up and go', timed and harmonized.
- Use of standard headways—i.e. the time between services—across the network, set up as multiples of 10 or 20 minutes.

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[4]Refer to Development of Training Material under " Sustainable Urban Transport Project, Travel Demand Modelling, Ministry of Urban Development, Section 2.7

[5]Development of Training Material under " Sustainable Urban Transport Project, Reference Guide Volume 2 Public Transport, Ministry of Urban Development, Section 4.2.1, iii

- Consistent definition of service periods—i.e. peak and off-peak for all connected modes.

The factors to be covered while planning for the Integrated Operation Plan – Public Transport are given below:

a. Harmonizing services: To achieve good coordination between modes, there is a need to ensure that services are harmonized. For example, a 10 minute metro rail service is harmonized with a 20 minute bus service because every second bus can be aligned with a metro rail service. In contrast, a 15 minute metro rail service does not coordinate well with a 20 minute bus service as only one of the three bus services per hour can be properly aligned with the metro rail service. The timetables are barely good as it had not been written consideration of inter-modal connectivity. It would be possible to achieve much better connections and therefore substantial travel time savings with better timetabling without increasing operating costs for operators.

b. Timetable Updates: In part, the dis-harmonization of services is a result of the historically uncoordinated approach to changing timetables, whereby timetables were independently prepared on an individual modal basis with little consideration of wider coordination goals. Authorities should conducts integrated timetable updates for metro rail, urban rail and buses or any other modes presents in consultation with all operators.

c. Frequency: Frequent public transport services are vital for providing viable alternatives to car travel. They also serve to minimize the time for connecting between services, and promote a 'turn up and go' mentality where users do not need to look at timetables before they travel.

   For example, in Zurich more than half of the tram and bus lines operate on a 'turn up and go' basis, with services running every six minutes, which means, short wait times at most interchanges. During periods where demand is too low to support high frequency services, the network operates on a lower frequency aligned with the change in demand, and timetables are synchronized to minimize waiting times.

d. Service Span: The span of a service is the number of hours and days during which it operates. This will usually vary by route depending on service type, the day of the week, and route demand. Generally, high-demand routes will have longer service spans. This variable and limited nature of services acts to compromise user confidence and achievement of patronage potential therefore, service span of the coordinated modes should match.

e. Directness: Where they are possible, direct PT routes support to achieve coordination objectives as they permit more frequent services and shorter wait times for connecting public transport services. While indirect PT routes can maximize geographical coverage of a service, this increases the journey length and time due to frequent stopping and turning. Since travel time is a crucial factor in the attractiveness of public transport, excessively indirect PT routes discourage patronage.

   It is important to recognize that there needs to be a trade-off between directness and serving available areas. However, excessively indirect routes and journey times can inhibit patronage growth.

   The directness ratio is an indicator used to judge the directness of routes. It is the ratio of the actual length of a service route to the most direct road routing distance between its origin and destination. The directness ratios of around 1.1 to 1.3 are considered desirable.

3.2.3 DESIGN STAGE

Operation integration is required to take decisions on the design of transit services. Transit services can be designed in two ways:

- **Customer Oriented Design:** Shaping the technology around the customer (Shown in Figure 3.10)

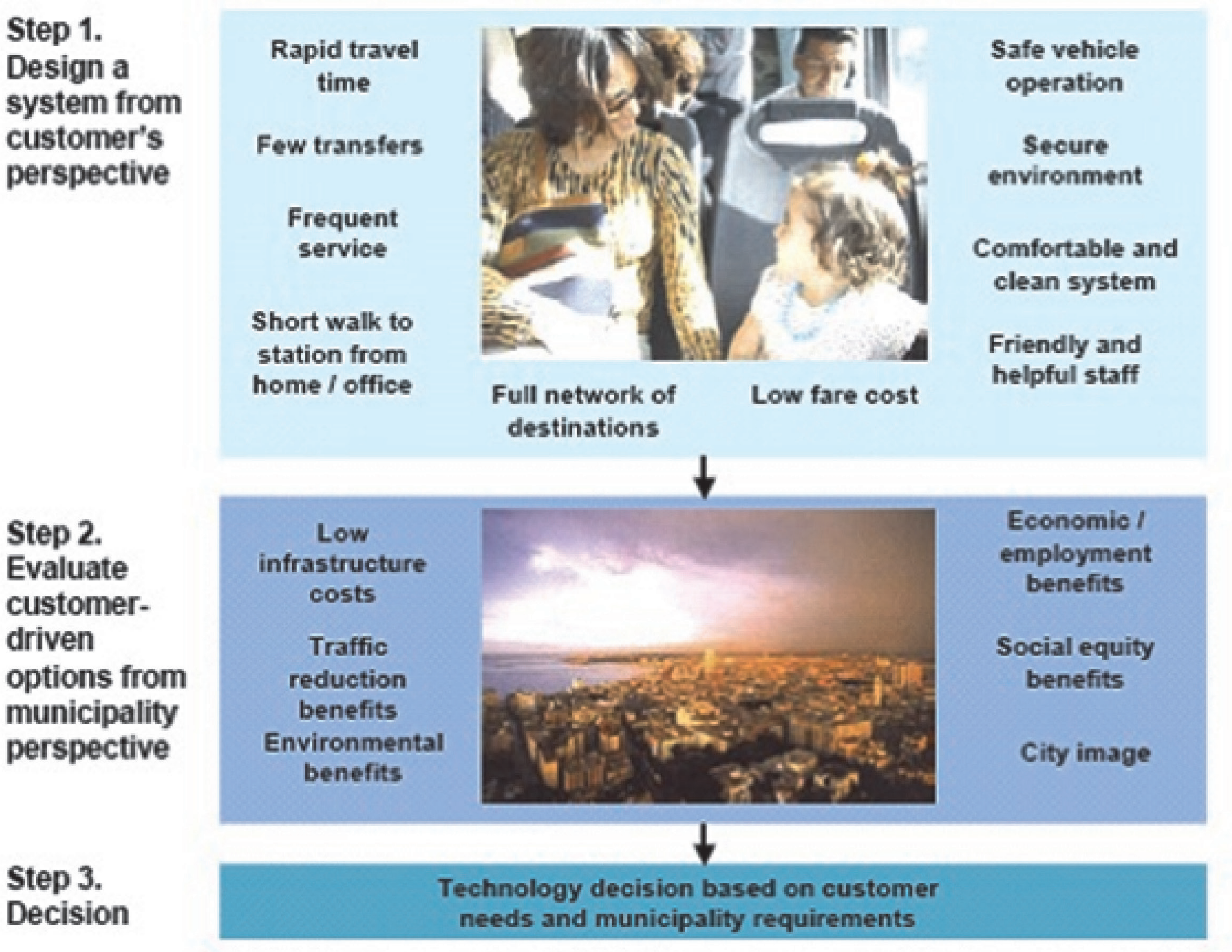


Figure 3.10: Customer Oriented Design Approach

Source: Bus System Toolkit, Developed with Assistance from DFID, MoUD, Volume 1, Section 1 Customer Oriented Design

- **Technology Driven Design:** making the customer adopt to a technology (Shown in Figure 3.11)

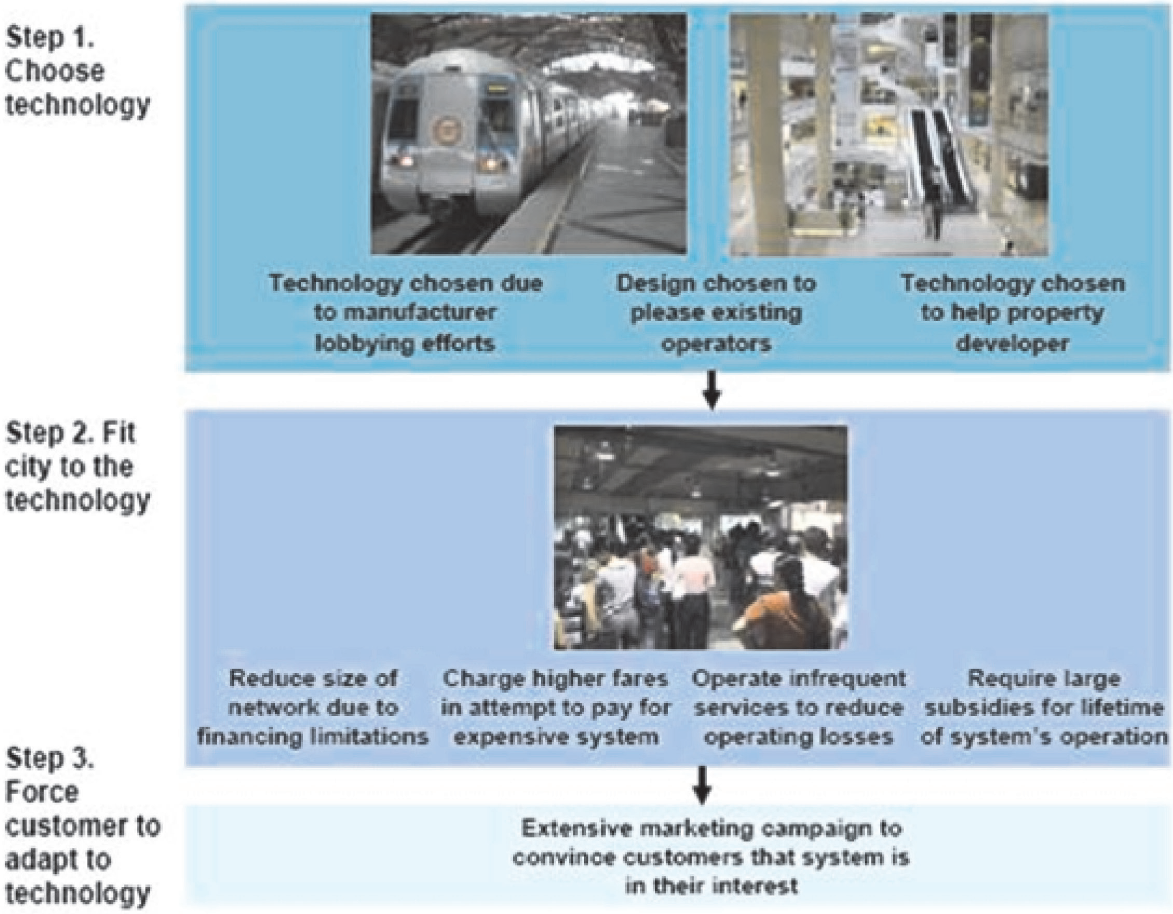


Figure 3.11: Technology Driven Design

Source: bus system toolkit, developed with assistance from DFID, MOUD, volume 1, section 1 Technology oriented design

The other factors which affects the design for operation integration are:

- Geographical Location of the region
- Traffic and Travel Characteristic
- Route / Corridor Network: Different types of route patterns are shown below:
- Socio-Economic Characteristics
- Existing Public Transport
- Transport Infrastructure (roads, station, stops etc.) or other (built-up, zone characteristics / activity) features presence.

Operation integration is a concept, which when planned and implemented differs from region to region, because of its different needs. Therefore, every region needs to have its own design.

3.3 PHYSICAL INTEGRATION

Physical integration refers to the provision of jointly used transport facilities & equipment to provide seamless mobility.

Figure 3.12: An Example of Physical Integration

Source: Service Level Benchmark for Urban Transport, MoUD, GOI

Seamless Mobility is the ability for users to remain connected while roaming across different transport networks i.e. mass rapid transit, city bus system, IPT, NMT and private modes i.e. cars, two wheelers etc. Figure 3.12 clearly reflects an idea of Physical Integration, with one commuter stop being adequately used by three different modes i.e. Bus, LRT and MRTS. The details of Physical Integration (Components & Sub-Components) are given below in Figure 3.13.

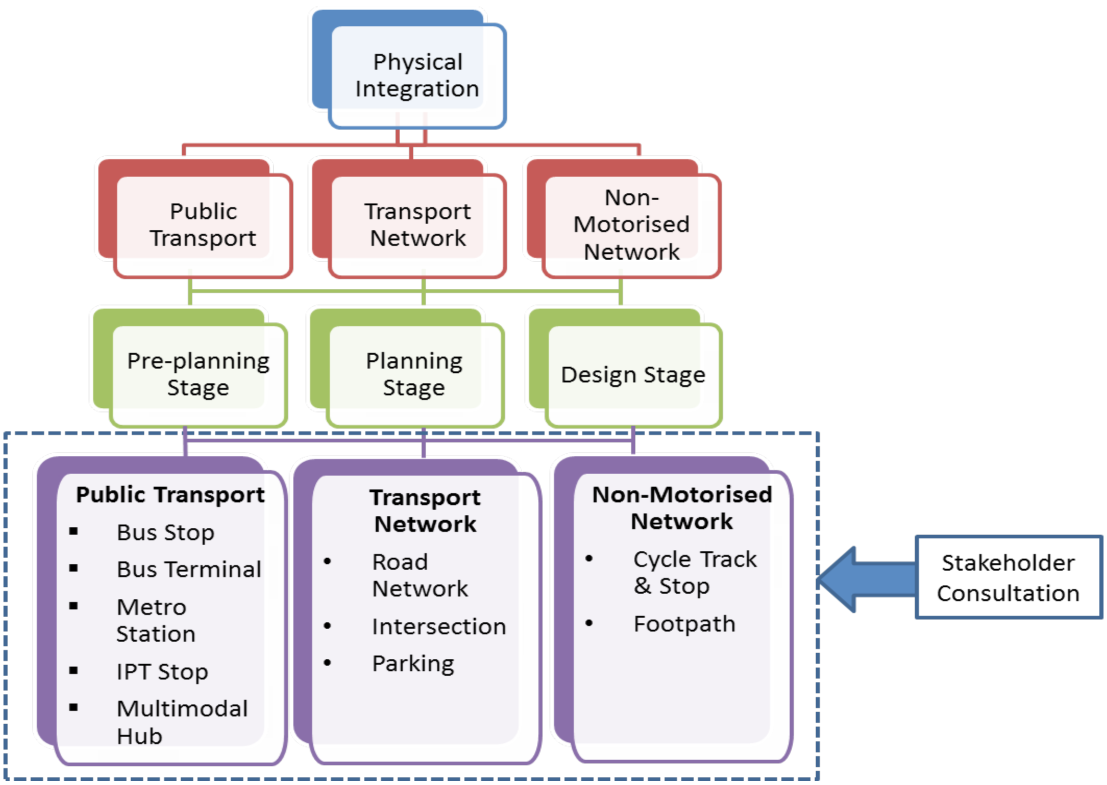


Figure 3.13: Physical Integration "Components & Sub-Components"

3.3.1 PRE-PLANNING STAGE

The pre-planning stage of a project is the stage when organization starts to draw up ideas. In this stage, data is collected through secondary sources and primary surveys (Details are given in Annexure 1) for various components and sub components as discussed below.

3.3.1.1 PUBLIC TRANSPORT

The secondary data and primary survey required for Public Transport component of physical integration are given below in Table 3.4.

Table 3.4: Data Requirement for Public Transport - Physical Integration

Data	Survey *	Level	Source
City Map	Existing Location of infrastructure, transfer points	Citywide	All concerned authority
Bus Stop / Metro Station / IPT Stop	Stop Survey (9a – Mode Inventory)	Sample	Primary Survey
Bus Terminal / Multi-Modal Hub (Interchange)	Terminal Survey (9h – Bus Terminal Survey) Interchange survey (9e – Interchange Survey)		

*Note: For survey details, Refer Annexure 1: List of Survey & its Format

3.3.1.2 TRANSPORT NETWORK

The primary and secondary data required for Transport Network component of physical integration are given below in Table 3.5.

Table 3.5: Data Requirement for Transport Network-Physical Integration

<table>
<tr><th>Data</th><th>Survey*</th><th>Data Level</th><th>Source</th></tr>
<tr><td rowspan="4">Road:
Road Network details
Traffic Pattern
Traffic Count</td><td>Secondary data collection in terms of existing road network, Intersections and other infrastructure such as parking locations</td><td>Citywide</td><td>Any Competent Authority like PWD, Development Authority etc.</td></tr>
<tr><td>Road Network Inventory (Survey 1 – Inventory of Road Network System)</td><td rowspan="8">Sample</td><td rowspan="8">Primary Survey</td></tr>
<tr><td>Level of Service of Road (Survey 2 – Classified Traffic Volume Counts)</td></tr>
<tr><td>Screen Line by Mode (Survey 4 – Road Side OD)</td></tr>
<tr><td rowspan="3">Intersection:
Intersection Detail
Delay and
Queue Length</td><td>Intersection (Survey 3a – Inventory)</td></tr>
<tr><td>At Intersection by modes (Survey 3b – Intersection- Turning Moment Count)</td></tr>
<tr><td>Delay by mode at Intersection (Survey 3c – Queue Length)</td></tr>
<tr><td rowspan="2">Parking:
Parking Detail
Demand & Supply</td><td>Parking (Survey 5a – Inventory)</td></tr>
<tr><td>Parking Usage (Survey 5b – On Street & Off Street Parking and 5c – Parking Usage Survey by Patrol)</td></tr>
</table>

*Note: For details, Refer Annexure 1: List of Survey & its Format

3.3.1.3 NON- MOTERISED TRANSPORT

The primary and secondary data required for Non - Motorized Transport component of physical integration are given below in Table 3.6.

Table 3.6: Data Requirement For Non-Motorized Transport Network -Physical Integration

Data	Survey*	Data Level	Source
Existing Infrastructure details	Secondary data collection in terms of Existing Footpath & Cycle Track	Citywide	Any Competent Authority like PWD, Development Authority etc.
Footpath	Footpath (8a – Inventory)	Sample	Primary Survey
	Intersections (3a – Inventory)		
	Access (8a – Inventory)		
Bicycle	Lane (7a – Inventory)		
	Intersection Treatment (3a – Inventory)		

*Note: For details, Refer Annexure 1: List of Survey & its Format

3.3.2 PLANNING STAGE

Step by step process for planning various identified components and sub components are explained below.

3.3.2.1 PLANNING PROCESS FOR PUBLIC TRANSPORT

In order to plan public transport systems to offer a seamless travel experience rather than behave as a set of individual routes serving a specified set of origin-destination pairs, it is necessary to integrate physical infrastructure of public transport using a series of steps as shown in Figure 3.14:

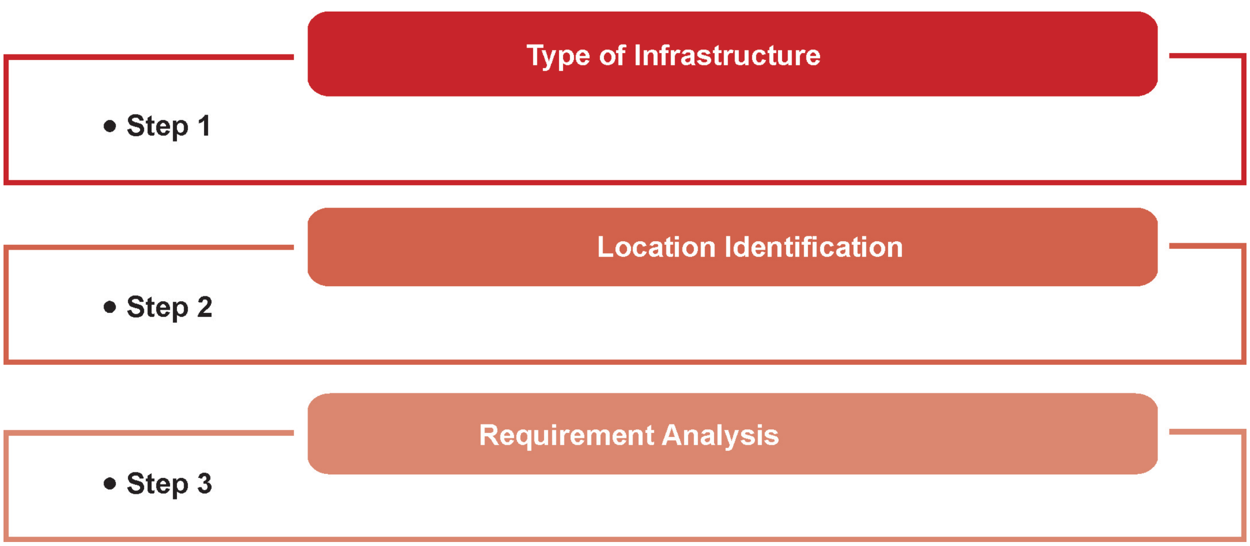


Figure 3.14: Step for Physical Integration - Public Transport


STEP 1 – Type of Infrastructure:

The various types of public transport infrastructure[6] details are given below:

1. **Bus Stop:** A bus stop is a designated place where buses stop for passengers to board or alight. Bus stop can be a pole or with proper shelter. A bus stop is to be envisaged as an integrated part of the project, taking into consideration the future development and expansion plans.

2. **Bus Terminal:** A "Terminal' usually refers to the large stations that are major points of interchange between different bus routes such as trunk, feeder and inter-city routes or different modes of transport[2]. An integrated Bus Terminal serves as a common facility to:

    - Govt. owned inter-state / inter-city buses, other State transport buses, etc.
    - Private bus operators (inter-state / inter-city)
    - Local city buses

The size of the terminal and the extent of amenities envisaged there depends on the amount and intensity of operations. It is to be a transit terminal with the following facilities:

- Bus station facilities
- Passenger facilities
- Other facilities

Tube Shaped BRT Station

Source: http://ecolocalizer.com/2010/11/25/curitiba-sustainable-transportation-sustainable-city-leader-video/

Victoria Bus Station, London

Source: https://geolocation.ws/v/P/33097578/london-victoria-bus-station-1993/en

[6] Refer Section 2.5 Table 2.1 – Component & Sub-Component of Integration

[7] Refer: Development of Training Material Under "Sustainable Urban Transport Project" Reference Guide Volume 2 Public Transport, Appendix B: Infrastructure Facilities for Managing Bus Operations, MoUD

3. **Metro Station:** A Metro Station is type of railway station for the rapid rail transit system, and are usually elevated, underground, or about ground level depending on the level of the train tracks. Also, at crossing of Metro Lines, they are multi-level. A metro station is to be envisaged as an integrated part of the project, taking into consideration the future development and expansion plans.

4. **Intermediate Public Transport (IPT) Stop:** Most of the passengers use intermediate public transport such as auto-rickshaws and taxis for short distances. These IPT Stops facilitate better operation management and less traffic tensions.

5. **Multi-Modal Hub:** A state of the art multi-modal hub, depending upon the decided modes in the hub, includes its desired component (as mentioned in point 1 to 4 above). A railway station can also be part of the hub based upon its planning. Apart from those components, a hub can have two other facilities given below:

   - Multi-Storey parking facility: Passengers normally use transit modes other than Buses and trains, such as cars, two-wheelers and intermediate public transports like taxis and autos therefore it is necessary to provide a facility that ensures easy circulation and parking of these vehicles. This parking facility is to be connected to the bus terminal, metro stations & HSRL via skywalks, subways or foot over bridges so that passenger circulation does not conflict with vehicular circulation. The parking facility is an essential component of the hub.

   - Property development – commercial / institutional: A multi-modal hub is the center of future development in the area and therefore commercial utilization of the available FSI is necessary. It provides supplementary services to the passengers traveling by metro, BRTS, HSRL as well as

Delhi Metro Station

Source: http://www.theglobalindian.co.nz/delhi-metro-becomes-worlds-first-metro-to-earn-carbon-credits/

Multi-Modal Hub

Source: http://en.wikipedia.org/wiki/File:Guangzhou_South_Railway_Station_Platform_CRH3_EMU.jpg

Transit Centre to be constructed at San Francisco

Source: http://transbaycenter.org/project/transit-center

road. The following are possible types of development that command a potential demand in a multi-modal hub.

- ✓ Property Development – Commercial / Institutional / Office
- ✓ Ticket reservation counters by private operators
- ✓ Tourism counters
- ✓ Food & beverage outlets
- ✓ Shopping center
- ✓ Retail hyper mart
- ✓ 3 star hotel
- ✓ Dormitory accommodation
- ✓ ATMs / bank / foreign exchange counters
- ✓ Visitor parking facilities
- ✓ Skywalk / inter-connectivity to metro station, HSRL, bus terminal
- ✓ Office space / area for it, BPO, institutions, etc.

STEP 2 - Location Identification:

The first step is to identify the existing public transport infrastructure and study the associated facilities through the surveys as mentioned in the pre-planning stage above. This helps to identify the gaps in the current service.

Open End Field Survey

Source: http://www.jmt.com/project-portfolio/sha-open-end-field-survey-services/

The factors that need to be considered for location identification of the service are given below:

- Regional connectivity: Multi-modal hubs on the outer cordons act as growth engines and generate more traffic.
- Public transportation services: Routes (of each PT mode), existing location of infrastructure (stops / station / Multimodal hub / terminal etc.), ridership and transfer points where many routes converge or meet.
- Surrounding road network: The extent of motorized access being provided by the nearby arterials to the location from the surrounding neighborhoods and regional areas.
- Stakeholder consultation.
- Approach to the site: Connectivity to the site in terms of its utilization capacity.
- On-site features: Construction suitability of the terrain.


- Off-site features including details of nearby area or locality, such as a railway station or airport in the vicinity.
- Applicable development controls, building norms and / or zoning regulations such as FAR, parking, height restriction, setbacks, etc.

Step 3 – Requirement Analysis:

The requirement analysis varies from one component to another (Table 2-1 "Component & Sub-Component of Integration"). Based upon the facility, the requirement analysis needs to be done as detailed below:

1. **Bus Stop:** Activities of the bus stop include the following:
   - ✓ Bus Bays
   - ✓ Ticket counters / Information kiosks
   - ✓ Waiting area
   - ✓ Foot over bridges (if necessary)
2. **Bus Terminal:** The terminal has to have following facilities:
   - ✓ Bus station facilities:
     - a. Bus Bays – Intercity and Intra-city buses
     - b. Bus parking area (for each operator)
     - c. Mini-repair shop for buses
     - d. Driver retiring rooms / cafeteria
     - e. Administrative offices (for each operator)
   - ✓ Passenger facilities:
     - a. Ticketing counters / information kiosks / enquiry
     - b. Passenger concourse area- Retiring / waiting rooms / cloak rooms
   - ✓ Other facilities:
     - a. Restaurants / coffee shops / fast food outlets
     - b. Commercial outlets-book stores, medical shops, etc.
     - c. Bank & finance companies / ATMs, internet cafes / business centers, stalls, etc.
     - d. Mini repair shop for the buses plying on longer routes on user charge basis. This includes small workshop shed, washing platforms, crew rooms, office area for bus operators and diesel fuel station.
3. **Metro Station:** Facilities of the metro station include:
   - ✓ Platform
   - ✓ Ticket counters (metro) / information kiosks

- ✓ Restaurants / coffee shops / fast food centers
- ✓ Commercial outlets – book stores, medical shops, souvenir shops, ATMs, etc.
- ✓ Foot over bridges (if necessary)

4. **Intermediate Public Transport (IPT) Stop:** These stop can have following facilities:
   - ✓ Platform / Waiting Area
   - ✓ Ticket counters / information kiosks
   - ✓ Restaurants / coffee shops / fast food centers
   - ✓ Commercial outlets – book stores, medical shops, souvenir shops, etc.
   - ✓ Foot over bridges (if necessary)
5. **Multi-Modal Hub:** Based upon the selection of modes, the requirement analysis for its desired mode component facility can be established. Railway Station can be a part of planning. Multi-storey parking and property development facility can also be figured out based upon necessity.

3.3.2.2 PLANNING PROCESS FOR TRANSPORT NETWORK

The components of planning for transport network includes:

- ✓ Road network
- ✓ Intersection
- ✓ Parking management

a) **Road Network:** The steps involved are given below in Figure 3.15:

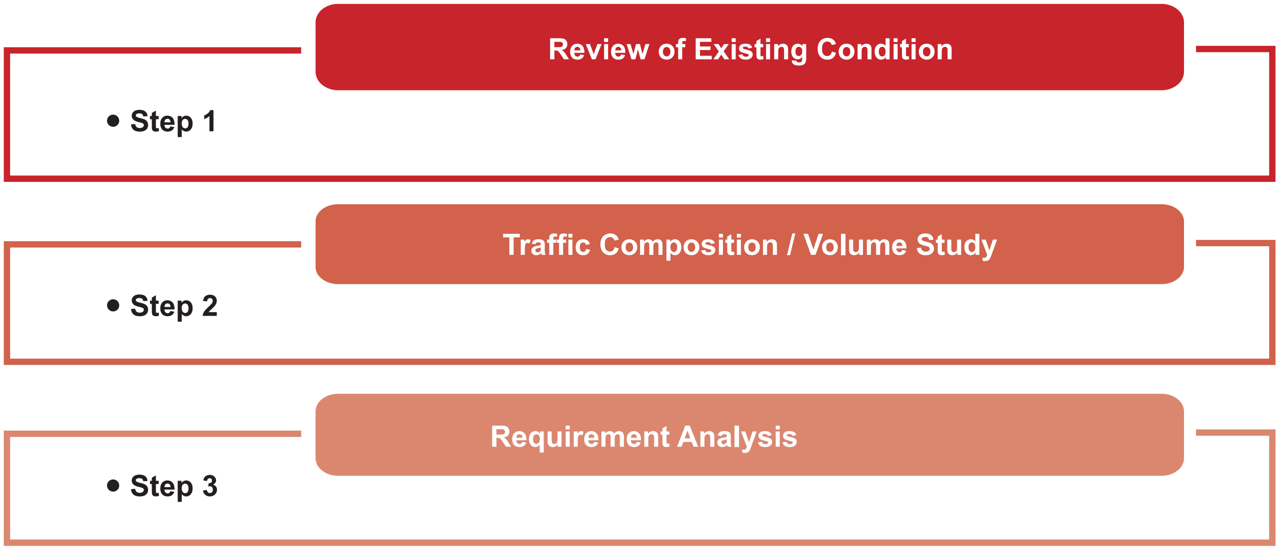


Figure 3.15: Steps for Physical Integration - Transport Network (Road Network)


Step 1 – Review of Existing Condition:

Review of existing condition involves road network inventory i.e. Right of way, pavement width, central reservation (median), shoulder, camber, side slopes, horizontal & vertical clearances, road pattern etc. This covers aspects such as classification of the street system, length, cross sectional dimensions, capacity, type and condition of the surface, intersection, control devices and street furniture. The details of road hierarchy are given in Table 3.9.

Figure 3.16: An Illustration of Good Road Section of Bhopal

Source: Handbook on 'Service Level Benchmark for Urban Transport', MoUD

Figure 3.16 shows perfect usage of Right of way which includes pavement width, central reservation (median), shoulder, camber, horizontal & vertical clearances, road pattern, road marking, traffic signals etc.

Step 2 – Traffic composition / volume study:

One of the fundamental measures of traffic on a road system is the volume of traffic using the road in a given interval of time as explained below.

- Average Annual Flow, expressed in terms of vehicles per year-. It is useful for estimating the total travel on a road system and for determining the gross annual revenues from road users.
- Annual Average Daily Traffic (AADT), expressed in terms of vehicles / day. It is a common measure utilized in geometric standards for highways, improvement in existing facilities and standards for pavement design and maintenance. If the flow is measured for few days, the average flow is known by the term Average Daily Traffic (ADT).

- Hourly Flow, expressed in terms of vehicles per hour. Short term variations occurring in the course of a day and specially the peaking situations in the morning and evening rush hours are needed for design of traffic control systems.

Analysis from the Classified Traffic Volume Count (TVC) survey (**Table 3.5 Section 3.3.1.2 for Road**) data will help in planning the flow characteristics one can easily determine whether a particular section of the road is handling traffic much above or below its capacity. The duration of the counts depends upon the purpose for which the data are needed and the financial and manpower resources. The examples of situations where the above types of counts are made with purpose and use are given in figure 3.17.

Short term count say for One or Two Hours	Counts for Full Day	Counts for Full Week	Continous Survey
•To determine the flow or traffic in the peak hour •Used in measuring the saturation flow at signalised intersection •Used in intersection counts during the morning and evening peaks	•To determine hourly fluctuation of flow •Used in intersection counts •Used in cordon line and screen line counts as part of trasnportation survey	•To determine the hourly and daily fluctuation of flow •Used generallly in developing countires as the only measures of traffic census on non urba highways •Used in cordon line and screen line counts as part of urban transportation susrvey	•To determine the fluctuations of flow, daily, weekly, seasonally and yearly •To determine the annual rate of growth of traffic •Used generally in develop countries at selected number of stations for continuous monitoring of traffic flow in urban and non - urban locations

Figure 3.17: Types of Vehicle, Volume Counts and their uses

Source: Traffic Engineering and Transport Planning, Dr. L.R. Kadyali

Step 3 – Requirement Analysis

Through the above analysis given in step 2, roads need to be revamped for the designated traffic volume. Urban roads are characterized by mixed traffic conditions resulting in complex interaction between various kinds of vehicles. To cater to this, it is usual to express the capacity of urban roads in terms of common unit called Passenger Car Unit (PCU) and each type of vehicle is converted into equivalent PCUs[8] based on their relative interference value as given in Table 3.7.

[8] IRC: 106-1990 Guidelines for Capacity of Urban Roads in Plain Areas Section 7

Table 3.7: Recommended PCU Factors for Various Types of Vehicles on Urban Road

Vehicles	Equivalent PCU factors (percentage composition of vehicle type in traffic stream)	
	5%	**10% and above**
Fast Vehicles		
Two Wheeler Motor Cycle or Scooter etc.	0.5	0.75
Passenger Car, Pick up Van	1.0	1.0
Auto Rickshaw	1.2	2.0
Light Commercial vehicle	1.4	2.0
Truck or Bus	2.2	3.7
Agricultural Tractor Trailor	4.0	5.0
Slow Vehicles		
Cycle	0.4	0.5
Cycle Rickshaw	1.5	2.0
Tonga (Horse drawn Vehicle	1.5	2.0
Hand Cart	2.0	3.0

The capacity of urban roads is a function of the roadside fringe conditions e.g. parking, extent of commercial activities, frontage access etc. For purpose of recommendations given further-on, the following fringe conditions are assumed:

a) Arterial: No frontage access, no standing vehicles, very little cross traffic.

b) Sub-arterial: Frontage development, side roads, bus stops, no standing vehicles, waiting restrictions.

c) Collector: Free frontage access, parked vehicles, bus stops, no waiting restrictions.

The design service volume [9]based on the traffic volume count for different categories of urban roads corresponding to above referred conditions is given in Table 3.8.

[9] IRC: 106-1990 Guidelines for Capacity of Urban Roads in Plain Areas Section 8

Table 3.8: Recommended Design Service Volumes (PCUs per Hour)

S. No.	Type of Carriageway	Total Service Volumes for Different Categories of Urban Roads		
		Arterial	Sub-arterial	Collector
1.	2-Lane (One-Way)	2400	1900	1400
2.	2-Lane (Two-Way)	1500	1200	900
3.	3-Lane (One-Way)	3600	2900	2200
4.	4-Lane Undivided (Two-Way)	3000	2400	1800
5.	4-Lane Divided (Two-Way)	3600	2900	-
6.	6-Lane Undivided (Two-Way)	4800	3800	-
7.	6-Lane Divided (Two-Way)	5400	4300	-
8	8-Lane Divided (Two-Way)	7200	-	-

Based upon the traffic volume, different types of road hierarchy are present for urban area, these are listed below in the Table 3.9.

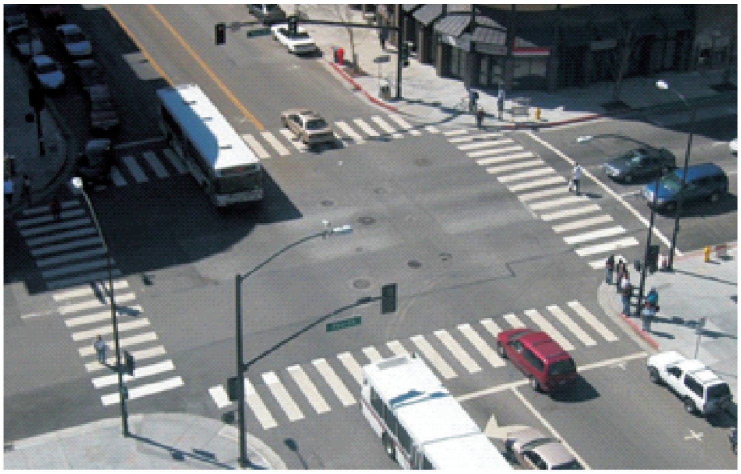
Table 3.9: Urban Road Hierarchy[10]

Features	Expressway	Arterial Highway/ Streets	Sub Highway/ Arterial	Collector Streets/ Road	Local Streets/ Road
Definition	A divided arterial highway for motor traffic with full or partial control of access and provided generally with grade separation at intersection	A general term denoting a highway / street primarily for through traffic usually on a continuous route	A general term denoting a highway / street primarily for through traffic usually on a continuous route but offering somewhat lower level of traffic mobility then the arterial street	A street or road for collecting and distributing traffic from and to local streets/ roads and also for providing access to arterial streets / roads	A street or road primarily for the access to residence, business or abutting property
Purpose	Provide movement of heavy volumes of motor traffic at high speeds under free flow conditions	Serve as a principal network for through traffic flow and should be in coordination with existing & proposed expressway	Similar to arterial but with lower level of travel mobility	Intended for collecting traffic from local streets and feed it to arterial/ sub-arterial streets and vice-versa	Primarily intended for access to residence, business or other abutting property

[10] Source: IRC: 69-1977 Space Standards for Roads in Urban Areas Section 3 & 5

Features	Expressway	Arterial Highway/ Streets	Sub Highway/ Arterial	Collector Streets/ Road	Local Streets/ Road
Access	Full or partial control of access with grade separation at intersection	Divided highway with full or partial controlled access	Full or Partial controlled access	Null controlled access from abutting properties	Null controlled access from abutting properties
Connectivity	Connects points of medium and long lengths between residential, industrial or CBD	Intra-Urban travel between CBD and outlying residential area or between major suburban centres is served by this facility	Connects adjoining areas	Travel in residential neighbourhoods, business areas and industrial areas	Traffic originates and terminates along its length
Traffic	Heavy & Light Motorised Traffic	Heavy & Light Motorised Traffic, 2-Wheeler	Heavy & Light Motorised Traffic, 2-Wheeler	Light Motorised Traffic, 2-Wheeler	Light Motorised Traffic, 2-Wheeler
Parking	Not permitted	Restricted & Regulated	Restricted & Regulated	Few restrictions during peak hours	Unrestricted parking
Pedestrian	Not permitted	Movement allowed only at intersections	Movement allowed only at intersections	Movement allowed	Movement allowed
NMT	Not permitted	Permitted	Permitted	Permitted	Permitted

b) Intersection: An intersection is defined as the general area where two or more roads join or cross, within



Designed intersection at Seatle, United States

Source: http://www.hardwickpendergast.com/seattle-personal-injury-attorneys-blog/tag/us-intersection-accident-statistics/

[11]Traffic Engineering and Transport Planning, Dr. L. R. Kadyali, Section 11.10.1

which are included the roadway and roadside facilities for traffic movements in that area.[11] The steps involved are shown in Figure 3.18.

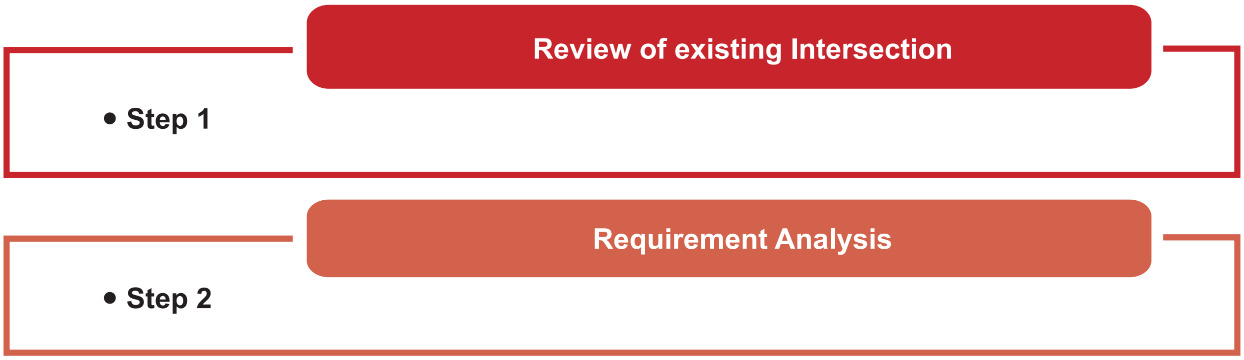


Figure 3.18: Step for Physical Integration - Transport Network (Intersection)

Step 1 – Review of existing Intersection:

The objective is to study the efficiency of operation, safety, speed and capacity of the junction which is directly governed by its design. It includes road geometry, weaving length, turning radius, exit entry radius, capacity & turning volume count of the intersection.

Step 2 – Requirement Analysis:

Analysis of data pertaining to intersection inventory, intersection turning movement and queue length survey (**Table 3-5 Section 3.3.1.2 for Intersection**) helps in identifying the improvement needed at junctions. The intersections can be classified into following categories depending on the traffic condition[12]:

- **Uncontrolled Intersection at-grade:** These are the intersection between any two roads with relatively lower volume of traffic and traffic of neither road has precedence over the other.
- **Intersection with Priority Control:** There is theoretically no delay occurring on the major road and vehicles on the minor roads are controlled by “Give Way” or “Stop” sign.
- **Time Separated Intersection / Signalized Intersections at-Grade:** The detailed warrants for signalized intersection are laid down in IRC code: 93-1985. A signalized intersection besides other warrants, is justified if the major street has a traffic volume of 650 to 800 vehicles per hour (both directions) and the minor street has 200 to 250 vehicles per hour in one direction only.

Different type of At-Grade Intersections are given in Figure 3.19 below: **Space Separated**

[12] IRC: SP 41 Guidelines for the Design of At-Grade Intersections in Rural and Urban Areas Section 1.4


- **Intersection / Grade Separated Intersections:** The detailed warrants for interchange or grade separated intersections are given in IRC: 92-1985. According to these, a grade separated intersection, besides other

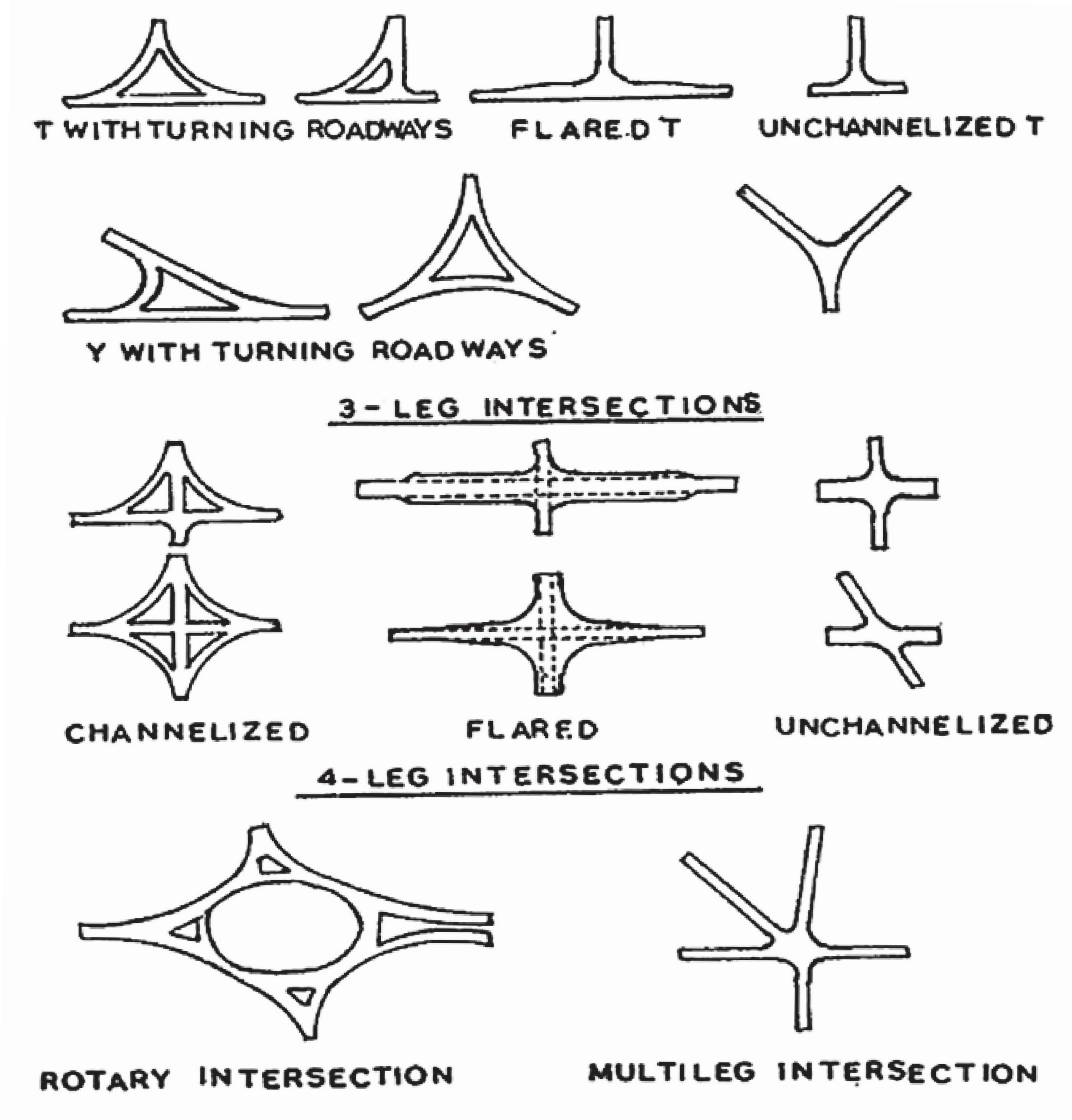


Figure 3.19: General Types of At-Grade Intersections

Source: IRC: SP 41 Guidelines for the Design of At-Grade Intersections in Rural and Urban Areas warrants, is justified when the total traffic of all the arms of the intersection is in excess of 10,000 PCU's/hour. Different types of Space Separated Intersection / Grade Separated Intersections are given below in Figure 3.20.

c) Parking: Parking is one of the serious problem that any city is facing these days. Before any measures for the betterment of the conditions can be formulated basic data pertaining to the availability of parking

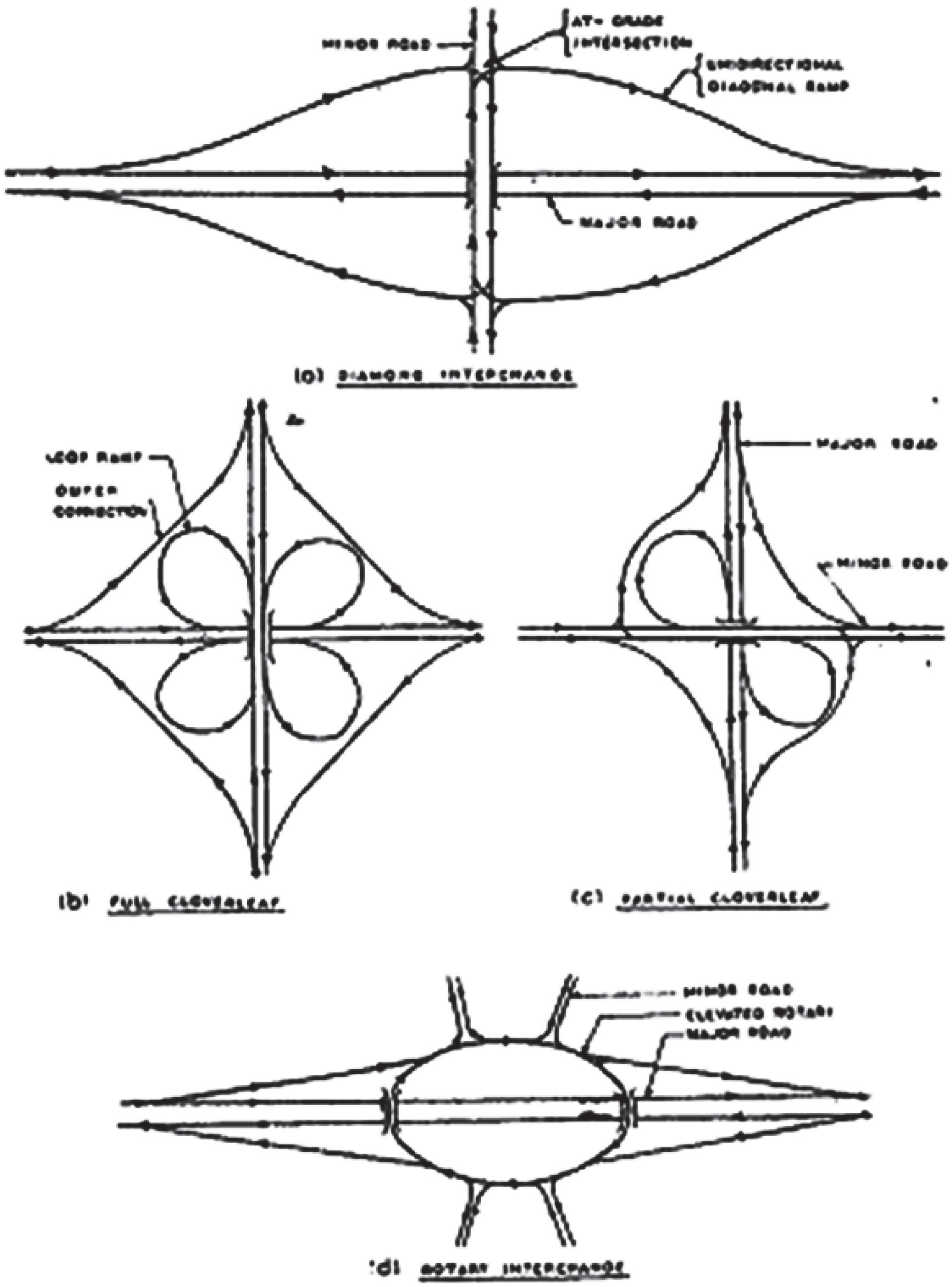


Figure 3.20: Space Separated Intersection/Grade Separated Intersections

Source: IRC: 92-1985 Guidelines for the design of Interchanges in Urban Areas space, extent of its usage and parking demand are essential. If it is proposed to implement a system of parking charges, it will also be necessary to know how much to charge and what will be the effect of the pricing policy on parking.

The focus of parking on transport network is to boost the demand of public transport, through different parking options of off-street and on-street parking. The steps involved in planning for parking facilities is given below in Figure 3.21:

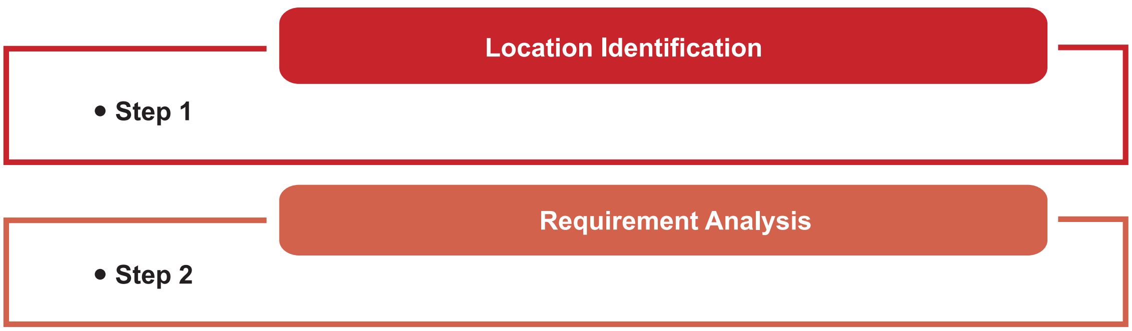


Figure 3.21: Step for Physical Integration - Transport Network (Parking)

Step 1 – Location identification:

Location identification of facilities: Location of parking spots needs to be such that it is easily accessible and in sync with the public transport system. This increases the patronage of public transport and improves the efficiency of the overall transport network.

The factors that need to be considered for location identification of the service are given below:

- ✓ Existing land-use pattern, the travel characteristics and the future growth pattern of the targeted areas.
- ✓ Study, the target areas existing concentration of parked vehicles and the deficiencies in provision of Off-street parking facilities.

San Francisco's Reduced Residential Parking

Source: http://reconnectingamerica.org/news-center/half-mile-circles/2011/san-francisco-s-reduced-residential-parking-requirements/

Step 2 - Requirement analysis:

Based upon the analysis drawn from survey, (**Table 3.5 Section 3.3.1.2 for Parking**) planning needs to be done. The planning components of parking are as follows:

a. Parking Demand and supply: Some of the common features that need to be seen while planning of parking facility are[13] as follows:

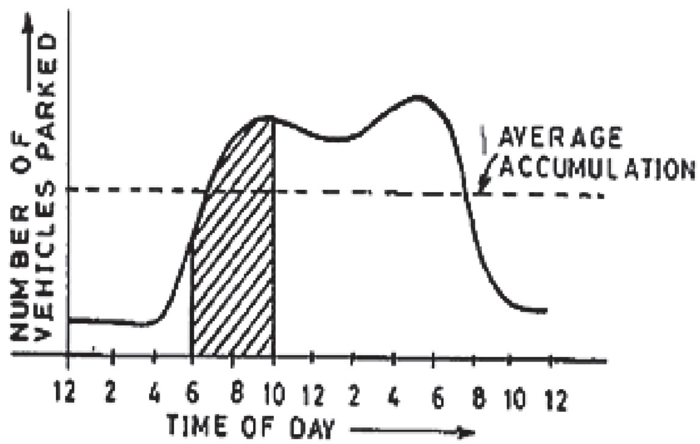


Figure 3.22: Parking Accumulation Diagram

Source: Traffic engineering and Transport Planning – L. R. Kadyali

- Parking Accumulation: It is defined as the number of vehicles parked at a given instant of time. Normally this is expressed by accumulation curve (Figure 3.22). Accumulation curve is the graph obtained by plotting the number of bays occupied with respect to time. The occupancy can be calculated by taking accumulation / total spaces. Peaking characteristics can be determined by graphing the accumulation data by time of day.
- Parking Volume: The number of vehicles parking in a particular area over a given period of time. It is usually measured in vehicles per day.
- Parking Load: The area under the parking accumulation curve during a specified period. For example, in Figure 3-22, the hatched area represents the parking load in vehicle –hour for a period of 4 hours from 6 AM to 10 AM. It can also be obtained by simply multiplying the number of vehicles occupying the parking area at each time interval with the time interval. It is expressed as vehicle hours.
- Parking Duration: The length of time spent in a parking space. It is the ratio of total vehicle hours to the number of vehicles parked.
- Parking Index: Parking index is also called occupancy or efficiency. It is defined as the ratio of number of bays occupied in time duration to the total space available. It gives an aggregate measure of how effectively the parking space is utilized. Parking index can be found out as follows

Parking index = Parking load / Parking capacity

- Parking Capacity can be calculated by the no. of parking bays X no. of hours parking is being used in a day.
- Parking Turn Over: It is the rate of the usage of the available parking space. For example, if there are 10 parking spaces used by 100 vehicles in a period of, say 12 hours, then the parking turnover is 100/10 = 10 vehicles per space in a period of 12 hours.

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[13] Traffic engineering and Transport Planning – L. R. Kadyali, Section 6.2

Based upon the demand and supply analysis, following parking options to be selected by the concerned authority:

Case Study: Diagnosis of existing situation of parking at Transport Bhawan, New Delhi
Steps followed are as follows:

Step 1: Parking Volume: The parking data has been collected from CPWD. It has been observed from the data that the parking volume per day at Transport Bhawan is:

i. Cars – 152 long duration parking cars and 50 short duration visitor's cars (ECS-202)
ii. Two-Wheelers – 150 – 200 Two-wheelers (ECS-50)
iii. Total ECS: 252

Step 2: Parking Accumulation: The graph below shows the parking accumulation of transport Bhawan which is calculated based on following assumptions

- At 9 am 25 % of total parking demand will occupy the parking lots
- By 11 am rest of 75% parking demand is fulfilled
- 30% of short term parking is assumed between 11:00am to 1: 00pm and 3:00pm to 5:00 pm

Step 3: Parking Load: It can also be obtained by simply multiplying the number of vehicles occupying the parking area at each time interval. For example: At 9 AM: Total vehicles parked is 38 and at 10 Am- Total Vehicles parked in 114. The parking load of 9AM to 10 AM is (114+38)/2 *(10-9) i.e. 76. After adding parking load of the hours, load comes to a total of 2118 vehicle hours, 1680 for cars and 438 for Two Wheelers

Step 4: Average Parking Duration: Av. Parking Duration: 2118/252 = 8.40 hours.

Step 5: Parking Index: It gives an aggregate measure of how effectively the parking space is utilized It can be calculated as Parking index = parking load/parking capacity

a. Parking Index for cars

- No of Car Bays Available: 64
- Parking Load for Car = 1680 Vehicle hours
- Parking Capacity for Car = 64*10 = 640 vehicle hours
- Therefore, Parking Index for cars = 1680/640 = 2.625.

b. Parking Index for Two-Wheelers

- No of 2W Bays Available: 60
- Parking Load for Two-Wheeler = 438 Vehicle hours
- Parking Capacity for Two-Wheeler = 60*10 = 600 vehicle hours
- Therefore, Parking Index for two-wheelers = 438/600 = 0.73.

Recommendation: The parking index of car and 2W shows that there is an acute shortage of bays for parking of cars but for two-wheelers, no need for extra bays. However, due to excessive demand for car parking, the problem persists in the Transport Bhawan Complex and accordingly there is a need to prepare the parking plan.

b. Type of Parking[14] : The various types of parking are as follows:

- **On – Street Parking:** These are –
  - ✓ Parallel Parking
  - ✓ 30 Degree angle Parking
  - ✓ 45 Degree angle Parking
  - ✓ 60 Degree angle Parking
  - ✓ Right angle Parking

Layout and dimension of on-street parking stalls is given in Figure 3.23

Parallel parking: With parallel parking cars are arranged in a line, with the front bumper of one car facing the back bumper of an adjacent one. It consumes the maximum curb length which decreases as the angle of parking increases. The maximum curb length is consumed by the right angle parking, which accommodates nearly 2 times the number of vehicles as parallel parking.

On the other hand, parallel parking makes the least use of the width of street, and it is an important consideration in narrow streets. As the parking angle increases the width of the street used also increases.

From the point of view of the maneuverability, angle parking seems to be better than the parallel parking which usually involves a backing motion. Delay to traffic is minimum with angle parking. As regards safety, it has been noticed that angle parking is more hazardous than parallel parking.

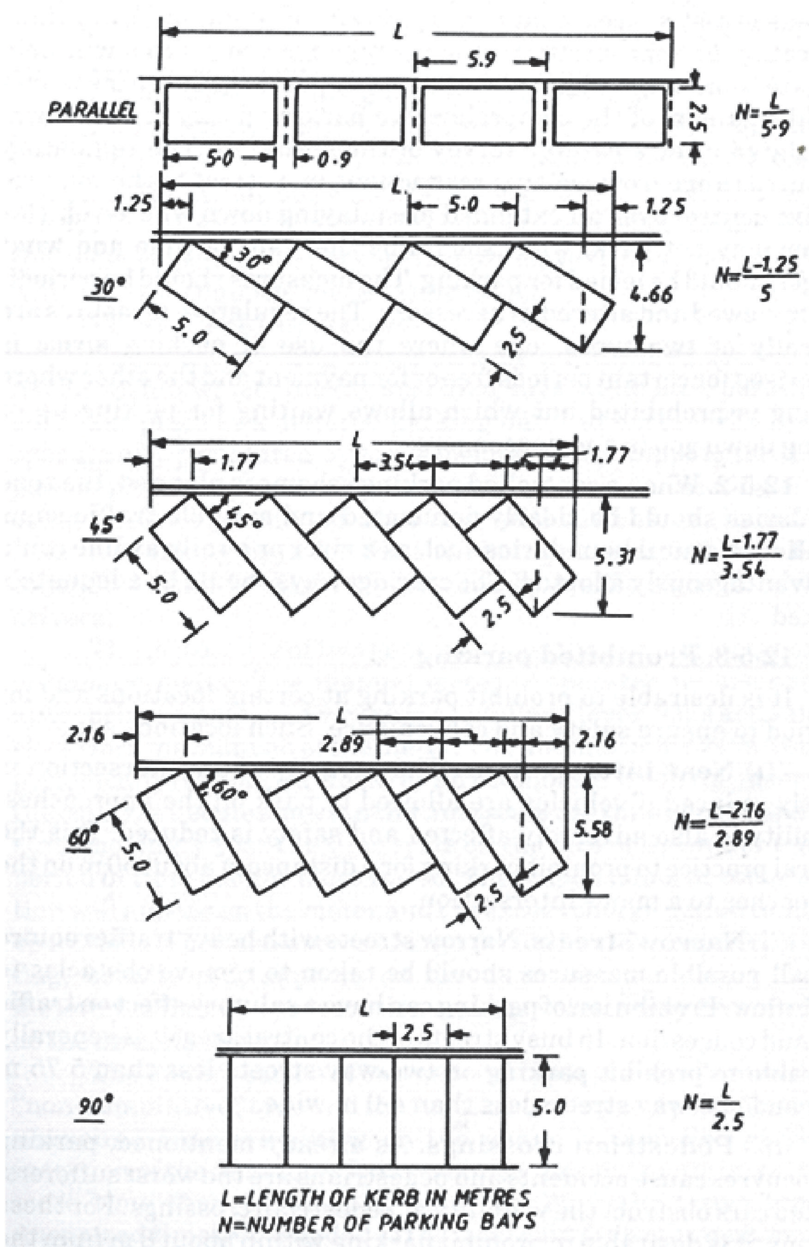

Figure 3.23: Layout and Dimension of on-street parking stalls

Source: Traffic engineering and Transport Planning – L. R. Kadyali, Section 12.4.1

In general, parallel parking should be favoured on streets. On exceptionally wide and low volume streets, consideration might be given for angle parking.

[14] Traffic engineering and Transport Planning – L. R. Kadyali, Section 12.4.1

- **Off – Street Parking**[15] **:** Based on the requirement and demand analysis, the types of off-street parking are as follows:

  ✓ **Surface park –** Located and developed on a piece of vacant land or surrounding an office complex or market popular with the motorists. Surface Parks are generally charged based upon the usage by different methods like, manually or through automatic ticket vending machine. Disadvantages of surface parks are that they consume more land and are not always feasible. E.g. Connaught Place, New Delhi (Figure 3.24).

Figure 3.24: Surface Park

Source: https://ashwinsharma.wordpress.com/2013/01/23/a-day-in-cp/

  ✓ **Multi-Storey park –** Multi-Storey comes into picture when the land acquisition is costly and few sites are available. Multi-storey car parks are usually designed for the capacity of about 400 to 500 cars. Increase in capacity leads to longer time to un-park the car, to overcome this not more than five floors are allowed. E.g. Percy Street near to Newcastle Upon Tyne, Great Britain (Figure 3.25).

Figure 3.25: Multi-Storey Park

Source: http://www.geograph.org.uk/photo/1666894

[15] Traffic engineering and Transport Planning – L. R. Kadyali, Section 12.6

- ✓ **Roof Park –** Popular with cities having parking problem. Access ramps or mechanical lifts to be provided for the access to the roofs. Additionally, many roofs can be linked together which can be served by a single access ramp. E.g. Goulburn Street, Sydney, Australia (Figure 3.26).

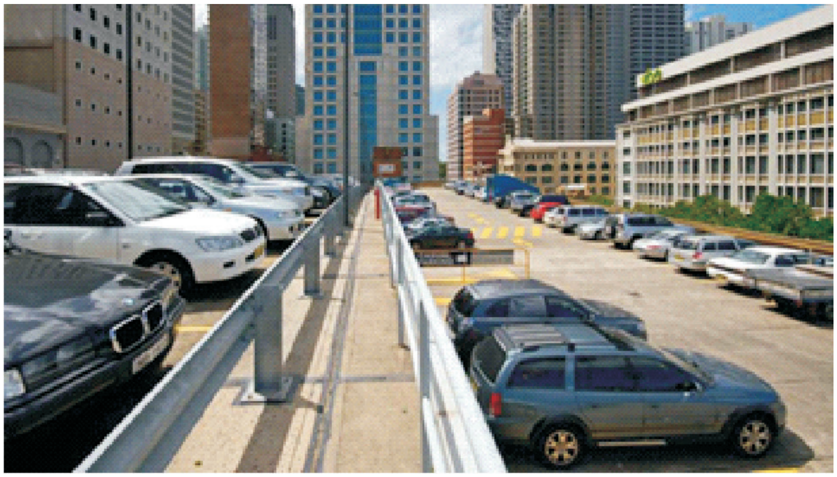

Figure 3.26: Roof Park

Source: http://www.geograph.org.uk/photo/2716042

- ✓ **Mechanical Park –** These parks provide lifts, to motors from floor to floor by means of a lift and transfer of motors to and from the parking stall by means wheeling or mechanically operated transfer dollies or cradle . There is no requirement of ramps or aisle hence it is economical in terms of space utilization. Major disadvantage is higher maintenance or in terms of power failure. E.g. AutoStadt in Wolfsburg, Germany (Figure 3.27).
- ✓ **Underground Park –** A major advantage is that the aesthetics of the place is maintained. Normally, built in the basement of the multi-storey building or below an open space. It is a little costly with respect to the construction. It can be single storey or multi-storey. E.g. Belfast, Near Ireland (Figure 3.28).

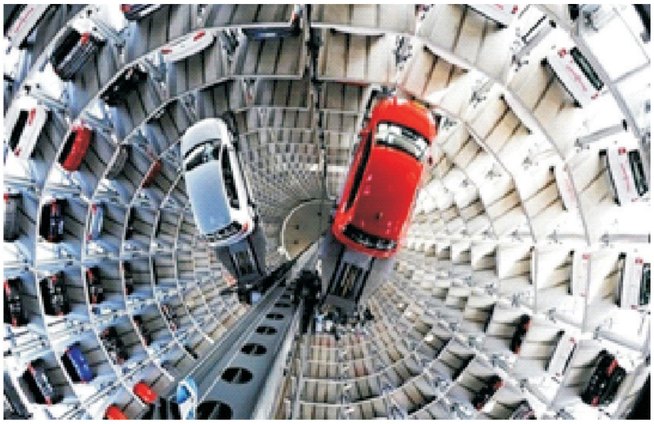

Figure 3.27: Mechanical Park

Source: http://www.jebiga.com/volkswagens-car-park-autostadt-henn-architekten/

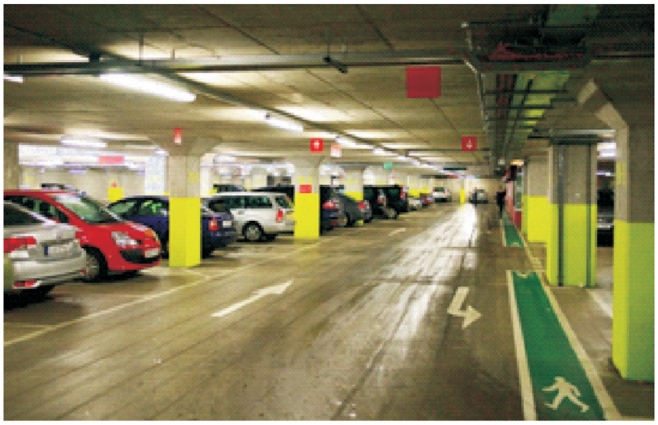

Figure 3.28: Underground Park

Source: http://www.geograph.ie/photo/3206659

3.3.2.3 PLANNING PROCESS FOR NON- MOTERISED TRANSPORT

Planning process for NMT network includes a study on different sub-component of physical infrastructure identified earlier in **Section 2.5.4 Table 2.1 – Component & Sub-Component of Integration.** This includes Footpath and Cycle track & its parking station. Planning process steps for these components is shown in Figure 3.29.

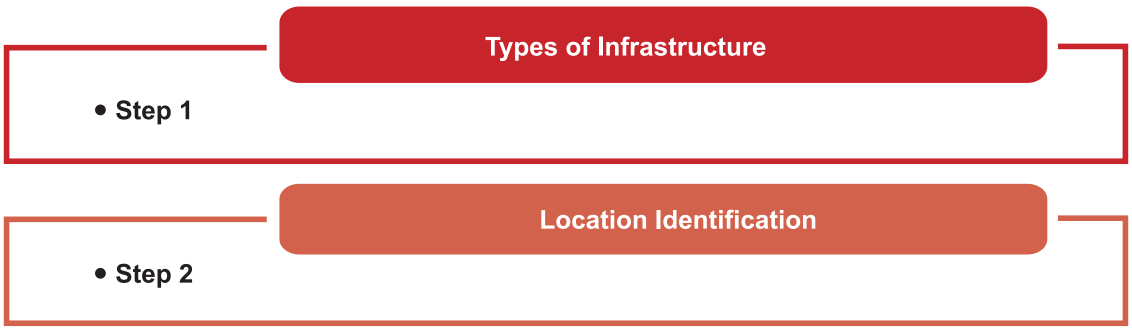

Figure 3.29: Step for Physical Integration - NMT Transport

STEP 1 – Type of Infrastructure:

This is based upon the same concept of public transport infrastructure study mentioned earlier. The following is to be done:

a) **Cycle Track:** A cycle track is a way or a part of a roadway designed and constructed for the use of pedal bicycles and over which a right-of-way exists. Cycle tracks are classified into the following two groups:

East Span of the San Francisco - Oakland Bay Bridge

Source: http://baybridgeinfo.org/path

- Cycle tracks which run parallel to or along a main carriageway. These are further sub-divided into following classes :
  - ✓ Adjoining cycle tracks: These completely fit in with the carriageway and are adjacent to and on the same level with it.
  - ✓ Raised cycle tracks: These are also adjoining the carriageway but are at a higher level.
  - ✓ Free cycle tracks: These are separated from the carriageway by a verge and may be at the same level as the carriageway or at a different level.
  - ✓ Those cycle tracks which are constructed independent on the carriageway.
- Separate cycle tracks may be provided when the peak hour cycle traffic is 400 or more on routes with a traffic of 100 motor vehicles or more but not more than 200 per hour. When the number of motor vehicles using the route is more than 200 per hour, separate cycle tracks may be justified even if the cycle traffic is only 100 per hour[16].
- Cycle Parking Stations: Cycles are a very desirable and affordable private feeder service to MRTS / BRTS Stations / Bus Stops. To encourage their usage, safe and secure cycle parking options must be provided at all MRTS / BRTS Stations / Bus Stops.

b) **Footpath:** It is a portion of right of way of road used for the movement of pedestrian traffic[17]. The facilities to be provided includes:

- Information kiosks
- Passenger shed
- Foot over bridges (if necessary)

The footpath facilities shall comply with following physical characteristics[18]:

- Footpath Surface: An even surface without cracks or bumps for comfortable walking. The surface throughout should be stable, firm and slip resistant.
- Footpath Width: The footpath should be wide enough to accommodate pedestrian flow at a given point of time.

New Chennai Streetscape

Source: https://www.itdp.org/category/location/india/chennai/

- Obstructions: Obstructions like an electric pole, tree, garbage bin, and hoardings to be located on one side of the footpath so as to give a clear walkway to the pedestrian.

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[16] IRC: 11 – 1962, Recommended Practice for The Design and Layout of Cycle Tracks, Section 4.1
[17] IRC: 103 – 2012 Guidelines for Pedestrian Facilities, Section 1
[18] IRC: 103 – 2012 Guidelines for Pedestrian Facilities, Section 5.3


- Encroachment: The informal commercial activities are an integral part of the footpath environment in India. The informal sector has to be integrated in the overall design of the footpath facility by providing space for them to operate.
- Potential for Vehicle Conflicts – Footpath needs to be segregated from the roads, where fast moving vehicles ply. The two ways to protect the pedestrian from vehicle conflicts are the raised footpath and the guardrails.
- Continuity – Frequent ups and downs make the footpath uncomfortable to use by the pedestrian especially the old and forces the pedestrian to share the carriageway along with the vehicles. The provision of kerb ramps is essential for continuity of the footpath.

Following user characteristics should be given consideration while planning / designing pedestrian facilities[19] :

- Safety & Security
- Comfort
- Walk Environment

STEP 2 - Location Identification:

The criteria for location identification for cycle track and footpath are as follows:

a) **Cycle Track[20] and Parking Station[21] –** This facility has to be planned and located at places so that it integrates with the existing road and public transport network. Some of the important criteria used in evaluating feasible cycle track are as follows:

- Potential demand for the use of the route must be determined.
- Basic width needed for the safe operation must be provided. It is best to consider one way operation.
- Continuity and directness of route without much detour is essential, connecting points of importance.
- Safety is of prime importance. Attempts to minimize vehicular / pedestrian conflicts should be given the highest priority.
- Grade should be within tolerable range. A maximum grade of 5% is desirable.
- The selection of pavement is of greater importance to the bicyclists as compared to motorists. Ride quality of pavement and even safely are affected by poor pavement surfaces.
- Areas with heavy automobile emissions should be avoided, carbon monoxide is particularly hazardous to pedestrians and cyclists.
- Motor vehicles traffic should be avoided, particularly trucks, moving at speeds of 50 mph (80 kmph), which can upset the balance of a bicyclist.

[19] IRC: 103 – 2012 Guidelines for Pedestrian Facilities, Section 5.4
[20] Transportation Engineering An Introduction, C. Jotin Khisty B. Kent Lall, Section 3.3
[21] Pedestrian Design Guidelines, UTTIPEC, DDA, Chapter

b) **Footpath[22] –** The general principles of pedestrian facility are:

- Footpath should be planned in an integrated manner so as to ensure a continuous pedestrian flow.
- Basic aim should be to reduce pedestrian conflicts with vehicular traffic to the minimum.
- While planning, the convenience of pedestrian should be a paramount consideration to ensure full utilization of the facilities.
- The quality of footpath network should take into account the following groups: children, families with young children, elderly persons, persons with disabilities, and people carrying heavy luggage.
- The mobility and safety of "all" the pedestrian, including those with disabilities and reduced mobility should be ensured to promote inclusive mobility and universal accessibility.
- Above all, regular maintenance of all facilities and design elements should be undertaken to maintain accessibility, reliability, usability, safety and continuity.
- While planning and designing the footpath, the overall objectives would be continuity, comfort and safety.

3.3.3 DESIGN

The design of physical integration covers the components & sub components of public transport, transport network and non-motorized transport (**Section 2.5.4 Table 2-1 Component & Sub-Component of Integration**). The details are as follows:

3.3.3.1 DESIGN FOR PUBLIC TRANSPORT

The general design guidelines for components of public transport i.e. bus stop, bus terminal, multimodal hub etc. are as follows:

3.3.3.1.1 DESIGN OF BUS STOP[23]

There are various factors which influence decision on spacing of bus stops. These include:

- Adjacent land use and activities

"When planning NMT infrastructure, due consideration should be given to the existing networks and not patches. For example, all roads where individual are likely to walk should include at least 2 meters of clear, walkable footpath. Moreover, all potential walking or bicycling locations should have NMT infrastructure, including comfortable footpaths, cycle tracks, streetlights, cycle stand, formal pedestrian crossing and NMT-designed signals at all junctions. The design of these facilities should be such that they are inclusive, and provide travel opportunities to disadvantaged sectors of society (the physically challenged, urban poor, women, children and individuals with special needs)"

[22] IRC: 103 – 2012, Guidelines for Pedestrian Facilities

[23] Refer Appendix B, Development of Training Material Under "Sustainable Urban Transport Project" Reference Guide, Volume 2, Public Transport, MoUD


- Bus route (for example, whether bus is turning at the intersection)
- Bus signal priority (e.g. extended green suggests far side placement.)
- Impact on intersection operations
- Intersecting transit routes and
- Intersection geometry
- Parking restrictions and requirements
- Passenger origins and destinations
- Pedestrian access, including accessibility for handicap / wheel chair patrons.
- Physical road side constraints (trees, poles, driveways, etc.)
- Potential patronage
- Presence of bus by pass lane
- Traffic control devices

The general acceptable standard practice for bus stop spacing within an urban area is a stop every 400 meters along the bus route (or three per kilometer). This equates to approximately a five-minute walking distance, which is the distance that most people find acceptable. Bus stops must also be located to allow passengers to board and alight safely and conveniently, and as close as possible to main shopping and business areas, transport interchanges and other main origins and destinations. The needs of elderly and disabled people should also be recognized. Bus stops should be located in close proximity to intersections / pedestrian crossing facilities. The criterion for selection of bus stop is given in Table 3.10 below.

Table 3.10: Criteria for selection of Bus Stop[24]

Environment	Spacing Range	Typical Spacing
Central core areas of CBDs	300 to 500 m	400 m
Urban areas	400 to 700 m	500 m
Suburban areas	500 to 800 m	700 m
Rural areas	800 to 1200 m	1000 m

The bus stop platform needs to be in a tapered design to facilitate smooth weaving of buses approaching and departing the stop. The schematic illustration of spacing and location of bus stop is shown in Figure 3.30.

[24] Refer Appendix B, Development of Training Material Under "Sustainable Urban Transport Project" Reference Guide, Volume 2, Public Transport, MoUD

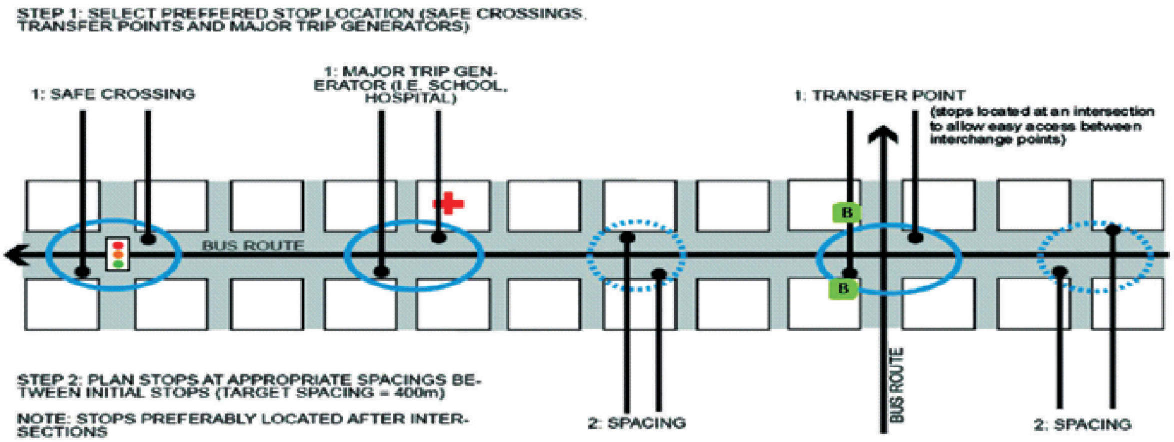


Figure 3.30: Schematic Illustration of Spacing And Location Of Bus Stop

Source: Productivity in Road Transport: A study in innovative Management

It is recommended that the bus stop platform should have a minimum width of 2.5 meter. Wherever, the ROW permits and / or there is heavy boarding and alighting the platform width should be increased to 3.5 meter or more. The height of the bus stop platform should be maintained at 380 mm permitting easy and efficient boarding and alighting of bus passengers. The bus stop platform shall be in a tapered design to facilitate smooth weaving of buses approaching and departing the stop. The sample layout of bus stop is shown in Figure 3.31.

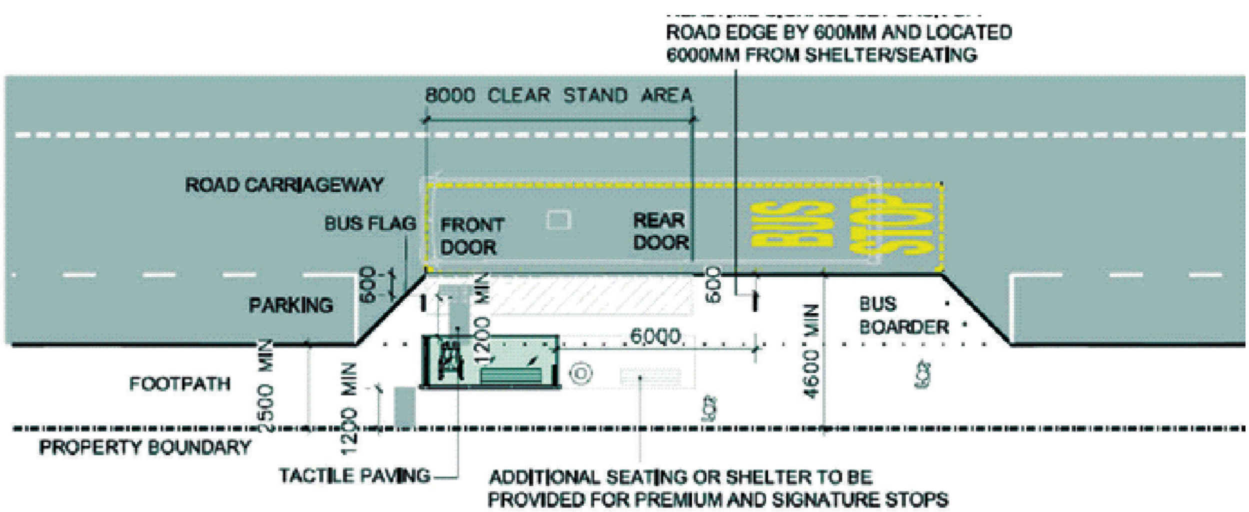


Figure 3.31: Sample Layout of Bus Stop

Source: Productivity in Road Transport: A study in innovative Management by Santosh Sharma

For detailed design standards of bus stop, please refer the following

- ✓ Street Design Guidelines, UTTIPEC – Chapter 5 Section 10 Public Amenities
- ✓ Bus Rapid Transit System Guidelines (TRIPP – IIT Delhi), MoUD – Section 4.3.1 Bus Stops

3.3.3.1.2 Design of Bus Terminal[25]

The design criteria of terminal determining the size of terminal and factors to be taken into consideration in planning the facilities and activities is primarily governed by the following factors:

- ✓ Traffic Demand
- ✓ Traffic Characteristics
- ✓ Function of Terminal
- ✓ Type and Sophistication of Facilities

The sample layout design of bus terminal is shown in Figure 3.32. The other factors to be considered in terminal design for appreciating activity and facility inter-relationship are:

- ✓ Segregation of terminal and non-terminal traffic Segregation of vehicular and pedestrians traffic and movement

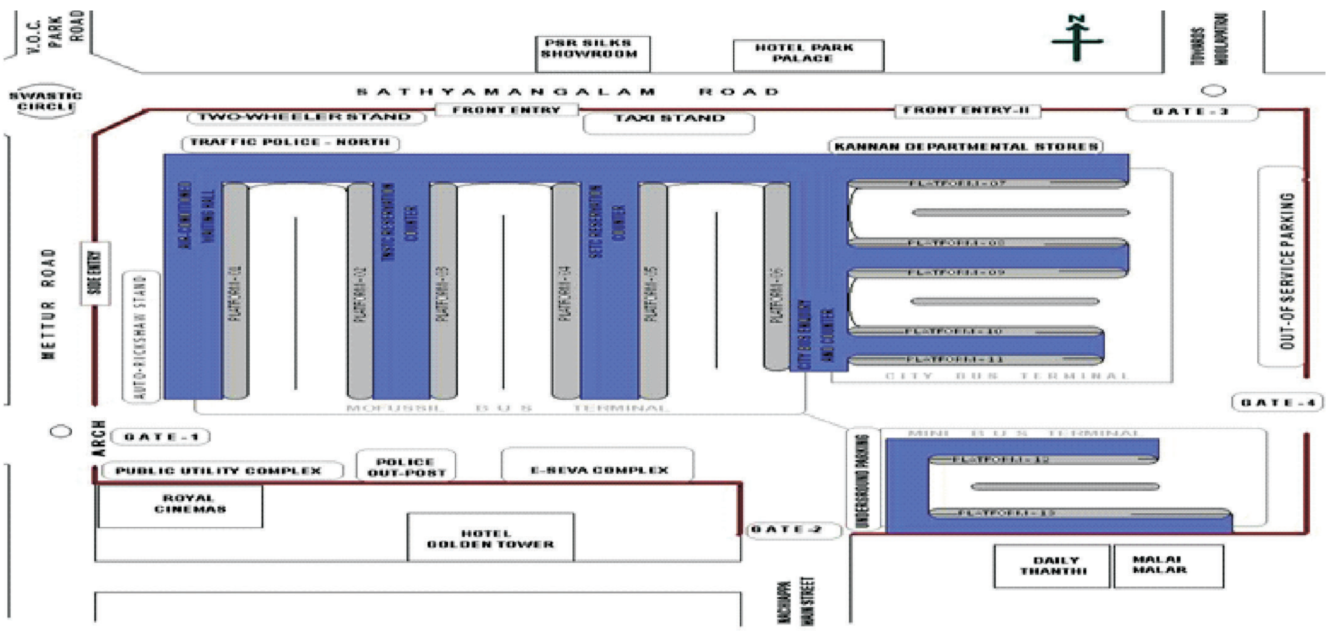


Figure 3.32: Sample Layout of Bus Terminal

Source: Productivity in Road Transport: A study in innovative Management by Santosh Sharma

[25] Refer: URDPFI Guidelines, Section 8.2.9 and Appendix B-Development of Training Material Under "Sustainable Urban Transport Project" Reference Guide, Volume 2, Public Transport, MoUD-

- ✓ Segregation of traffic by type, function and direction
- ✓ Coordination of different activities in terms of functional and spatial inter-relationship
- ✓ Provision of good user and vehicular information
- ✓ Provision of necessary and identified facilities to meet requirement of all user groups achieving minimum passenger and vehicular processing time
- ✓ Achieving overall functional and spatial efficiency
- ✓ Achieving smooth flow of all types of traffic to and from terminal.

a) **Planning Norms**[26]: The planning norms for design of bus terminal is given in Table 3.11 below:

Table 3.11: Planning Norms for Design of Bus Terminal

Norms	Unit
Capacity of an intra-city bus terminal	1.5 lakh passengers/day
One bus bay for 5,000 passengers per day	Loading
One bus bay for 10,000 passengers per day	Unloading
Peak hour load	10% of daily passenger load
Occupancy/bus	50 ideal
Time taken for loading	6 min to 12 min
Time taken for unloading	3 min to 6 min

b) **Space standards for Parking Facilities:** The parking standards for bus bays, as mooted by UDPFI Guidelines 1996 are given in Table 3.12 below:

Table 3.12: Bus Bays – Parking Standards for Bus terminal

Type of Parking	Area/Vehicle (sqm.)
Idle Parking	145
Angular	76
Parallel	104

For detailed design standards of bus terminal, please refer the following

- ✓ URDPFI Guidelines - Section 8.2.9 Bus Terminals
- ✓ Development of Training Material Under "Sustainable Urban Transport Project" Reference Guide, Volume 2, Integrated planning of Infrastructure, MoUD- Section 3.2.7
- ✓ Appendix B-Development of Training Material Under "Sustainable Urban Transport Project" Reference Guide, Volume 2, Public Transport, MoUD

[26] Refer: URDPFI Guidelines, Section 8.2.9

3.3.3.1.3 Design of Metro Station[27]

Transit stations can be characterized into five zones: surface entrance, concourse, platform, circulation, and bus facility. An additional zone can be parking, that should be planned only for important locations. These zones are connected by circulation routes, mechanical and electrical equipment rooms that support the operation and maintenance of the station. Many stations also require a traction power substation which, although not publicly accessible, is the sixth zone.

There are various factors that influence decision for stations. These include:

1. Entrance Building
2. Concourse
3. Platform
4. Circulation
5. Bus / Parking / IPT facility
6. Sub-station (Traction power)

The Prototypical Plan & Spatial Configuration of Platform Level and Station Zones for Underground Station are shown in Figure 3.33 and 3.34 respectively.

3.3.3.1.4 Design of Multi-Modal Hub

Based upon the **Section 3.3.2.1 Planning for Public Transport Step 3 - Requirement Analysis,** the planning of Multi-Modal Hub can be done for the State-of-the-art Bus Terminal, Rail Link, Metro Station, IPT, personal mode (Car & 2W) & NMT traffic.

The design should be such that there is "no different mode interaction" i.e. easy and separate circulation should also be provided for public transport, private vehicles & NMT and therefore adequate parking/ resting area should also be provided for various modes. Apart from this, the hub can be made

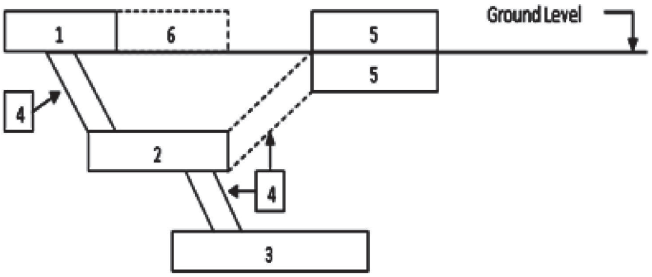


Figure 3.33: Station Zones For Underground Station

Source: Conceptual Design Report – FINAL, Toronto Transit Commission York Region Rapid Transit

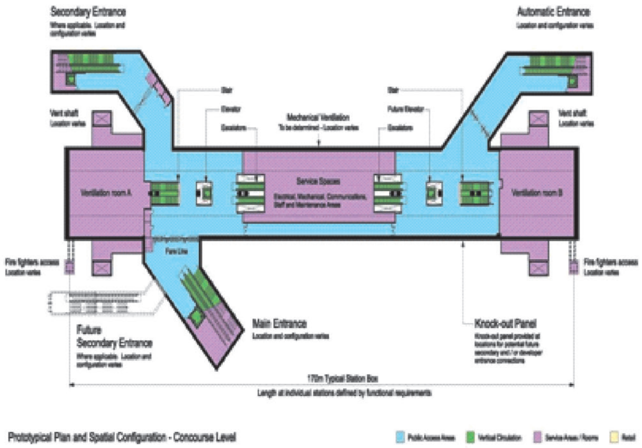


Figure 3.34: Prototypical Plan and Spatial Configuration - Platform Level

Source: Conceptual Design Report – FINAL, Toronto Transit Commission York Region Rapid Transit Corporation, March 2012

Figure 3.35: Sample Layout for Multi-Modal Hub

Source: http://www.ecovallee-cotedazur.com/projects/grand-arenas/multimodal-transport-hub

[27] Conceptual Design Report – FINAL, Toronto Transit Commission York Region Rapid Transit Corporation, March 2012

economically viable through inclusion of property development. The sample layout for multimodal hub is shown in Figure 3.35.

3.3.3.2 DESIGN FOR TRANSPORT NETWORK:

The general design guidelines for components of transport network i.e. road network, bus stop, bus terminal, multimodal hub etc. are as follows:

3.3.3.2.1 DESIGN OF ROAD:

Some of the basic concept of road design are as follows:

a. Design Speed[28] :

The Design Speed is a tool used to determine geometric features (i.e. Super elevation rates and radius of curves, sight distance, and the lengths of crest and sag vertical curves. Roads with higher travel speeds require sweeping curves, steeper curve banking, longer sight distances, and more gentler hill crests and valleys. Lower speed roads can have sharper curves, less banking, less sight distance, and sharper hill crests and valleys) of a road during road design. Keeping in view the type of functions expected of each class of the urban road system, the design speeds given in Table 3.13 are recommended for adoption.

Table 3.13: Design Speeds of Various categories of Roads

Classification	Design Speed (km/hr.)
Arterial	80
Sub-Arterial	60
Collector Street	50
Local Street	30

A lower or higher value compared to that designated in Table 14 may be adopted depending on the presence of physical controls, roadside development and other related factors.

- A lower design speed may be adopted in the central business area or areas with extremely heavy roadside development. On the other hand, in suburban areas, a higher value may be more appropriate.
- For divided highways, running speed of vehicles are in general higher therefore, in such cases a higher value may be adopted.

[28] IRC: 86-1983 Geometric Design Standards for Urban Roads in Plains, Section 4


➢ It should however be kept in view that sudden change in design speed along any road should be avoided. Change where necessary, should be made in stages in step of 10km/h at a time.

b. **Space Standards[29] :**

The space standards recommended for the various categories are given in Table 3.14 below;

Table 3.14: Recommended land Widths for Roads in Urban Areas

Classification	Recommended land width (m)
Arterial	50-60
Sub-Arterial	30-40
Collector Street	20-30
Local Street	10-20

Note: The term "space standard" is often referred to as "right-of-way".

c. **Cross-Sectional Elements[30] :**

The width and layout of urban road cross-sections depends on many factors, the chief amongst them being the classification of road, design speed, and the volume of traffic expected.

- Road Width and Design Traffic Volumes
- Carriageway Width
- Footpath (Sidewalk)
- Cycle Track
- Medians
- Verge
- Parking Lanes, Bus-bays, Lay-byes

For detailed design standard of roads, please refer the following:

- ✓ IRC: 86-1983 Geometric Design Standards for Urban Roads in Pains
- ✓ IRC: 106-1990 Guidelines for Capacity of Urban Roads in Plain Areas
- ✓ IRC: 69–1977 Space Standards for Roads in Urban Areas can be referred for the design of roads
- ✓ Codes of Practice (Part – 1) Cross Section, IUT, Ministry of Urban Development

[29] IRC: 69-1977 Space Standards for Roads in Urban Areas, Section 6

[30] IRC: 86-1983 Geometric Design Standards for Urban Roads in Plains, Section 6

d. **Typical Cross Section[31] :** Typical cross-sections of different classes of streets are shown in the Figure 3.36 below:

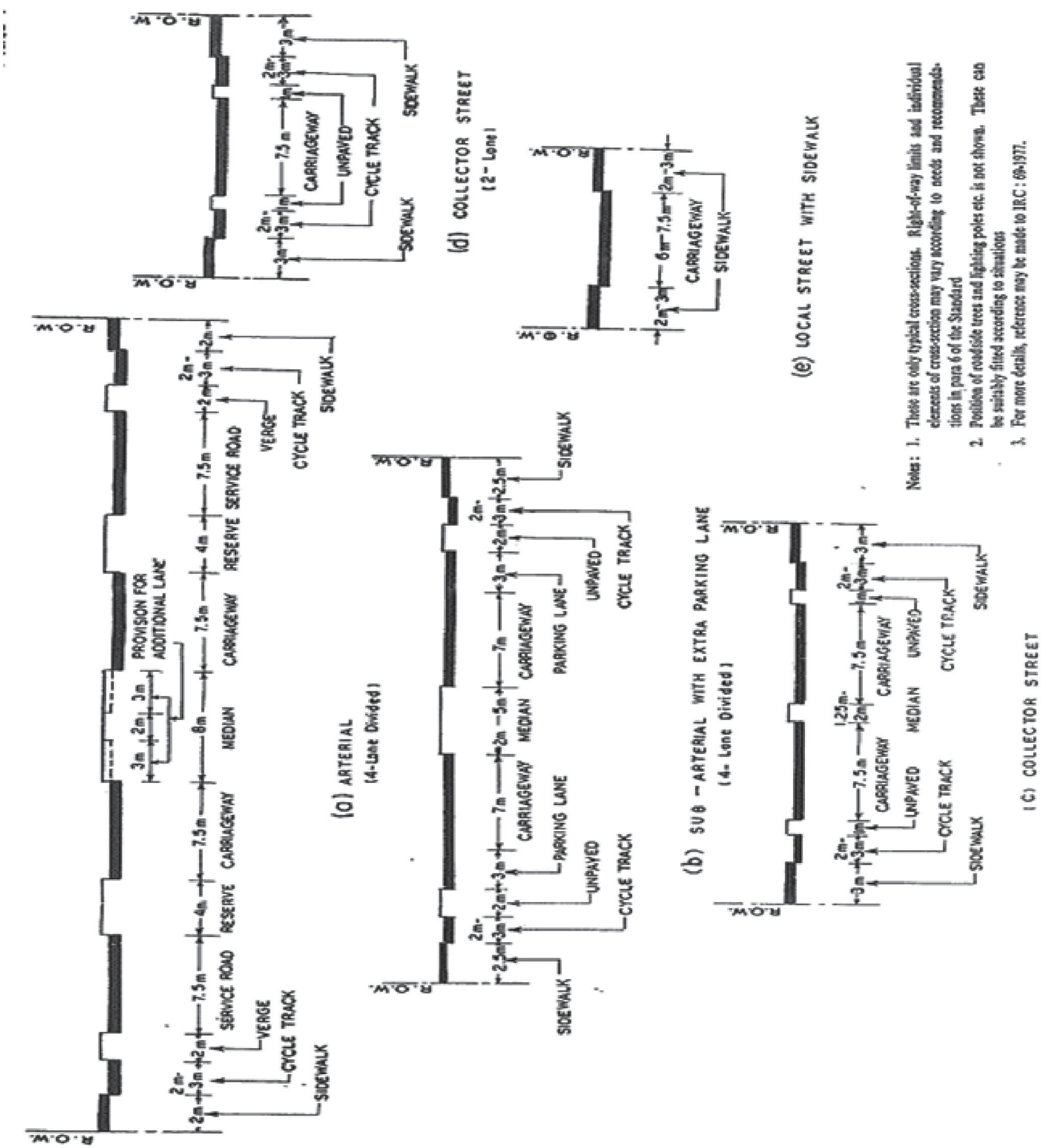


Figure 3.36: Typical Cross Sections of Urban Roads

Source: IRC: 69-1977 Space Standards for Roads in Urban Areas, Section 6

[31] IRC: 69-1977 Space Standards for Roads in Urban Areas, Section 7

3.3.3.2.2 DESIGN OF INTERSECTION:

The importance of design of intersection stems from the fact that efficiency of operation, safety, speed, cost of operation and capacity are directly governed by the design. Since an intersection involves conflicts between traffic in different directions, its scientific design can control accidents and in case of delay orderly movement of traffic is ensured. The following principles should be considered in a good design:

a. **Basic Design Principles[32] –** In designing an intersection the primary considerations are safety, smooth and efficient flow of traffic. To achieve this, following basic principles must be followed:

- ✓ Uniformity & Simplicity – Intersections must be designed and operated for simplicity and uniformity. The design must keep the capabilities and limitations of drivers, pedestrians and vehicles using intersection.
- ✓ Minimize Conflict Points – Any location having merging, diverging or crossing manoeuvers of two vehicles is a potential conflict point (Figure 3-37). Conflict avoidance can be done by:
  - ■ Space Separation: by access control islands through channelization.
  - ■ Time Separation: by traffic signals on waiting lanes.
- ✓ Safety - The safety of a particular design can be best assessed by studying the frequency with which types of accidents occur at particular type of intersection and its correlation with volume and type of traffic.
- ✓ Alignments and Profile – Safety can be considerably improved by designing the intersection with modification in alignment and grades.

[32] IRC: SP 41 Guidelines for the Design of At-Grade Intersections in Rural & Urban Areas, Section 2

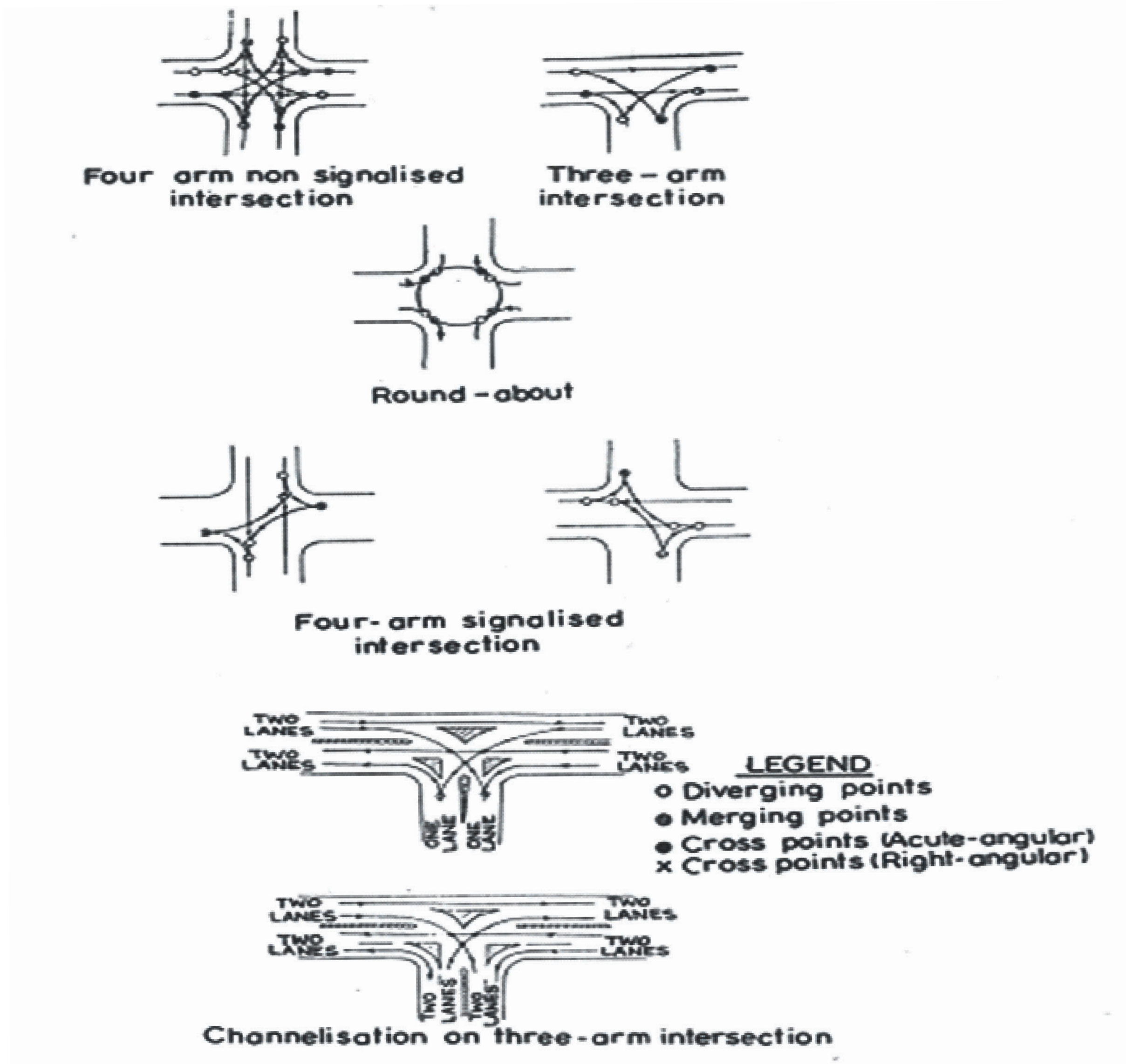


Figure 3.37: Potential Conflict Points At Different Types Of Intersections

b. **Parameters of Intersection Design[33]** : Intersections are designed having regard to flow speed, composition, distribution and future growth of traffic. Design has to be specified for each site with due regard to physical conditions of the site, the amount and cost of land, cost of construction and the effect of proposal on the neighborhood. The parameter are:

- ✓ Design Speed
- ✓ Design Traffic Volumes
- ✓ Radius of Curves at Intersection
- ✓ Design Vehicle

[33] IRC: SP 41 Guidelines for the Design of At-Grade Intersections in Rural & Urban Areas, Section 3


- ✓ Radii of Curve in Urban Situations
- ✓ Width of Turning lanes at Intersection
- ✓ Auxiliary Lane

c. **Warrants for Interchange[34] :**

Interchanges, in general, are expensive to construct and a major factor influencing the cost is the type of arrangement made for the various traffic movements. The arrangement may range from separating only one traffic movement from other to the complete separation of each traffic movement from every other movement so that only merging and diverging movements remain. Similarly, the vehicle operating cost will vary depending on the type of ramp arrangement, from direct conflict – free connections to indirect connections involving extra travel distance. As interchanges are custom designed to suit the prevailing conditions, it will be necessary to carry out cost-benefit study taking into account the total transportation cost, i.e. the cost of construction, maintenance and vehicle operation to evaluate the techno-economic merits of the individual cases before a final decision is taken. However, the following points may be helpful in guiding the choice of an interchange at the preliminary planning stage:

i. Interchange will be necessary at all crossings of a highway which is to be developed to completely access controlled standard. Similarly, interchanges will be required at all major crossings on highways developed to expressway standard.

ii. An interchange may be justified at the crossing of a major arterial road with another road of similar category carrying heavy traffic.

iii. An interchange may be justified when an at-grade inter-section fails to handle the volume of traffic resulting in serious congestion and frequent choking of the inter-section. This situation may arise when the total traffic of all the arms of the intersection is in excess of 10,000 PCU's per hour.

iv. High and disproportionate rate of fatal and major accidents at an intersection not found to respond to other traffic control or improvement measures may warrant an interchange.

v. In some situations, the topography is such that interchanges are the only type that can be constructed economically.

For detailed design refer:

- ✓ IRC: SP 41 Guidelines for the Design of At-Grade Intersections in Rural & Urban Areas
- ✓ IRC: 92 – 1985 Guidelines for the Design of Interchanges in Urban Areas can be referred for the design of intersection.
- ✓ Code of Practice (Part – 2) Intersections, IUT, Ministry of Urban Development

[34] IRC: 92-1985 Guidelines for the design of Interchanges in Urban Area, Section 3

3.3.3.2.3 DESIGN OF PARKING[35] :

The design components of parking includes the following:

a. **Equivalent Car Space (ECS) for different vehicles:** The recommended ECS required for different type of vehicles are given in Table 3.15 below:

Table 3.15: Recommended ECS for various types of vehicles

Vehicle Type	ECS
Car/taxi	1.00
Two Wheeler	0.25
Auto Rickshaw	0.50
Bicycle	0.10
Trucks/Buses	2.5
Emergency Vehicles	2.5
Rickshaw	0.8

b. **Permissible ECS for different land uses:** The permissible ECS for different land uses is given in Table 3.16 below:

Table 3.16: Permissible ECS for different land uses

Use Premises	Permissible Equivalent Car Spaces (ECS) Per 100 sqm. of floor area
Residential	2.00
Commercial	3.00
Manufacturing	2.00
Government	1.8
Public and Semi-Public Facilities	2.0

c. **Space Standards for Parking :** For the provision of car parking space, the space standards shall be given as per Table 3.17 below:

For detailed design standard of parking, please refer the following:

- ✓ IRC: SP 12 Tentative Recommendations on the Provision of Parking Spaces for Urban Areas
- ✓ URDPFI Guidelines Section 8.2.8 Parking

[35] URDPFI Guidelines - Section 8.2.8 Parking

Table 3.17: Space Standards for parking

Type of Parking	Area in sqm per ECS
Open	23
Ground Floor covered	28
Basement	32
Multi-Level with Ramps	30
Automated Multilevel with lifts	16

3.3.3.3 DESIGN FOR NMT NETWORK COMPONENT:

3.3.3.3.1 DESIGN OF FOOTPATH[36] & OTHER FACILITIES:

a) **Footpath –** Pedestrian footpaths are defined as any area primarily used by 'all' pedestrian. They can be adjacent to roadways, or away from the road.

- ✓ Clear Walking Zone: The minimum 1.8 m (width) x 2.2 m (height) walking zone should be clear of all obstructions – both horizontally and vertically. No utility ducts, utility poles, electric, water or telecom boxes, trees, signage or any kind of obstruction should be placed within the "Walking Zone". (Shown in Figure 3.38)
- ✓ Kerbs – Maximum height of a pavement (including kerb, walking surface, top-of-paving) should not exceed 150 mm – 200 mm[37] from the road level, which is the standard anthropometric height of a public step / riser. Medians should be maximum 250 mm high or be replaced by crash barriers. Only along Segregated Busways / BRT corridors, the kerb height of the Bus Stop could match the height of the bus floor.
- ✓ Continuity and Consistency – It is mandatory for footpaths to be continuous between junctions or where at-grade crossing is provided. A change in colour of pavers can emphasize and highlight the crossing area to all users.

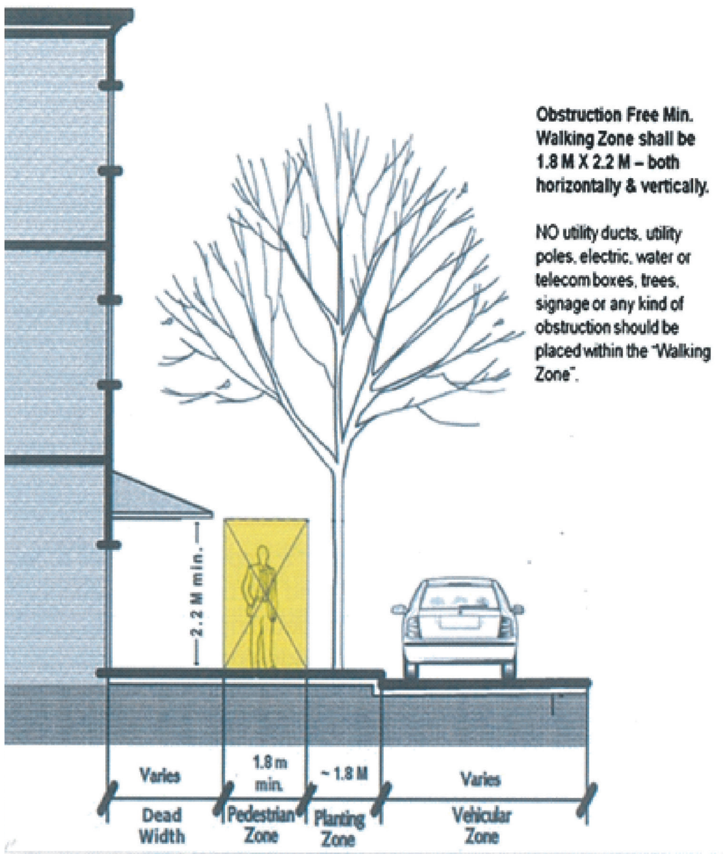


Figure 3.38: Clear Walking Zone is Separate from Planting Zone

Source: IRC: 103 – 2012 Guidelines for Pedestrian Facilities

[36] IRC: 103 – 2012 Guidelines for Pedestrian Facilities, Section 6

[37] Code of Practice (Part – 1) Cross Section, IUT, Ministry of Urban Development

- ✓ Tactile Pavers – Usually persons with visual impairment need guidance in using a pedestrianized area, especially if the footpath crosses larger open spaces where the usual guidance given by the edge of the footpath or building base is not available or when pedestrian need guidance around obstacles.
- ✓ Level Change – It may be possible to adjust ground levels more broadly to eliminate the need for a ramp or steps altogether. Arbitrary changes of level should be avoided. For instance, in creating a sense of importance for a building approach, a change in quality of paving or street furniture can have the desired effect, rather than introducing a level change.
- ✓ Maintenance – Regular maintenance of footpath will ensure uninterrupted accessibility. Maintenance should prevent or replace cracked and uneven paving slabs and those with loose joints, as they become tripping hazards and are difficult to walk on.

b) **Pedestrian Crossing –** The key guidelines to design the pedestrian crossing are as follows:

- ✓ Minimum 3 m wide pedestrian crossing and 2.5 m wide cycle crossing must be provided at all road crossings.
- ✓ All crossings should have universal accessibility features (for persons with disabilities, reduced mobility, vision and hearing impairment) and street directional signage.

c) **Street Furniture –** Furniture in the external environment consists of a diversity of elements such as light post, seats, Kiosks, hawker zones, bins, information panels, traffic signs, parking meters and post boxes etc., often placed independently over time and without co-ordination. Following are the requirements to outline a design space for this vital component of road infrastructure. The determinants for the design are location, material, edge treatment, change in elevations and access. Other features for street furniture that must be looked upon are - placement of street furniture, need for resting places / seats and colour & contrast.

d) **Pedestrian Facilities at Transit Areas –** Pedestrian are highly exposed and vulnerable even within the transit areas due to the presence of vehicular traffic in most of the Indian cities. Transit areas include right from the bus stop, bus station, bus terminal to railway and airport terminal. Even at the interchange where both, a central bus station and a metro station co-exist, the dispersal of pedestrian traffic is of paramount importance. The facilities for pedestrian in transit area are given in Table 3.18

Table 3.18: Facilities for Pedestrian in Transit Areas

Facilities For Pedestrian In Transit Areas	
A.	**Walkable Area Within The Transit Area**
	The permissible walking distance in transit area is 400m & the sufficient area for pedestrian to be aware of other pedestrian in transit area is required to be 1.9-3.3 sq.m/person
	The maximum flow of pedestrian for public transit occurs when transit steps are within a 10 minute walking distance from source.
	Direct pedestrian path makes it easier for people to walk.


	Facilities For Pedestrian In Transit Areas
B.	**Pedestrian Facilities In Transit Areas – Walkways**
	Pedestrian walkways should be planned with minimum width of 2m with accessible grade changes.
	Pedestrian should not have to walk more than 200m to ramp or elevators to change floor level to access transit.
C.	**Footpath / Footpaths**
	1.8-2m footpath / footpaths for light pedestrian traffic
	5m footpaths for heavy pedestrian traffic
	To allow walking at near normal speeds, the footpaths must provide continuity without any obstacles
D.	**Crosswalks**
	The cross walks should be provided at every 30m o the pedestrian streets.
	At the zebra crossing, width of zebra crossing should be within the range of 2m – 4m
	The minimum island size should be 15sq.m.
	The radii at the corner of the streets varies from 0.7m to 1.7m and with curbside parking it can vary from 1.7m to 3.5m.
	In case of raised median, being used as pedestrian refuge, such portion could be suitable depressed with curb height not exceeding 150mm.
E.	**Ramps**
	Ramps must have maximum slope of 1:20. A level walking space should be provided at the top of the ramp.
	The ramps and landing are required where the slope is 8.33% with minimum width of 1m.
	The hand rails should be installed along the side of the ramp, more than 0.15m or the length should be greater than 2m.
	The diameter of the hand rail should be more than 35mm for proper gripping.
F.	**Other Pedestrian Facilities in Transit Areas**
	Signage can add several pedestrian friendly qualities to the streets.
	Use of special paying to break up an expanse or the link pedestrian path with the transit stop restricting pedestrian and vehicular conflicts
	Street trees should be placed less than 30m apart.

Source: IRC: 103 – 2012 Guidelines for Pedestrian Facilities

For detailed design standard of Footpath, please refer the following:

- ✓ URDPFI Guidelines Section 8.2.3 Footpath & UTTIPEC Guidelines Chapter 1 Section 1 Pedestrian Only Zone
- ✓ IRC: 103 – 2012 Guidelines for Pedestrian Facilities
- ✓ Code of Practice (Part – 1) Cross Section, IUT, Ministry of Urban Development

3.3.3.3.2 GUIDELINES FOR DESIGN OF CYCLE TRACK[38] :

The design facilities of cycle track includes the following parameters:

a) Capacity – The width of cycle track is dependent on number of cycles per day as given in Table 3.19:

Table 3.19: Capacity of Cycle Track

Width of Cycle Track	Capacity in number of cycles per day	
	One-way traffic	Two-way traffic
Two lanes	2,000 to 5,000	500 to 2,000
Three lanes	Over 5,000	2,000 to 5,000
Four lanes	-	Over 5,000

a) Horizontal Curves – As far as possible, a cycle track should be so aligned that the radius of the horizontal curves are not less than 10 meters (33 ft).

b) Vertical Curves – Vertical curves at changes in grade should have a minimum radius of 200 meters (656 ft) for summit curves and 100 meters (328 ft) for valley curves.

c) Sight Distances – It is desirable that a cyclist should have clear view of not less than 25 meters (82 ft). In case of cycle tracks at gradients of 1 in 40 or steeper, cyclists should have a clear view of not less than 60 meters (197 ft).

d) Lane Width – The width of a cycle at the handle bar, the widest portion, ranges from 45 centimeters to 50 centimeters (1 ft 6 in. to 1 ft 9 in.).

e) Width of Pavement – The minimum width of pavement for a cycle track should not be less than 2 lanes, i.e., 2 meters (6 ft 6 in.). If overtaking is to be provided for, the width should be made 3 meters (9.8 ft). Each individual lane where required should be 1 meter (3 ft 3 in.) wide.

f) The key guidelines for cycle parking stations (Shown in Figure 3.39) is as follows:

- **Long-Stay Parking –** Cycle parking lots must be enclosed, ticketed (like car- parking lots) and shaded . Cycle parking lots can be combined with ticket counter booths, local police booths, cycle service stations or shared areas within private building complexes.
- **Short-stay parking –** should be open to view and close to entrances of destinations.

[38] IRC: 11 – 1962 Recommended Practice for The Design and Layout of Cycle Tracks

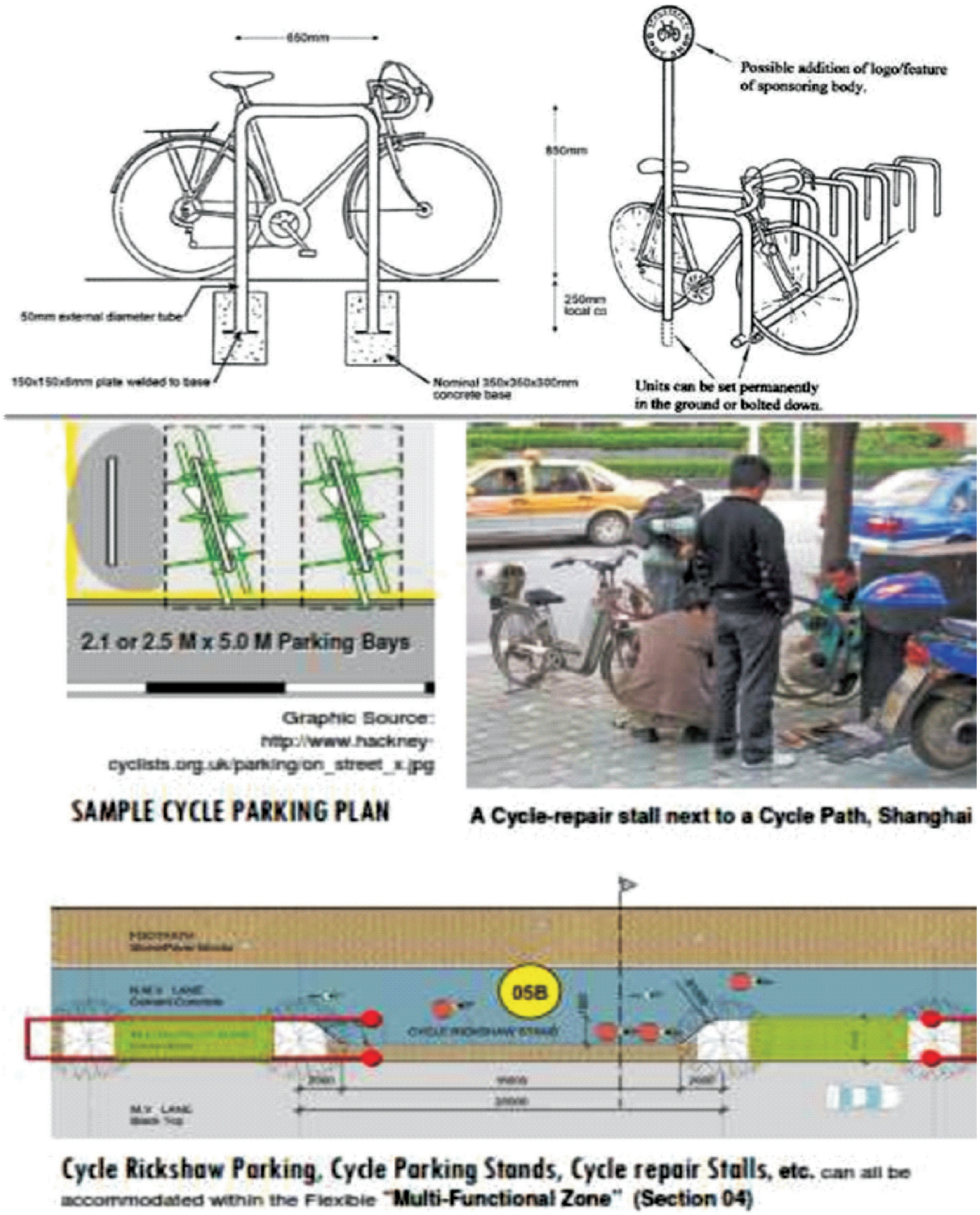


Figure 3.39: Typical Plan of Cycle Stand

Source: UTTIPEC Guidelines- Chapter 5 Section 5 Bicycle and Non-Motorized Transport Infrastructure

For detailed design standard of Cycle Track, please refer the following:

- ✓ URDPFI Guidelines Section 8.2.4 Cycle Tracks
- ✓ UTTIPEC Guidelines Chapter 1 Section 5 Bicycle and Non-Motorized Transport Infrastructure
- ✓ IRC: 11 – 1962 Recommended Practice for The Design and Layout of Cycle Tracks
- ✓ Code of Practice (Part – 1) Cross Section, IUT, Ministry of Urban Development

3.4 FARE INTEGRATION

"The underlying principle behind fare integration is that a single ticket provides access to all modes of transport even when managed by different companies."

The financials of public transport provide important indicators to assess its sustainability. Choice of fare structure is very important part of public transport planning. It directly influences operators' revenue. At its simplest, integration of fares, allows a person to make a journey that involves transfers (within or between different transport modes) with a single ticket that is valid for the complete journey, (modes being buses, trains, subways, taxies, parking, etc.). The major benefits of fare integration are as follows:

- It encourages people to use public transport by simplifying the switch between transport modes and by increasing the efficiency of the services
- Provides a common ticket across the modes
- Improves the experience of seamless mobility

Therefore, for fare integration the component & sub-component is shown in Figure 3.40.:

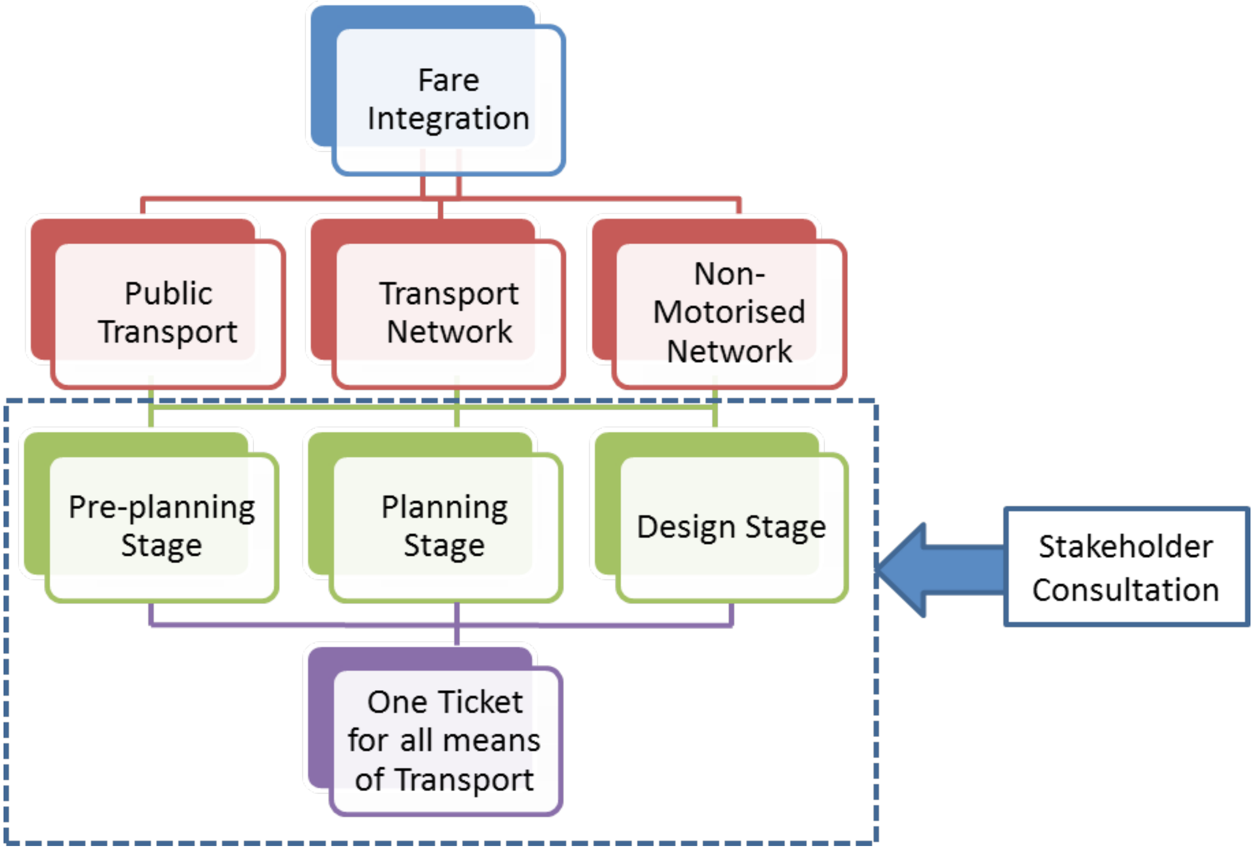


Figure 3.40: Fare Integration "Component & Sub-Component"

3.4.1 PRE PLANNING STAGE

In this section, the data required for various components (public transport, transport network and NMT) for fare integration is discussed below:

The secondary surveys will be required for fare integration as given in Table 3.20 below:

- ✓ Fare Structure (For various Modes of Transport)
- ✓ Financial Performance Report
- ✓ Fare Policy / Revision
- ✓ Earlier Study Report, if any

Table 3.20: DATA REQUIRED FOR FARE INTEGRATION

Data Level	Source
Citywide	SRTC & City's Bus / Other Mode Company if any or any city level authority

3.4.2 PLANNING STAGE

A step-by-step process for planning of fare integration has been explained below in Figure 3.41:

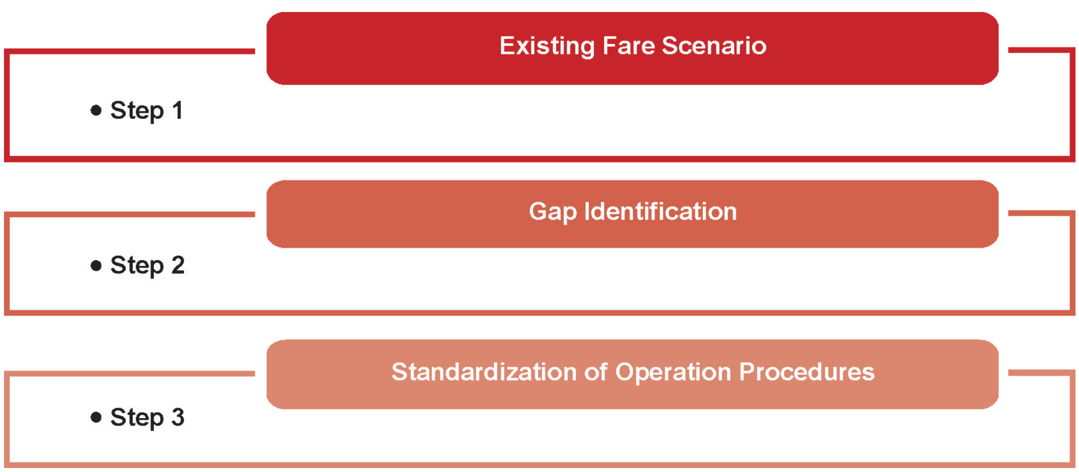


Figure 3.41: Steps for Fare Integration

STEP 1 - Existing Fare Scenario:

The very first step is to identify and list various public transport modes available in the city and identify various factors to understand the existing scenario as mentioned below:

- Operator: List and name of public transport operators available in the city
- Fare System: Understand the following:
  - ✓ Fare structure - Type of fare structure in city with respect to various modes.

- ✓ Fare Products - Type of fare products (ticket typology such as valid for single trip, round trip etc.) in the city for all the modes.
- ✓ Fare Pricing - Fare pricing differentiation typology (fare variations within same system w.r.t. to level of comfort) for all the modes.
- ✓ Provision of concessionary fares (if any concessions provided for students or passes) for all the modes.
- ✓ Ticket: Kind of ticket used i.e. paper, token, smart card or any other method of payment used.
- ✓ Collection System: Kind of fare collection system present across all modes in the city - manual or automatic.

In order to understand the fare collection system, the data is analyzed according to the surveys organized in Pre – Planning Stage (Refer Section 3.4.1).

STEP 2 – Gap Identification:

There are a number of different approaches to the planning process. They differ depending upon the issues the city seeks to address. In order to undertake fare integration, appropriate emphasis needs to be placed on those issues, which are likely to be most significant to the fare, operational and physical integration. Issues such as those given below can be identified.

- Identification of current fare needed to be paid by commuters
- Accessibility of point of sale
- Verification of correct fare at alighting
- Issues corresponding to existing fare structure
- Collection Process

STEP 3 - Standardization of operation procedures: Operation Typology

It is difficult to enable large-scale operation unless a common operation procedure and policy is achieved amongst the participating public transport modes. Individual mode operators may have clear guidelines and procedure for the process of decision making, fare structure and passenger boarding. However, when multiple operators are involved and integrated, the process is more challenging and operational guidelines and procedures do not exist. In such a scenario, the operational procedures need to be standardized by selecting a single fare collection system / fare integration system for all modes. The fare integration can follow 4 main models:

- **Distance Fare:** fare according to the distance of the trip.
- **Time Fare:** a ticket that provides access to the whole network for a certain amount of time.
- **One trip Fare:** fixed price for one trip, regardless of the distance or the time.
- **Zone Fare:** fares related to the number of zones crossed on a journey.

a) Distance fare – The fare that the commuters pay depends on the distance they travel. This model needs a system which is able to calculate the distance of trips in order to set the proper fare for each commuter.

To know the trip length, it is necessary to know where the commuter boarded and left each mode. It is thus necessary to offer a solution that requires the commuter to check-in and check-out for each mode.

- **Approach:** Such integration needs an automation of the fare collection through the installation of an AFC system (Automated Fare Collection). The media generally used in this system is the contactless smart card. The commuter owns an electronic card which is validated every time he enters or exits a mode of transport. There are two models of payment that can be implemented:

✓ Prepaid model: the card can carry a certain amount of money. For each travel, the fare is deducted from this amount.

  - o Advantages: The money is given upstream which is advantageous for the operators.
  - o Inconvenient: Such card can block a commuter during his travel if there is not enough money in his card, therefore recharge options must be available on each mode.

✓ Post-paid model: The card registers every trip. The user has to pay at the end of a certain time for his trips (similar to a monthly electricity bill)

  - o Advantages: convenient for the user.
  - o Inconvenient: needs a special fare collection department which would be costlier to maintain.

- **Management:**

✓ Such system enables one to know which modes are used by the commuter. The fare collected can thus be easily distributed to each operator.

✓ A technical centralized entity is necessary to set up in order to manage the fare calculation, collection and distribution to all the operators.

Example: The concept of distance fare integration is shown in Figure 3.42. This model is adopted by Singapore

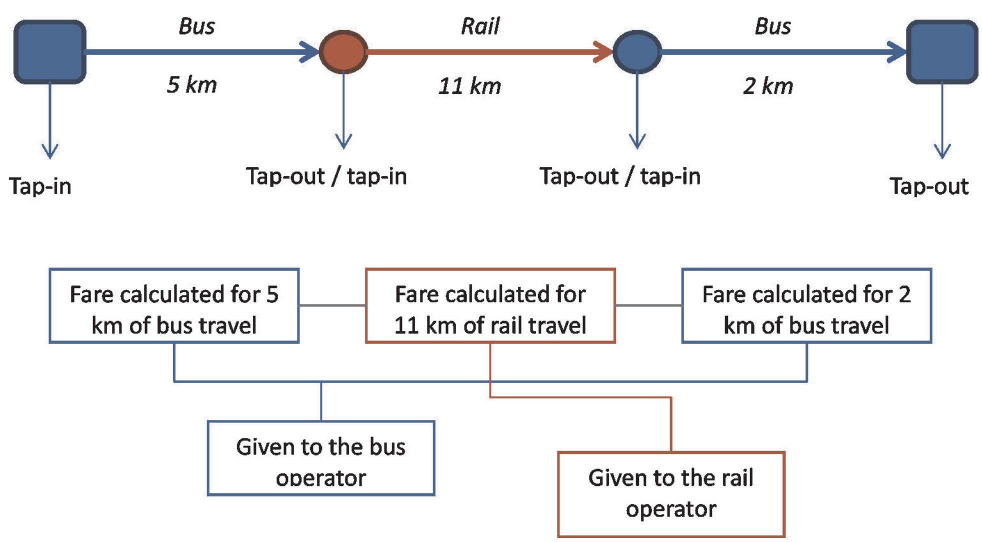


Figure 3.42: An Example of Distance Fare integration

b) Time fare – The commuters get a ticket enabling them to travel for a certain length of time. During this period, they can use any mode and exit or enter the network again. The idea is to give an access to a unified network for some time.

- **Approach:** There are two main solutions that can be implemented for such model:
  - ✓ A one trip ticket or token offering a 1 or 2 hours validity (or other) that would be validated at the first entrance in the network, and checked in each mode, manually (if paper ticket) or with an automated system (if electronic token).
  - ✓ An AFC using the smart card system. On each smart card, a certain amount of money is stored corresponding to number of trips. The user has to tap-in his card in each mode on a special card validation machine.
- **Management:** As it will not be possible to know what modes are used by the commuter, and what distance is travelled, an agreement between the planning authorities and an operator has to be set up upstream in order to define a funding model. Such a model can be built on a ridership basis, on a kilometre basis or a zone basis.
- **Example:** The concept of Time fare integration is shown in Figure 3.43. This model is adopted by Milan, Italy.

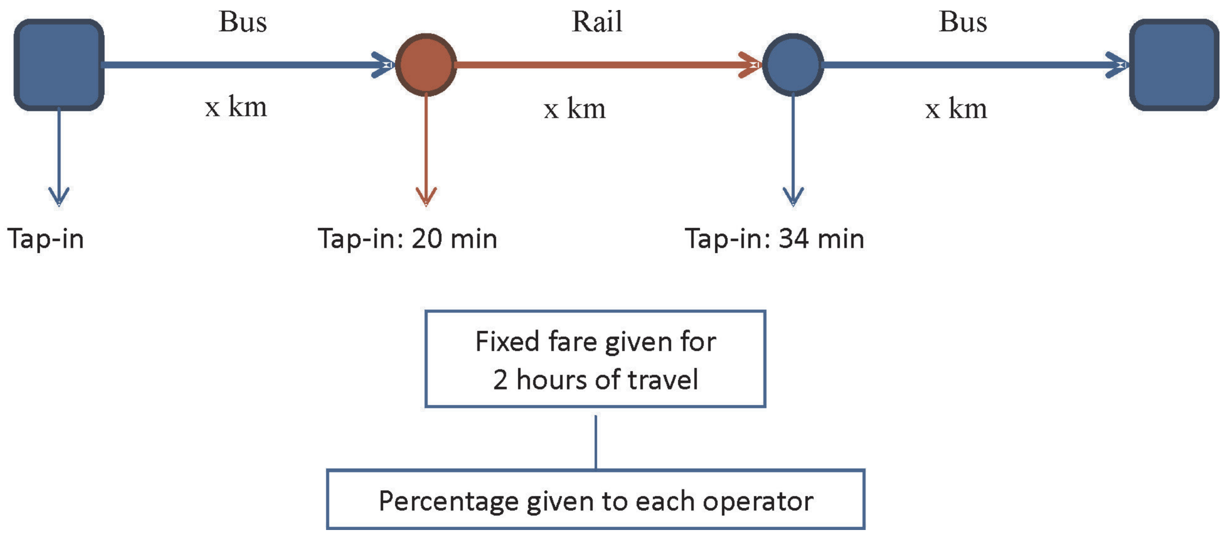


Figure 3.43: An Example of Time Fare Integration

c) One -trip fare – The commuters pay one fare for one trip. Such a trip can take any time and the commuters can use any mode. The tickets are valid until the commuters exit the network. Such model needs a closed network, enabling user to switch modes without exiting the network at the interchange point.

- **Approach:** Similar to the time fare, two solutions can be implemented: the single ticket and the smart card system (see earlier sections). However, here, there is no need to validate at the entrance of each mode as the fare covers the whole trip. Once again, such a fare system can be implemented only in a closed network.

- **Management:** Similarly to the time fare, it is not possible to follow the commuter and calculate the distribution for each trip. Thus, an upstream funding agreement is needed.
- **Example:** The concept of one trip fare integration is shown in Figure 3.44.

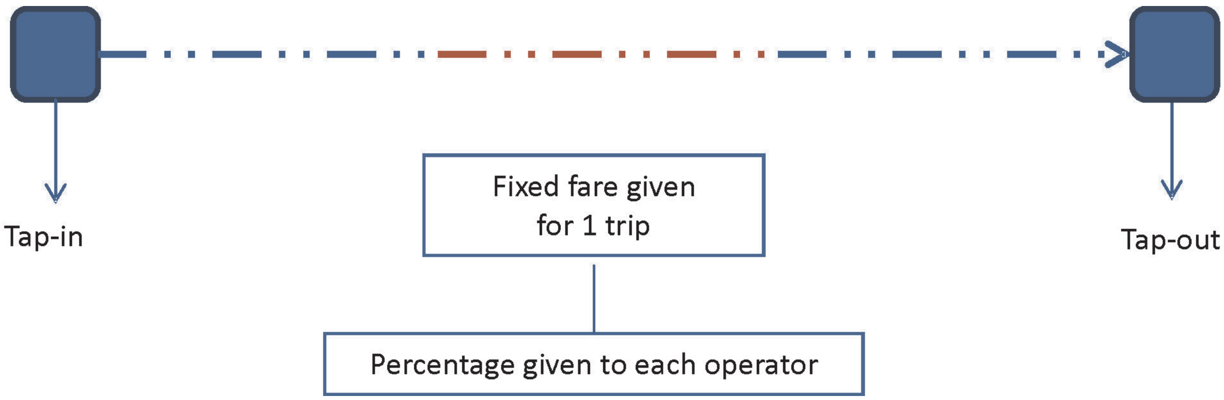


Figure 3.44: An Example of One-Trip Fare Integration

d) Zonal Fare – Zonal fare systems are hybrid in nature with features of both flat fare and fare-stage systems. The main advantage of zonal fares is that that whilst fares are broadly related to distance travelled, the range of fares is small and can be easily understood. The more zones crossed the higher the fare.

- **Approach:** The zones are typically concentric rings around the central business district that acts as the attractor for the majority of commuter trips. However, some larger cities have travel nodes in the suburbs and have subdivide the outer zone radially, to recover the cost of the resulting longer trips. A coarsely graduated fares system results, with the stages large geographic areas. In the pilot corridor, which is largely segregated from the rest of the network, with only a few interchange points, the latter approach is clearly preferable. Because zonal fares differ depending on the number of zones crossed, tickets are for one, two or three zones etc. Short trips across a zonal boundary may be penalized, unless a special short distance fare is available.

  Zonal fares require care in setting the zonal boundaries. It is difficult to change boundaries once established. Where a boundary is an important traffic generator (major market, hospital or college),or close to it, there may be a marketing advantage in providing a zonal overlap for the generator so that trips to it from both zones are within the single-zone fare.

  The attraction of zonal fares is that that they enable some fare discrimination between long and short distance travel, yet are not as complex as stage fares. However, there can be a high price penalty for route interchange, unless the main interchanges are at zone boundaries with overlapping zones. Changing to zonal fares requires high quality support and publicity to familiarise all users with the system. This should include a simple map or scheme illustrating the zones and the fares between them. Zone number should be indicated on each bus stop.
- **Management:** Similar to the time fare, it is not possible to follow the commuter and calculate the distribution for each trip. Thus, an upstream funding agreement is needed.

- **Example:** The concept of Zonal fare integration is shown in Figure 3.45. This model is adopted by TfL, London.

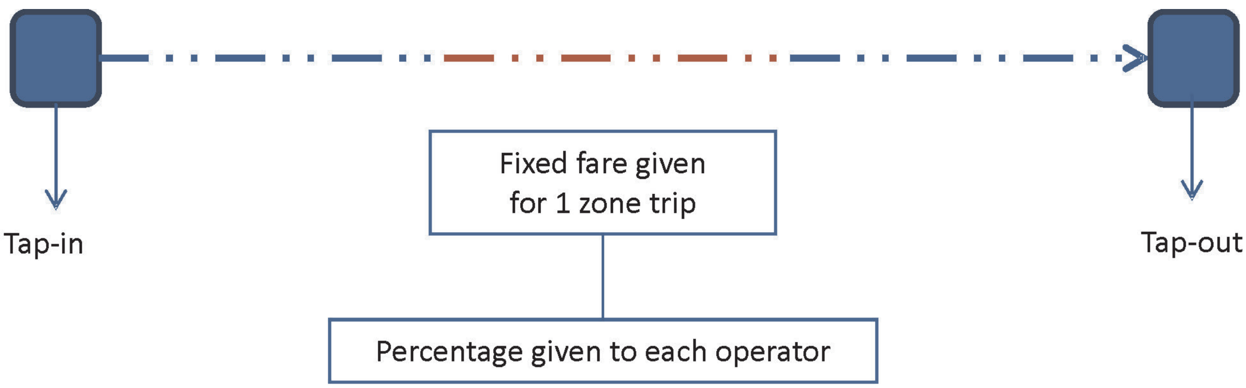


Figure 3.45: An Example of Zone-Trip Fare Integration

The technical steps needed for proper implementation and operation are:

- Definition of the transfer modalities: defining the model, choosing between full integration or rebate from agreement between authorities and operators.
- Selection of travel authorisation and evidence: choosing a travel evidence type and an authorisation process.
- Selection of travel sale and payment: how to operate and manage the selling of travel authorisations.
- Implementation of fare calculation and charging system: calculating the right fare, performing transaction and recording it.
- Operating the revenue accounting and distribution: collecting the revenue, recovering and managing the data, choosing a model of allocation and transferring the funds.

3.4.2.1 DESIGN OF MORE CARD[39]

More Card launched in 2012 in Delhi by Ministry of Urban Development, is a rechargeable smart card for paying transportation fares in public transport systems in India as part of the initiative for Fare Integration (Figure 3.46). Tipped as a nationwide interoperable transport card, the card aims to be a single point of transaction, applicable in state buses, metro, train, parking, taxi, ferry and Toll.

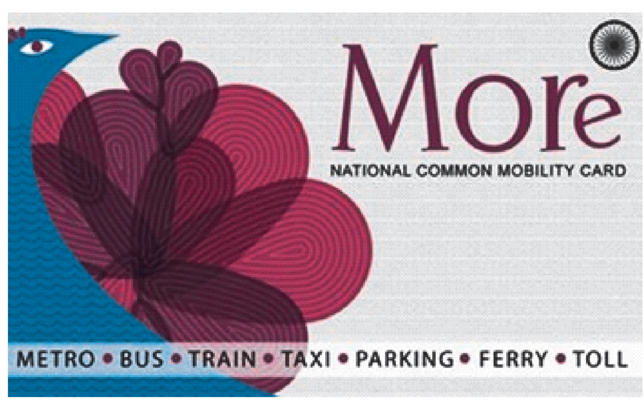


Figure 3.46: National Common Mobility Card

[39] Refer to MoUD Website: http://moud.gov.in/MobilityCard

3.5 INFORMATION INTEGRATION

Information Integration is providing the traveler with information across all the modes and for all the modes. Information services include route maps, timetables, fare schedules, promotion materials, uniform street signs and vehicle identification, display at stops, transfer points and major stations and telephone inquiry answering service. Providing integrated information during the journey, before its start and in between is important to make them attractive. The components and sub components of information integration are shown in Figure 3.47.

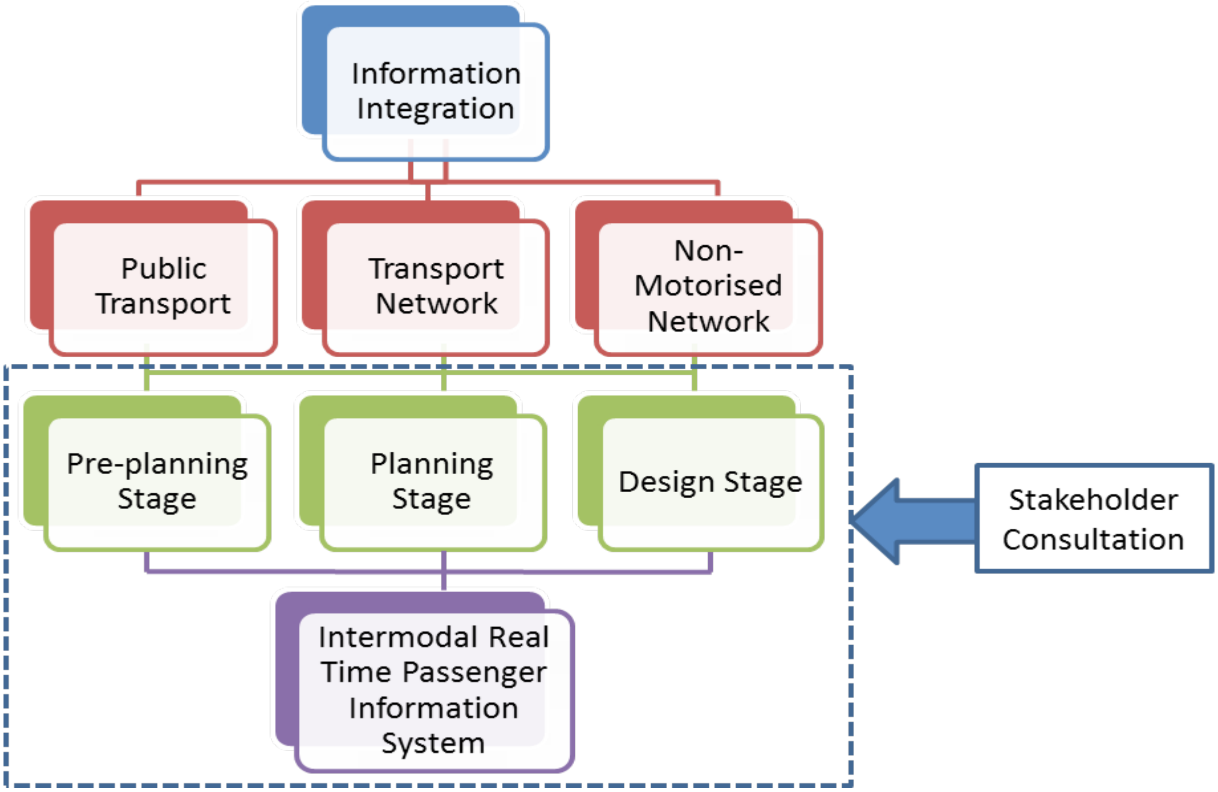


Figure 3.47: Information Integration "Components & Sub Components"

3.5.1 PRE-PLANNING

The survey required (Table 3.21) under for Information integration are given below:

- ✓ Existing ways of information flow to commuters, if any
- ✓ Details of its Operations & Maintenance
- ✓ Earlier Study Report, if any

Table 3.21: Data Required for Information Integration

Data Level	Source
Citywide	SRTC & City's Bus / Other Mode Company if any or any city level authority

3.5.2 PLANNING STAGE

Traveler information technologies allow travelers to receive roadway and transit network information.

- ✓ **Pre-Trip** planning systems are provided at home, workplace, park and ride facilities, transit stations or at intermodal locations.
- ✓ **En-route** traveler information is provided while traveling using devices on roadways, at transit platforms and stations, equipment mounted within vehicles in autos, buses, or trains, and via radio and TV broadcasts.
- ✓ **Tourism and events** are similar to pre-trip planning.

A step-by-step process for planning information integration has been explained below in Figure 3.48:

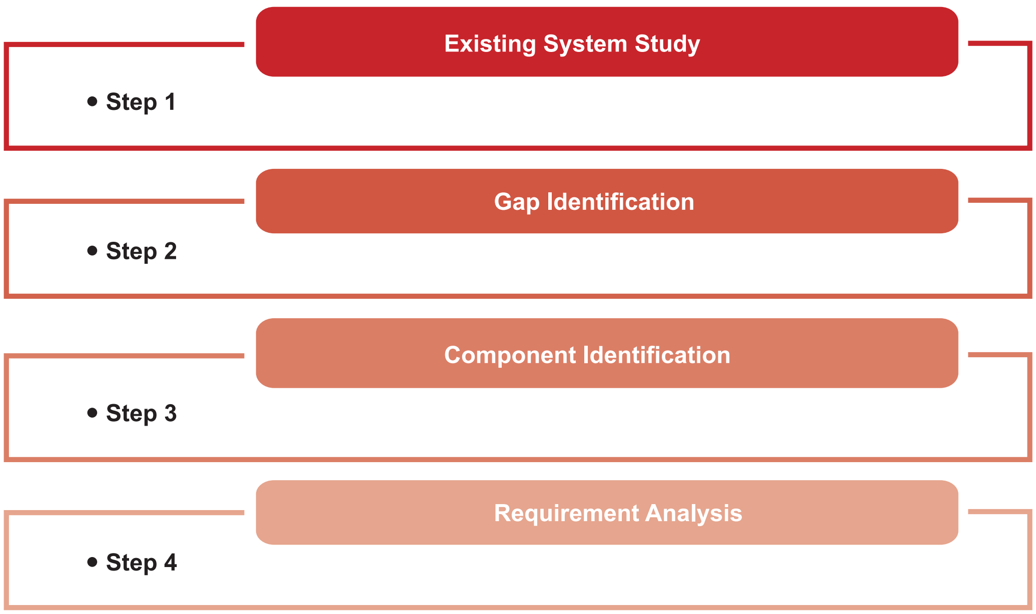


Figure 3.48: Step for Information Integration

STEP 1 - Existing System Study:

The first step is to identify and study the existing components (List of Components given in Step 3 below) supporting the information integration and study the current architecture of various public / private transport modes available in order to upgrade it. For further understanding the information integration, data is analyzed according to the secondary surveys done in pre – planning stage.

STEP 2 - Gap Identification:

Based upon the shortcomings in components identified and design cavity in terms of information flow between all the modes and for all modes, one can identify the underlying gap in the planning process.

STEP 3 – Component Identification:

A state-of-the-art Information Integration System comprises many components that must be integrated using communication links and computer systems. A city's Intelligent Transportation System is used to manage information dissemination related to public transport and private traffic updates. Figure 3.49 depicts the information dissemination tool through ITS at various stages of trip making by the commuter. The List of Component for information dissemination is as follows:

- Pre-trip information
  - ✓ Telephone based
  - ✓ Internet based
  - ✓ TV or radio broadcast
  - ✓ Mobile applications, including social media
- En-route information
  - ✓ Telephone based
  - ✓ Pagers
  - ✓ Mobile applications, including social media
  - ✓ Kiosks
  - ✓ Variable message signs (transit stations, on transit vehicles)
  - ✓ Dynamic message signs (roadway network)
  - ✓ Automated communication systems
  - ✓ Radio broadcasts (including Highway Advisory Radio (HAR))
  - ✓ In-vehicle systems

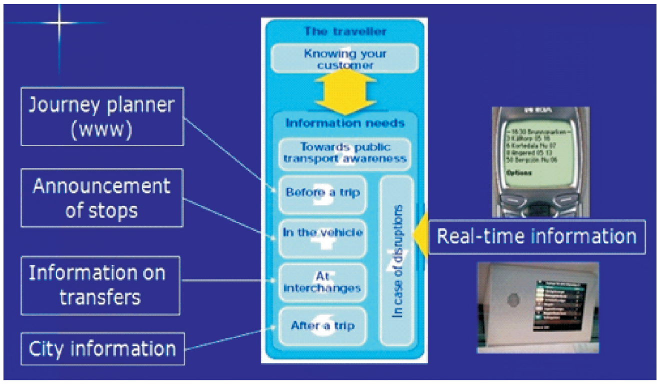


Figure 3.49: Transport Related Information Flow

Source: https://mubbisherahmed.wordpress.com/2011/11/29/the-future-of-intelligent-transport-systems-its/

Figure 3.50: Concept of Information Integration

Source: Development of Training Material Under "Sustainable Urban Transport Project" Reference Guide Volume 2 Integrated Planning of Infrastructure

The concept of information integration is shown in Figure 3.50. The figure clearly depicts how different communication medium such as mobile, Lan, satellite etc. helps in information flow, like vehicle to vehicle, passenger information, fleet management, travel assistance, navigation, trip planning and other activities. Once the components have been identified, the next objective is to frame the requirement.

STEP 4 – Requirement Analysis:

The requirement is fulfilled by an ITS architecture, which is a useful tool for integrating different ITS components (**List of Component in section 3.5.2, Step 3**) across all modes for information flow. The ITS architecture defines the comprehensive set of data that should be shared by various agencies of transportation network through the use of components.

Through this initiative the objective of *"Information Integration: Traveler information across all modes and for all modes" can be realized.*

With the knowledge of what data must be exchanged, these agencies develop a common interest in cooperating on planning efforts for all transportation projects. The ITS Architecture provides a common framework for planning, defining and integrating intelligent transportation systems. It specifies how different ITS components interact with each other to help solve transportation problems. It provides the transportation professionals a tool to address their needs with wide variety of options. It identifies and describes various functions and assigns responsibilities to various stakeholders of ITS. The ITS architecture should be common and of specified standards throughout the State or region so that it can address solution to several problems while interacting with various agencies.

3.5.3 DESIGN

The design of ITS architecture should be such that it is:

- Interoperable - The ITS architecture should be such that the information collected, function implemented or any equipment installed be interoperable by various agencies in different State and regions.
- Capable of sharing and exchanging information - The information by traffic operations may be useful in emergency services.
- Resource sharing - regional communication towers constructed by various private agencies are required to be shared by ITS operations.

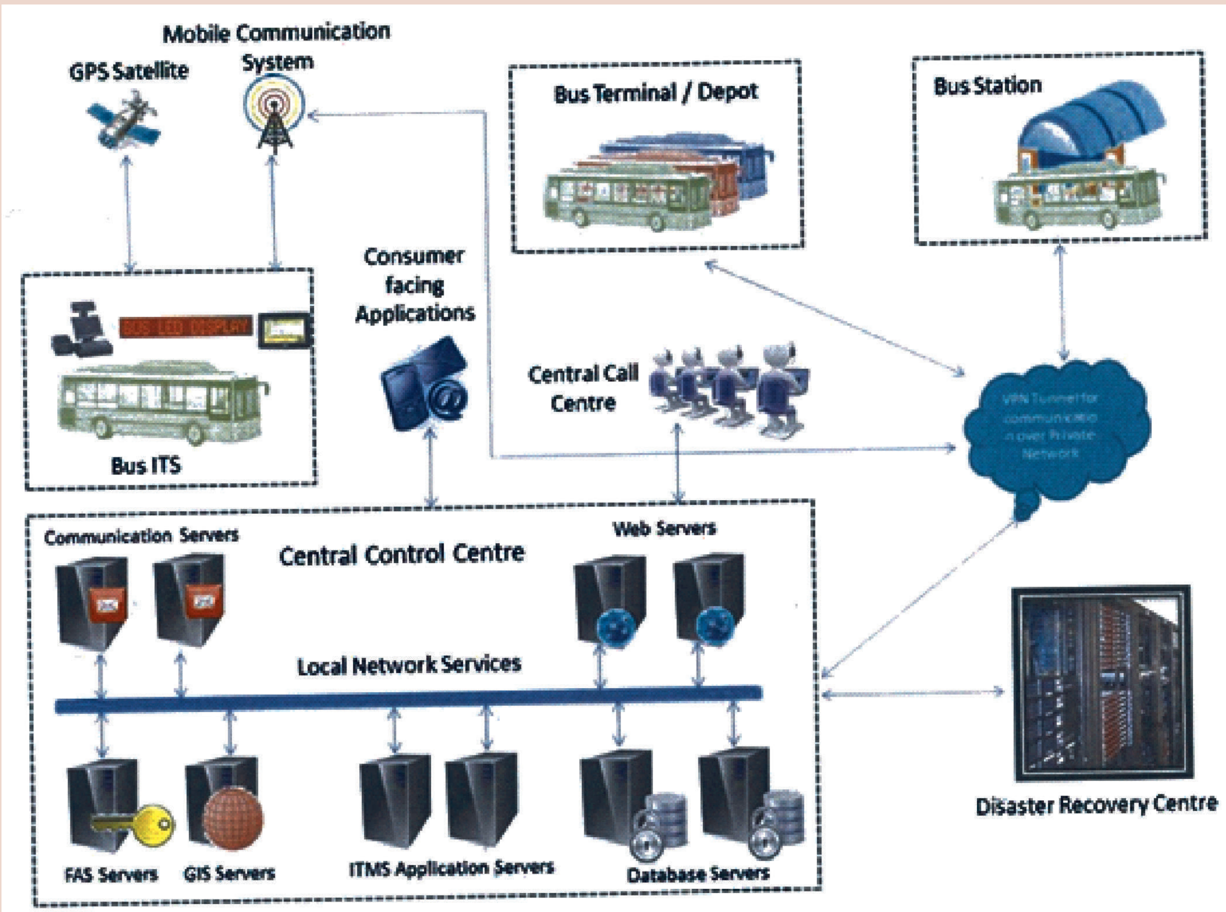
The ITS framework design will vary from city to city and upon its need. Some of the essential factors with respect to transport system that governs its design are listed below:

- Public Transport – Information dissemination on fare and operation service of each mode and across every mode.
- Transport Network – Information on PT connectivity, congestion, route planner, parking availability and others.
- NMT – Information on PT connectivity, route planner, parking availability, incident information and others.

The concept of control center is shown in Figure 3.51;

Common Central Control Centre (CCC)*

The common central control central form as a nerve centre for the operation management and service delivery for ITS system. The CCC offers centralised services for applications and infrastructure to drive filed operations using variety of ITS tools and techniques.



All the agencies related to urban transport of the city will sit under single roof to feed transportation related data to CCC, so that it can disseminate validated and important information to the commuter using its services.

Note: * - For further details, refer 'Toolkit on Intelligent Transport System' for Public Transport, BRTS, MoUD

Figure 3.51: Concept of Central Control Centre

Source: Toolkit on Intelligent Transport System for Public Transport & BRTS, MoUD

Case Studies – Best Practices

4.1 LONDON

Controlled by a board whose members are appointed by the Mayor of London according to the London Authority Act. Transport for London (TfL) acts as an authority and a direct operator, depending on the mode of public transport involved

- Responsible for both the strategic road network and public transport
- TfL as a body is organised in three main directorates
  - London Underground, responsible for running London's underground rail network
  - London Rail
  - Surface transport-London Buses, London Dial a ride, river service, streets, congestion charge, public carriage office, Cycling Centre of Excellence, Walking, London Road Safety Unit, Metropolitan Police Service, Transport operational command unit, (TOCU) and the British Transport police, Freight Unit

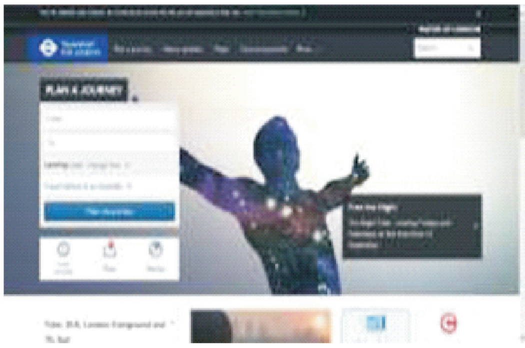
The city covers an area of 1572 km² including 8.3 Million of inhabitant, while the metropolitan area covers 8382 km² with more than 15 Million inhabitants. London's overall public transport network is characterized by a well-established historical and modern fixed infrastructure networks (the heavy rail network, the London underground, Docklands Light Rail and Croydon Light Rail), complemented by an extensive bus network and a well-functioning ferry network along the Thames.

The fixed infrastructure networks are integrated by interchange stations which in, most cases, are physically connected and, in many cases, designed for ease of interchange for high volumes of passengers (e.g. island platform interchanges, special connecting passages for adjacent lines in the underground system and undercover walkways).

At major stations, bus interchanges have been developed to be within walking distance of the railway and underground stations, often manned by bus station staff and furbished with real time information systems. The features in London Transport System are briefed in Table 4.1 below:

Table 4.1: Overview of Integration - London

Types of Integration	Added Features	
Physical Integration	• An extensive network of transport nodes and hubs with embedded interchange facilities (e.g. island platform interchanges, special connecting passages for adjacent lines in the underground system, undercover walkways and retail centres) throughout the city.	 **Source:** Integrating Australia's Transport Systems: A Strategy for an Efficient Transport Future, Infrastructure Partnerships Australia ('IPA')
Operation Integration	• Integrated fixed infrastructure networks: the National Rail (heavy rail) network, the London Underground (tube) network, Docklands Light Rail and Croydon Light Rail, e.g. where stations can serve a number of modes. • The "turn-up-and-go" service frequencies of most bus and underground services mean that timetable connectivity between rail, bus and tube services is reasonably well-embedded in the system. • Network integration is also strong for airports as airport access is provided by airport express services (such as Heathrow Express and Gatwick Express), the underground (the Piccadilly Line), heavy rail (by South West Trains) and coaches and buses.	 **London Tube and Rail Service** **Source:** https://www.tfl.gov.uk/maps/track


Types of Integration	Added Features	
Fare Integration	• The Oyster card was first introduced in 2003 in limited form and as a fully functioning smart card in 2007 • High take-up of Oyster	 **Oyster Card** **Source:** http://www.eurotriptips.com/londons-
Information Integration	• London has led the way in public transport signage since the development of its internationally recognised roundel sign for London Underground in 1908 and has since developed an extensive range of signage for all modes of transport and direction signage over the decades.	 **Journey Planner** **Source:** https://tfl.gov.uk/
Institutional Integration	• The City of London, under Ken Livingstone, assumed control of London Underground network, which further paved the way for even stronger integration of transport services in London, including the introduction of the Oyster card.	Transport for London **Source:** http://rmt.org.uk/news/tfl-staff- to-strike-on-friday-over-attack-on-pay- and-pension

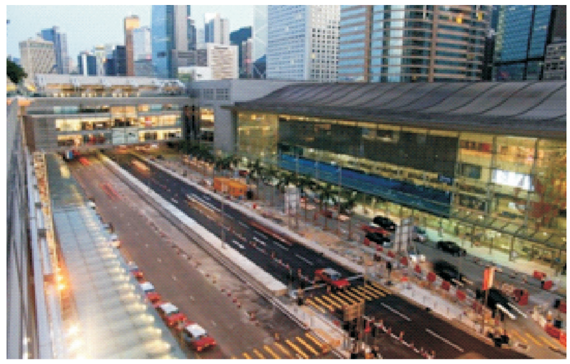
Success Story –

- Bus usage has increased by over 40% since 2000/01, with currently 2 billion journeys/year.
- Underground has seen over one billion journeys per year.
- Traffic in central London has reduced by over 20%.
- London has achieved a 5% modal shift from car to public transport, walking and cycling.
- Scale of this shift has not been matched by any other comparable city in the world.

4.2 HONG KONG

Public transit services in Hong Kong superbly address the accessibility needs of the city. Every day, about 11.3 million passenger journeys are made on the public transport system, which include railways, trams, buses, minibuses, taxis and ferries. An astonishing 90 per cent of Hong Kong's daily trips are made on public transport. Also remarkable is the very low car ownership at 50 cars per thousand population. The features in Hong Kong Transport System are briefed in Table 4-2 below:

Table 4 2: Overview of Integration - Hong Kong

Types of Integration	Added Features	
Physical Integration	• Government focus on infrastructure investments to facilitate integration through the creation of more and better modal interchanges and extra heavy and light rail routes: I. "Extension of the southern terminal of the East Rail by 1.6km to facilitate interchange with MTR station at Tsim Sha Tsui II. "Construction of the West Rail and better integration with the Light Rail Transit (LRT) in the west side of New Territories" and III. "Construction of the Ma On Shan rail to the Sha Tin Station of the East Rail". • Good integration of MTR stations with activity centres and local neighbourhoods. • Location of bus stops and taxi ranks cLOIe to MTR and KCRC stations and at the airport.	 **Hong Kong Integrated Transit Station** **Source:** https://zh.wikipedia.org/zh-hk/file:hong_kong_station_outside_view_2009.jpg
Operation Integration	• Several networks are connected by well-designed nodes / hubs such as Tsim Sha Shui. • Buses and mini-buses are timetabled to meet trains and MTR at the outer suburbs.	 **Integrated Australia Transport System Map** **Source:** Integrating Australia's Transport Systems: A Strategy for an Efficient Transport Future, Infrastructure Partnerships Australia ('IPA')

Types of Integration	Added Features	
Fare Integration	• Octopus integrated fare collection system introduced in 1997 which facilitates multi-modal transport. • High take-up of Octopus	 **Octopus Integrated Card – Hong Kong** **Source:** http://hongkonghonky.blogspot.in/2012/04/getting-to-know-hong-kong-subway-mtr.html
Information Integration	• Good signage to facilitate intra-modal and intermodal connections • "Hong Kong e-Transport" Mobile Application	 **Journey Planner – Hong Kong** **Source:** http://www.td.gov.hk/en/home/index.html  **Mobile Application – Hong Kong** **Source:** http://www.td.gov.hk/en/transport_in_hong_kong/its/its_achievements/hong_kong_etransport/index.html
Institutional Integration	• Single governing authority helps to implement integration with a minimum of political obstacles.	Transport Department The Government of the Hong Kong Special Administrative Region **Source:** http://www.td.gov.hk/en/home/index.html

Success Story[40] –

- Over 90% of the daily trips are on public transport, making it the highest rate in the world.
- Over 12 million passenger trips are made on a public transport system which includes railways, trams, buses, minibuses, taxis and ferries
- Hong Kong's railways are run by the MTR Corporation Limited (MTRCL), which carried about 4.62 million passenger trips per day in March 2015. The Airport Express (AEL), carried about 41,400 passenger trips per day in March 2015 and Light Rail about 479,000 passenger trips every day at the same time.
- City Bus, in 2014 carried about 648,000 passengers a day.

4.3 SINGAPORE

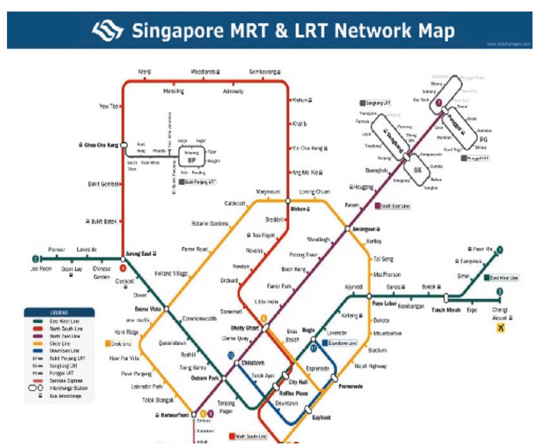
In less than two decades, Singapore has become an international benchmark in offering easy and accessible integrated multi-modal transport. Despite a small population of 4.2 million inhabitants, it has made significant achievements:

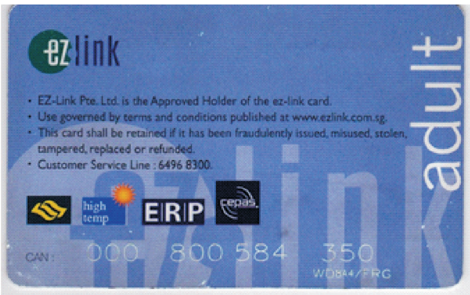
- Home of the world's first Area Licensing Scheme (ALS) and subsequent Electronic Road Pricing (ERP) system;
- Vehicle Quota System – quota for new vehicles kept fixed at 3% of the previous year's vehicle population;
- Transit's modal share is high, accounting for 63% of all motorized trips;
- Government plans to continue to invest in public transport (especially rail) to reach a modal split target of 75% of all motorized trips (2003);
- Government provides funding for the infrastructure construction; the transit operator funds the rolling stock, other mechanical and electrical system replacement costs and the on-going operating cost;
- SBS Transit and Trans-Island Bus Services (TIBS) provide bus services on the island;
- In 2002 TIBS was merged with the SMRT Group which operates all the heavy and light rail systems in Singapore.

[40] http://www.td.gov.hk/en/transport_in_hong_kong/public_transport/index.html

The features in Singapore Transport System are briefed in Table 4.3 below:

Table 4.3: Overview of Integration – Singapore

Types of Integration	Added Features	
Physical Integration	• New transit stations are designed to integrate with commercial development and at least one other transport mode; new stations offer covered walkways to connecting modes; • The North-East Line, which opened in June 2003, has all its stations well-integrated with adjacent activity centres; • The Senkang LRT and the Punggol LRT act as feeder services to the North-East Line and are integrated with local neighbourhoods; • Existing MRT stations were upgraded to achieve better integration e.g. Woodland MRT/Bus interchange; Novena MRT was integrated with nearby commercial development; and • Architectural design of new MRT stations is important from both aesthetic and accessibility point of view – safe and easy walk paths and elevators are now provided for all users, especially for the disabled and elderly.	 **Source:** http://hillionresidences.org/
Operation Integration	• Increase in the percentage of population within the MRT catchment area from 19 to 24% with the completion of the North-East Line (2002); • In general, it has been estimated that 50% of the Singapore's population lives within 500 metres of a MRT station • Current catchment of bus network is very extensive with 90% of the population living within 300 metres of a bus stop (bus network is the backbone of the PT services supporting almost 41% of all motorised trips); and • There is active advice to use Bus or LRT network only as a feeder service to MRT so that there is less surface congestion on arterial roads.	 **Singapore Integrated MRT Map** **Source:** http://www.seacitymaps.com/singapore/singapore_mrt_map_1.htm

Types of Integration	Added Features	
Fare Integration	• A single fare card is usable on all public transport modes, which greatly facilitates integrated transport - called the EZ card is also suitable for other applications such as park-and-ride and small retail purchases; and • Rebates for intermodal transfers using EZ card (e.g. rebate of up to $0.25 is given to an individual passenger who transfers from an MRT station to a bus within 30 mins).	 **Single Fare Card for Transport in Singapore** **Source:** http://hjtann.blogspot.in/2011/12/i-was-super-rider.html
Information Integration	• TransitLink Guide provides coordinated and comprehensive information on all aspects of travelling on bus, MRT and LRT; • Signage system improved to facilitate multi-modal travel; and • Suggestions to introduce an 'i-Transport platform' – IT platform that integrates traffic information from road based ITS measures and transit based measures.	 **Journey Planner – Singapore** **Source:** http://www.transitlink.com.sg/
Institutional Integration	• First step towards integration taken in 1989 with TransitLink; • 1995 – the Land Transport Authority (LTA) was formed; • Publication in 1996 of the LTA's White Paper, a major milestone in promoting PT; • Corporate co-operation, for example, between the SMRT Group and SBS Transit; and • Some overlap of the bus network of SBS Transit and TIBS, and hence some competition.	Land Transport Authority We Keep Your World Moving **Source:** http://www.lta.gov.sg/content/ltaweb/en.html

Success Story –

- 63% daily mode share in favour of public transport.
- More than 1.3 million commuter travel on the Rapid Transit Systems (RTS) every day.
- 3 Million People use the comprehensive bus network.

4.4 LEARNING FROM CASE STUDIES

The best practice examples outlined in the previous section feature high degree of integration across a number of measures, including physical, network, fare, information and institutional integration. In more practical terms some of the key common themes of transport network integration include:

- Comprehensive interchange integration – particularly in ticketing, where the monetary cost to the user of changing modes is limited or eliminated;
- Consistent and high quality signage designed with the user experience in mind – this includes cross network branding and real-time transit information;
- An applied disincentive to car use or ownership such as a congestion charge, taxation and registration costs designed to limit ownership, restrictions of available parking or a mandated limit on number of vehicles;
- Delivery of a safe, secure and efficient service (from the user's perspective);
- A high-frequency / non-timetabled service or an integrated timetable where modes at transfer nodes are designed to allow for an efficient interchange; and
- Modal neutrality in transport network decision making – with the best mode selected to suit the task.

4.5 WAY FORWARD

In each of the examples explored, integration has been pursued at a strategic level rather than at project or node level – while each project, interchange and node has focused on integration as an outcome, they have been part of broader strategies to create a fully integrated greater urban transport network.

Even though, the five pillars of integration are to be implemented, it requires continuous assessment to improve its functionality and understanding of the surrounding environment. Therefore there is a need to identify "Level of Integration (LOI)" for its periodic evaluation. This should include all Component and Sub-component of Integration (Table 2.1) as indicators and concept of integration that can be measured for different sub-component.

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Annexures

Annexure 1: List of Surveys and Formats

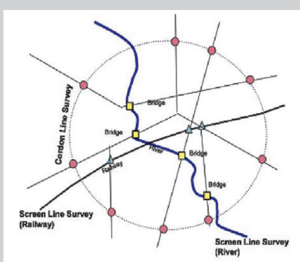
The details transportation surveys required for five pillars of integrations along with survey format is given below;

i. Transportation Survey[41]

Details of Transportation Survey

S. No.	Survey Name	Survey	Survey Method	Objective	Sample Size	Expected Output
1.	Inventory of road network system	N/A	Manual	• To appreciate the physical characteristics of the identified road network in terms of right-of way, carriage way, number of access points, surface type, abutting land use, etc. • To assess the capacity potential of the identified road network. • To understand the existing transport situation in order to develop a rational land use and transport plan and mobility improvement measures	• Two sample for a road section with similar land uses • Samples to be collected wherever section has variation	Physical characteristics and physical constraints of road network and transport infrastructure

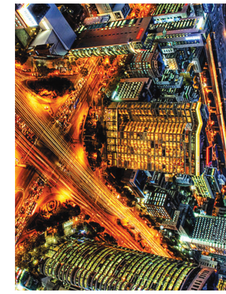
[41] Format adopted from URDPFI Guidelines, Volume 1, Section 7.3.5 Transportation Surveys

S. No.	Survey Name	Survey	Survey Method	Objective	Sample Size	Expected Output
2.	Classified traffic volume counts	N/A	Manual Method, Using automatic devices like Sensors, Video Photography	• To appreciate traffic characteristics in terms of size composition and variation – directional and temporal. • To appreciate the spatial distribution of traffic • To establish the level of service on the road network system	• As even day count will then give the Average Daily Traffic (ADT)	• Traffic Characteristic of the study area • Traffic volume • Spatial distribution of traffic • Circulation of traffic
3.	Intersection Survey	a. Intersection Inventory b. Intersection Turning Movement Survey c. Queue length Survey	Manual	• To identify physical constraints and bottleneck points along the identified road network. • Measures turning movements at key intersections during the morning and evening peak hours. • A queue length survey at major bottlenecks can show the severity of traffic congestion quantitatively.	• Two samples for a road section with similar land uses • Directional movement of traffic in the peak hour • Counts for 3 - 4 hours each in the morning and evening peak periods unless there exist extended peak hours.	Performance characteristics of an Intersection
4.	Road Side Origin and destination surveys at • Cordon and • Screen lines	N/A	Manual	• To appreciate the traffic characteristics • To appreciate the desired patterns of passenger and goods traffic • To assess the intensity of through and destined traffic • To use in model validation 	The survey should normally be on any one days during a representative week in the year.	• Travel pattern • O-D matrix to calibrate a transport demand model


S. No.	Survey Name	Survey	Survey Method	Objective	Sample Size	Expected Output
5.	Parking Demand Characteristics and Supply	a. Parking Inventory b. On-Street & Off-Street parking survey c. Parking Usage Survey by Patrol	Manual	• To assess the parking characteristics in terms of parking duration and accumulation by mode • To assess future levels of demand • To develop a parking policy • To assess the Parking Supply	Each on-street and off-street parking to be covered / representative sample to be collected during peak hour	Determine availability of existing parking
6.	Terminal studies	a. Inventory	Manual	• To appreciate physical characteristics of the terminal regarding size, space usage etc. • To appreciate the operational characteristics in terms of flow of vehicles/good/people to and from the terminal • To appreciate the user characteristics (in case of passenger terminal) regarding their origin, destination, and mode used, trip length etc. • To appreciate the parking characteristics in the terminal • To appreciate the problems, constraints and potentials for expansion of the terminal activity	Sample size to be decided based on the size and characteristics of study area and availability of users	Physical characteristics of the terminal, operational characteristics in terms of flow of vehicles/ good/people, parking characteristics in the terminal
7.	NMV System Study	a. Inventory	Manual	• To appreciate system and operational characteristics • To appreciate the performance characteristics	Sample size to be decided based on the size and characteristic of study area	System and operational characteristics

S. No.	Survey Name	Survey	Survey Method	Objective	Sample Size	Expected Output
8.	Pedestrian Survey Volume Counts – Along – Across Accessibility	a. Inventory	Manual Video Attitude	• To appreciate pedestrian characteristics in terms of size composition and variation –directional and temporal. • To appreciate the spatial distribution • To establish the level of service on the road network system • Safety: Continuity of street lighting for carriageway and pavements • Comfort: Continuity of shade, provision of access ramps • Convenience: Presence of pedestrian path-finding signage, street furniture such as garbage bins, seating, drinking water	Peak hour during volume count survey	Level of service of the pedestrian system and need for additional pedestrian facilities
9.	Public transport system study	a. PT Inventory b. Route Inventory c. Stop Inventory d. Boarding Alighting Survey e. Interchange Survey f. Cost & Fare Survey g. Fleet Inventory h. Bus Terminal Survey	Manual	• To appreciate system and operational characteristics • To appreciate the performance and economic characteristics	Sample size to be decided based on the size and characteristic of study area For 16 hours covering both peak and off peak hours	System and operational characteristics
10.	Para Transit Study	a. Inventory	Manual	• To appreciate role and function of Para-transit • To appreciate the system characteristics of Para-transit • To appreciate characteristics Para-transit users	Sample size to be decided based on the size and characteristic of study area For 16 hours covering both peak and off peak hours	System and operational characteristics

Note: If data is available for the last two years, then the same data can be used.



ii. Survey Performa:

1. Inventory of Road Network System[42] –

Road Namr	Node Number		Length (in Kms)	Pavement Type (Flexible/Rigid/Unpaved)	No of Lanes	Divided/ Undivided	Carriage Way (Curb to Median)			Service Lane				Shoulder						Footpath						Right Of Way Width (m)	Any Auto Stand (On street/ Off street)		Any Taxi Stand (On street/Off street)		IS it a bus Route? (Yes/ No)	No of Designated Bus stops		On-street Parking (Yes/No)		Encroachments on footpaths (Yes/No)		Street Lighting (Yes/No)			Encroachment on Road					
										LHS		RHS		LHS			RHS			LHS			RHS																		LHS			RHS		
	From node	To node					LHS Width (m)	Median Width (m)	RHS Width (m)	Length (m)	Width (m)	Length (m)	Width (m)	Type (P/UP)	Length (m)	Width (m)	Type (P/UP)	Length (m)	Width (m)	Type (P/UP)	Length (m)	Width (m)	Type (P/UP)	Length (m)	Width (m)		LHS	RHS	LHS	RHS		LHS	RHS	LHS	RHS	LHS	RHS	LHS	Median	RHS	(Yes/No)	Road width Encroached (m)	Type of Encroachment*	(Yes/No)	Road width Encroached (m)	Type of Encroachment*

R- Residential, C-Commercial, I - Institutional, A-Agricultural, O - Others, W-Waste Land

[42]Adopted from Service Level Benchmarks for Urban Transport- MoUD

2. Classified Traffic Volume Count[43]

<table>
<tr><th colspan="7">Location</th><th colspan="9">Direction from</th><th colspan="5">Date/Month Year</th></tr>
<tr><th colspan="5">Count station no.</th><th colspan="2">Direction</th><th colspan="3">Right</th><th colspan="3">Straight</th><th colspan="3">Left turn</th><th colspan="5">Day</th></tr>
<tr><th colspan="16">Passenger vehicle</th><th colspan="5">Goods vehicle</th></tr>
<tr><th></th><th colspan="2">Heavy fast</th><th></th><th colspan="7">Light fast</th><th colspan="3">Slow</th><th rowspan="2">Other</th><th colspan="2">Heavy fast</th><th colspan="2">Light fast</th><th colspan="2">Slow</th></tr>
<tr><th></th><th>City Bus</th><th>Intercity Bus</th><th>Mini bus</th><th>Car</th><th>MTW</th><th>Auto</th><th>Van</th><th>Jeep</th><th>Shared Auto</th><th>Taxi</th><th>Cycle</th><th>Cycle Rickshaw</th><th>Pedestrian</th><th>Truck</th><th>MAV/Trailers</th><th>LCV</th><th>Others</th><th>Cycle rickshaw trolley</th><th>Others</th></tr>
<tr><td>6 – 7 am</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>5 – 6 pm</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

3. Intersection Survey

a. Intersection Inventory[44]

Name of Intersections	Geometric Characteristics (Shape of intersections, number of lanes etc.)	Inflow Traffic Volume (PCI/Day)	Traffic control devices (such as signalized etc.)	Existence of pedestrian crosswalks	Existence of Traffic Calming Measures (such as rumble strips, etc.)	Existence of intersection hazards (such as obstructed signals/ signs, unregulated intersections that are unsafe for pedestrians, etc.)

[43] Adopted from Preparing a Comprehensive Mobility Plan (CMP) – A Toolkit (Revised), MoUD, Section IV: Annexure Survey Format 3

[44] Adopted from URDPFI Guidelines, Volume 2, Appendix F Transportation Survey Format, Section 6.6


b. Intersection Turning Movement Survey[45]

Location:
Direction From:
Date/Month/Year:
Count Station No.:
Direction:
Right Turn/Straight/Left Turn:
Day:
Road Name & No.:

	Passenger Vehicle								Good Vehicle					Grand Total
	Heavy Fast	Light Fast				Slow		Total	Heavy Fast	Light Fast		Others	Total	
	Bus	Mini Bus	Car	2-Wheel	3-Wheel	Cycle	Other			Truck	LCV			
6-7 AM														
7-8 AM														
8-9 AM														
1-2 PM														
2-3 PM														
3-4 PM														
4-5 PM														

Note: Critical intersections should be identified and inventoried, in particular those intersections that are important from the viewpoint of the entire road network or that are heavily congested. It is anticipated that approximately 10-30 intersections will be selected. Available traffic counts should be included or referenced and the requirement for new or updated surveys identified.

c. Queue Length Survey[46]

Queue length	Reading in Meters	Hour			Elapse Time
Sequence of reading*	Queue length (m)	(hr.)	(min.)	(Sec.)	(Sec.)

[45] Adopted from URDPFI Guidelines, Volume 2, Appendix F Transportation Survey Format, Section 6.25
[46] Adopted from URDPFI Guidelines, Volume 2, Appendix F Transportation Survey Format, Section 6.26

4. Road Side Origin and destination surveys at[47] ;

- **Cordon and**
- **Screen lines**

Sl. No.	Direction (inbound or outbound)	Time	Traffic Mode[1]	No. of Passenger	Where did this trip begin?[2]	Where did this trip end?[2]	Trip purpose[3]

Note:
- 1 -Bus, 2-Mini Bus, 3-Car, 4-Two-wheeler, (motorcycle), 5-Three wheeler (Auto-rickshaw), 6-Bicycle, 7-Railways, 8-walk
- 2 Put zone together
- 1-Going to work, 2-Going to school, 3-Going home, 4-Shopping, 5-Leisure and 6-Business

5. Parking Demand Characteristics and Supply

a. Parking Inventory[48]

Location	Ownership of facility Public/ Private / Informal	The number of parking spaces/ vehicle types	Parking Tariff	Occupancy rate during peak hours	Condition of street markings	Type of restriction (e.g. for on-street)

[47] Adopted from URDPFI Guidelines, Volume 2, Appendix F Transportation Survey Format, Section 6.30

[48] Adopted from URDPFI Guidelines, Volume 2, Appendix F Transportation Survey Format, Section 6.7


b. Parking Survey[49]

On-Street Parking																					
Road Name	Node/ Name		Length of Parking	Count of Vehicles								Parking Fee								Nearest PT Stop	Distance to PT Stop
	Start	End		Car	2W	Auto	Cycle	Rickshaw	Tempo	Truck	Others	Car	2W	Auto	Cycle	Rickshaw	Tempo	Truck	Others		

Off-Street Parking																			
Name of Parking Lot	Area of Parking Lot	Count of Vehicles								Parking Fee								Nearest PT Stop	Distance to PT Stop
		Car	2W	Auto	Cycle	Rickshaw	Tempo	Truck	Others	Car	2W	Auto	Cycle	Rickshaw	Tempo	Truck	Others		

[49]Adopted from Preparing a Comprehensive Mobility Plan (CMP) – A Toolkit (Revised), MoUD, Section IV: Annexure Survey Format 4

c. Parking Usage by Patrol Survey[50]

Parking Survey — Patrol:

On Street — Duration: — Street:

Section: L / R

Day:

AM																PM							
8:00		8:30		9:00		9:30		10:00		10:30		11:00		11:30		12:00		12:30		1:00		1:30	
L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R

6. Terminal Studies

a. Inventory[51]

Name of Interchange facilities	Location	Layout and size of facilities	Determination of capacity and geometric characteristics of pedestrian walkways	Number of daily and hourly (peak) passengers	Number of hourly/ daily vehicle move-ments	Number of transport operators houses	Number of loading births	Availability of load-ing births to accept various bus types

[50] Adopted from Traffic Engineering and Transport Planning, Dr. L. R. Kadiyali, Fig. 6.4

[51] Adopted from URDPFI Guidelines, Volume 2, Appendix F Transportation Survey Format, Section 6.15

7. NMV System Study

a. Inventory[52]

Location (street)	Type of facilities (NMV Path, Overpass, underpass)	Description	Obstructions (if any)	Existing pavement conditions	Adequate drainage facilities	Clear markings	Adequacy of signage/ signalling	Existence of parking restriction to safeguard pedestrian right-of-way etc.	Adequacy of NMV and Pedestrian and Vehicle Flow Separation (such as on- street lanes etc.)

8. Pedestrian Survey

a. Inventory[53]

Location (street)	Type of facility (footpath, overpass, underpass)	Length (m)	Width offootpath		Safety	Comfort	Convenience	Obstructions (if any)	Continuity of the walkway	Existing pavement conditions	Adequate drainage facilities	Clear markings
			Left	Right								

Note: Safety, Comfort and Convenience be rated as- 1(poor), 2(fair), 3(partially good), 4(good) and 5(very good).

[52]Adopted from URDPFI Guidelines, Volume 2, Appendix F Transportation Survey Format, Section 6.10

[53] Adopted from URDPFI Guidelines, Volume 2, Appendix F Transportation Survey Format, Section 6.9

9. Public transport system study

a. Mode Inventory[54]

Name of road	Applicable in case of BRT corridor								Type of bus stop (Stag-gered/ island)	Average speed (kmph)
	Node (bus stop)		From To Width of Bus lane (m)		Length (km)	Bus lane location wrt road section (Median/ left side)	Type of bus infrastructure (open/close)	Bus lane Segregation tools (Kerbs/ lane marking/ fences)		
	From	To	L	R						

Inventory for City Bus							
Route Name & Number	Length (KM)	Name of Bus Stop	Location (Coordinates)	Bus Stop Capacity		Average Speed (Kmph)	Near/Far Junction
				X	Y		

[54] Adopted from Preparing a Comprehensive Mobility Plan (CMP) – A Toolkit (Revised), MoUD, Section IV: Annexure Survey Format 7


b. Route Inventory[55]

Route inventory – Secondary Data							
Route number	Route length	Location covered	Headway (minutes)	Average passengers/ day	Average Speed (Kmph)		Average Delays (minute)
					Peak hr.	Average	

c. Stop Inventory[56]

Bus stop details											
Name of Bus stop	Location (coordinates)		Bus stop capacity	Applicable for BRT		Near/ far junction	Traffic calming tools (Rumble strips/ speed breakers)	Safe crossing facility (Zebra crossing/ signalized crossing/ FOB/ subways)	Access distance to bus stop from either side (m)	Barrier free access (y/n)	Passenger amenities (Sitting area/ toilets/ hawkers)
	X	Y		Location wrt road section (Median/ left side)	Type of bus stop (Stag-gered/ island)						

[55] Adopted from Preparing a Comprehensive Mobility Plan (CMP) – A Toolkit (Revised), MoUD, Section IV: Annexure Survey Format 7f

[56] Adopted from Low Carbon Comprehensive Mobility Plan – A Toolkit, MOEF

d. Boarding Alighting Survey[57]

Time	Bus Stop Name	Route Name	Boarding	Alighting	On Board	Remark

e. Interchange Survey[58]

Type of Interchange	Name	CCTV		Passenger Information System (PIS)		Parking Available for Cycle & Rickshaw Stand Within 250m	
		Y/N	Count	Y/N	Count	Y/N	Count

f. Cost & Fare[59]

Secondary Data						
Operator	Operation Cost per Km (Rs)	Tax Levied (Rs)	Type of Fare Structure & Fare Structure	Revenue per Km (Rs)	Profit/Loss (Rs)	Fuel Efficiency

[57] Adopted from Preparing a Comprehensive Mobility Plan (CMP) – A Toolkit (Revised), MoUD, Section IV: Annexure Survey Format 7g
[58] Adopted from Preparing a Comprehensive Mobility Plan (CMP) – A Toolkit (Revised), MoUD, Section IV: Annexure Survey Format 7h
[59] Adopted from Preparing a Comprehensive Mobility Plan (CMP) – A Toolkit (Revised), MoUD, Section IV: Annexure Survey Format 7e


g. Fleet Inventory[60]

Secondary Data								
Owner	Fleet Size	Type of Fleet (As per Urban Bus Specification, 2013)	Fleet Utilization Rate	Vehicular (Km)	Average Vehicle Age	Occupancy		Average Passenger per Day
						Peak Hour	Average	

h. Bus Terminal Survey[61]

Time	Bus Route Number	Route Name	Type of Bus	AC/Non AC	Remark

10. Para Transit Study

a. Inventory[62]

Number of Operators	Number of type of registered vehicles	Fare	Revenue	Cost (operating an fixed)	Operating distance and hours (km and hour)	Average age of vehicles	Conditions of vehicles	Type of ownership and degree of regulation	Jurisdic-tional areas of operators (if any)	License fees and franchise costs)

[60] Adopted from Preparing a Comprehensive Mobility Plan (CMP) – A Toolkit (Revised), MoUD, Section IV: Annexure Survey Format 7d

[61] Adopted from Preparing a Comprehensive Mobility Plan (CMP) – A Toolkit (Revised), MoUD, Section IV: Annexure Survey Format 7c

[62] Adopted from URDPFI Guidelines, Volume 2, Appendix F Transportation Survey Format, Section 6.14