

BHUBANESWAR ON THE MOVE

TOOLS AND GUIDELINES FOR CITY BUS OPERATIONS



Estimating infrastructure
requirement for bus operations
fleet, depots and terminals

Service planning including
network, bus stops, bus routes,
schedules and fares

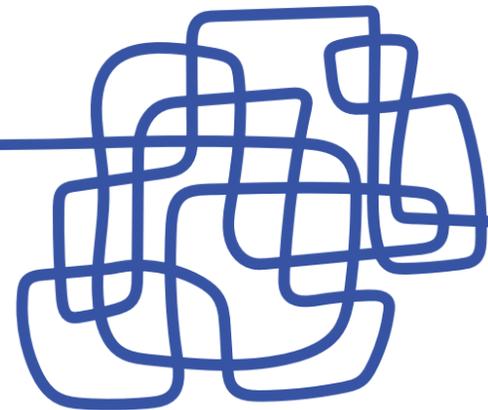
Setting up performance
monitoring systems for
bus operations

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TOOLS AND GUIDELINES FOR CITY BUS OPERATIONS

PART TWO PLANNING, SCHEDULING AND MONITORING

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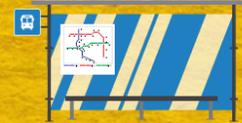
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ABBREVIATIONS

AFCS:	Automatic Fare Collection Systems
ATL:	Average Trip Length
AVLS:	Automatic Vehicle Location System
CRUT:	Capital Region Urban Transport
GPS:	Global Positioning System
ITS:	Intelligent Transportation System
OR:	Occupancy Ratio
PIS:	Passenger Information System
PT:	Public Transport
RTT:	Round Trip Time
TSP:	Transit Signal Priority
VHMD:	Vehicle Health Monitoring and Diagnostics



FOREWORD



G. Mathi Vathanan, IAS
Principal Secretary
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With a vision to create more liveable and sustainable urban centres in the state, and with the objective of providing a comfortable, affordable and environmentally friendly mode of mobility for the people of Bhubaneswar (and Odisha at large), the State launched the “Mo Bus Service” on 6th November 2018. The Capital Region Urban Transport (CRUT), a Special Purpose Vehicle (SPV), was created by the Department of Housing & Urban Development (HUDD) to manage the operations of city bus services (Mo Bus Service) in Bhubaneswar, Cuttack and Puri-Konark urban areas.

In the one year that has passed since its inception, CRUT has taken many initiatives to build infrastructure, streamline its organisational processes, and invest in the skill development and capacity building of its staff. On

an average, Mo Buses undertake around 1800 trips each day, serving about 85,000 passengers across 21 routes. I hope that this trend continues in the same direction, and that the people of Odisha increasingly choose public transport as their preferred mode of daily commute, especially over their private vehicles, thereby creating a sustainable mobility culture in the capital region.

I compliment the Integrated Sustainable Urban Transport Systems for Smart Cities (SMART-SUT) project, implemented jointly by the Housing & Urban Development Department (Government of Odisha), the Bhubaneswar Development Authority (BDA), and the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, for its efforts towards improving mobility planning in Bhubaneswar.

(G. Mathi Vathanan)

FOREWORD



Arun Bothra, IPS
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Capital Region Urban Transport (CRUT)
Bhubaneswar

Just like most other Indian cities, the capital region of Odisha (comprising Bhubaneswar, Cuttack, Khurda and Puri) is also witnessing high levels of economic growth, resulting in increased travel demands. This requirement is largely being met by private motor vehicles, especially two-wheelers. Alarmingly, more than 80 per cent of commuters in Bhubaneswar are dependent on private vehicles. Also, the total number of registered vehicles in the city, pegged at 14 lakhs by the Regional Transport Office, exceeds the city's total population, which was estimated as 10 lakhs in 2019!

Till date, our standard response to increasing traffic problems has been to make new roads, and/or widen the existing roads. With the city's population expected to double in the next 20 years, we need to pause and think whether this is the course of development we would want to take. Should we keep providing for more and more vehicles, or could we consider disincentivising the use of private vehicles and at the same time, incentivise the use of cleaner modes of travel? Do we want Bhubaneswar to be a healthy, beautiful, thriving, and liveable place for all, or a city choked with polluting and noisy vehicles, with no safe places to walk and play?

The answer lies in providing the city's residents with a reliable, fast-moving and high-quality public transport system, which is low-carbon, more energy and space-efficient, and safer than private vehicles. An alternative that does not pose the challenge of finding parking on

a daily basis, one that does not eat up public spaces meant for people. Experiences worldwide have demonstrated that cities having high-quality public transit services (buses, metros, etc.) are also the most "liveable". These are cities where it is not just the poor who use public transport out of compulsion, but the well-off also *choose* to use the same for convenience and comfort. In such cities, driving personal vehicles is perceived as a luxury that comes at a very hefty price. Investing in creating a high-quality and cost-efficient public transportation system and developing strategies for increasing its ridership and appeal (so as to move people away from personal modes of travel) needs to take centre stage in the debate on mobility choices today.

The Capital Region Urban Transport (CRUT), which was known as the Bhubaneswar-Puri Transport Services (BPTS) in its earlier avatar, is operating 200 buses (with 100 more to be added) and 2000 cycles (under its public bicycle-sharing programme) in the capital region. CRUT has been improving its services through building transit infrastructure (in terms of new fleets, depots, terminals, bus queue shelters, etc.), adoption of the gross-cost contract (GCC) model of operations, and the installation of Intelligent Public Transportation Systems (IPTS). CRUT is also undergoing institutional strengthening through the enhancement of individual capacities and the development and streamlining of its organisational processes.

The Mo Bus service was launched by Shri Naveen Patnaik, Hon'ble Chief Minister of Odisha, on November 6, 2018. Since then, our focus at CRUT has been on customer service, employee development and the use of technology to bring precision to our work. We have aimed to provide the *best* public transportation possible to our commuters and enhance the quality of life in our cities. We are in the process of evolving and learning from our past and peers, and it gives me immense pride and joy to inform you that ahead of its first anniversary, Mo Bus has already touched a daily ridership mark of 1 lakh! I would like to take this opportunity to congratulate all individuals and teams who made this possible through sheer perseverance and hard work.

On behalf of CRUT, I would also like to warmly acknowledge and compliment the efforts made by the Integrated Sustainable Urban Transport Systems for Smart Cities (SMART-SUT) project. Implemented jointly by the Housing & Urban Development Department (Government of Odisha), the Bhubaneswar Development Authority and the GIZ as a part of the Indo-German technical cooperation, its goal is to make sustainable mobility a reality in our capital region. I especially want to thank all the collaborators for their wholehearted support, expertise and contribution in preparing this document. My hope is that the tools and guidelines shared here serve as a helpful reference for other cities undertaking similar operations.



17/11/19
(Arun Bothra)



PREFACE



Dipti Mahapatro, OAS
General Manager (P & A)
Capital Region Urban Transport (CRUT)
Bhubaneswar

In 2010, the Bhubaneswar-Puri Transport Services was created with a mandate to manage and operate bus services on intra-city as well as inter-city routes within the capital city of Bhubaneswar, and between Bhubaneswar, Puri, Cuttack and Khurda. On May 4, 2018, the BPTS evolved into the Capital Region Urban Transport, more commonly known as CRUT, with the vision to reorganise public transit services in the city.

As part of their efforts to offer technical and capacity-building support to sustainable mobility projects in Bhubaneswar, Integrated Sustainable Urban Transport Systems for Smart Cities (SMART-SUT), in partnership with the Capital Region Urban Transport (CRUT), Bhubaneswar, have prepared a guidebook called *Bhubaneswar on the Move: Tools and Guidelines for City Bus Operations*. This guidebook documents the tools and practices that Bhubaneswar has adopted over the last one year (since the launch of the Mo Bus services on 6th November, 2018) with the support of SMART-SUT, and with the goal of streamlining its city bus operations. It collates useful information on addressing issues faced during bus operations running on PPP models, specifically the Gross-Cost Contract (GCC) model, and provides detailed insights on a variety of relevant topics, such as the organisational structure of an SPV, job descriptions, the standard operating procedures, processes for the

planning and monitoring of bus services, training and capacity building of the organisation's staff, etc.

This guidebook is intended to act as a ready reference for other Indian cities (especially those focussing on gross-cost contract models for their buses) to adapt and use. It does not claim to substitute any existing comprehensive manuals on bus operations planning, management or capacity building. Some aspects in the document are technical in nature, while others can serve as a tactical guide for practitioners on operations planning and as a ready reckoner for understanding the roles, responsibilities and training needs within a city bus agency.

As bus operations is a dynamic field, this guide is expected to be updated regularly to include technological advancements. Bhubaneswar's bus modernisation strategy includes the introduction of e-buses in the coming years, and at that point, the organisational structure proposed here will be modified to include this. This will also lead to the inclusion of new processes, especially those related to bus maintenance, training and capacity building, etc.

I hope this guidebook adds to the existing knowledge on the subject, and that cities find it a useful tool for planning and managing their bus operations.

Dipti Mahapatro

BHUBANESWAR ON THE MOVE: TOOLS AND GUIDELINES FOR CITY BUS OPERATIONS

SUMMARY

Context

As cities become the engines of economic growth, effective mobility becomes more and more of a central requirement. In this context, a decided preference for personal automobiles makes cities major contributors to GHG emissions, air pollution, noise pollution, congestion – not to mention increasing incidences of road accidents, all of which negatively impact the health and productivity of the citizens.

The most common and widespread response of the governments has been to expand the existing road spaces and create flyovers and similar road-based infrastructure, with the hope of accommodating the exponential growth of vehicles. Another response has been to increase the sanctions for rail-based mass-transit projects (like the metro). However, owing to their high costs and limited coverage, these have had low user-appeal, and have not yet succeeded in getting anywhere near their expected ridership targets.

Given that a major share of urbanisation in India is expected to take place in her small and medium-sized towns and cities (which typically

have low densities and trip lengths averaging between 4-8km), and given that the road infrastructure capacities in these cities is limited, there is an urgent need to place a road-based, more ubiquitous, and low-cost public transport system (like the bus) at the heart of our plans and policies. This could be a safe, cleaner (less emitting), more space-efficient alternative, and if prioritised, has the ability to perform at par with high-speed rail systems.

The introduction of public-private partnership (PPP) models in urban bus operations in India over the last few years has thrown up a number of challenges as well as opportunities for re-looking at how bus operations can be managed and monitored in cities. An increasing number of cities are procuring fleets (under the aegis of various government schemes), and forming Special Purpose Vehicles (SPVs) for running bus operations. However, due to the absence of suitable guidelines, many of them still follow the practices of State Transport Undertakings (STUs), which may not be an optimal approach for addressing the nuances of city bus operations running on PPP models. These agencies often have limited in-house capacity for estimating



infrastructure requirements, service planning, and setting up of key performance indicators; regular capacity building, though extremely important, is often overlooked, and needs to be institutionalised. This guidebook attempts to address all these aspects of city bus operations.

About CRUT and the Guidebook

Capital Region Urban Transport (CRUT), Bhubaneswar, is a young organisation currently operating 200 buses on 21 routes across

Bhubaneswar, Puri, Cuttack and Khurda, using the gross-cost contract (GCC) model. It has successfully recorded a daily ridership of 1 lakh commuters in October 2019. As part of its ongoing efforts to offer technical and capacity-building support to sustainable urban mobility projects in Odisha, SMART-SUT, in partnership with CRUT, has prepared this guidebook, entitled *Bhubaneswar on the Move: Tools and Guidelines for City Bus Operations*. It documents the tools and practices that have helped CRUT set up its



efficiency of its buses in Bhubaneswar and the capital region over the last one year (since the launch of the Mo Bus services in November 2018).

The guidebook collates useful information on various aspects of city bus operations (especially those operating on the gross-cost contract model). The topics covered range from organisational structure and job descriptions to standard operating procedures, reporting formats, methods to be adopted for service planning, setting up of key performance indicators, and a list of recommended training modules and curricula, all of which can act as a ready reference and offer guidelines for other Indian cities implementing bus operations on similar models.

The guidebook consists of three parts, each focusing on a different aspect of city bus operations.

Part 1: Organisational Structure and Processes

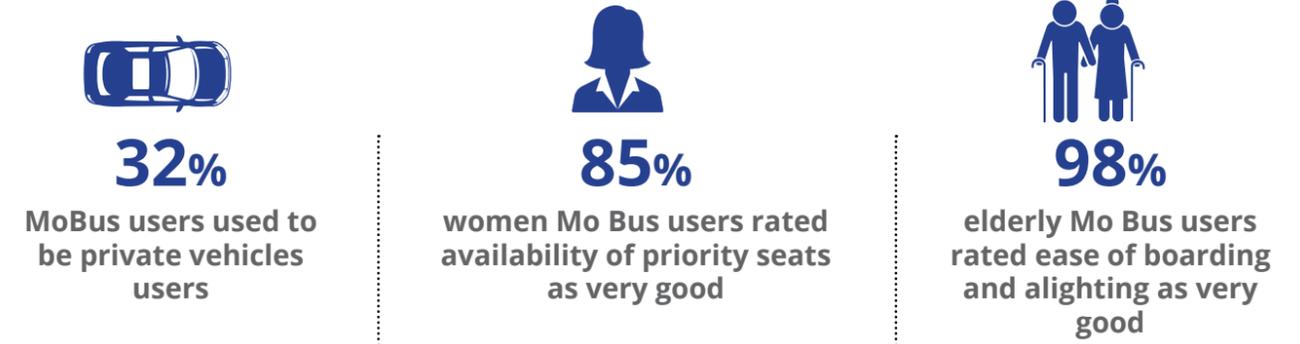
Part 1 of the guidebook proposes a compre-

hensive organisational structure that can be helpful in managing the large amounts of manpower that GCC operations typically require. Under this model, services need to be procured from multiple private partners, and the city bus agency is required to closely monitor the roles and performances to ensure quality and avoid the duplication of responsibilities. To help with this, a list of Standard Operating Procedures (SOPs) for various functions within a bus organisation has been provided, along with an exhaustive list of job descriptions for all employees. The SOPs have been prepared after extensive and critical study of the practices followed by STUs, bus companies, and bus operators. These generally exist only in memos and internal circulars, and are not readily available in the public domain.

Part 2: Planning, Scheduling and Monitoring

The prime objective of transit agencies is the provision of efficient and cost-effective services, and service planning and monitoring form

* Surveys conducted by GIZ (2019)



the key components in achieving this. Besides sharing some key technical terms (related to bus-operations planning) and their meanings, Part 2 also provides step-by-step guidance on subjects like planning bus infrastructure (fleets, depots, terminals and bus stops) and services (networks, bus stops, bus routes, schedules and fares). It also shares guidelines for performance monitoring of technology, demand, supply and fleet-based indicators. This section can serve as a practical reference for any city, for planning, scheduling and monitoring its bus operations.

Part 3: Training and Capacity Building

Organisations investing in and committed to meticulous and consistently high-quality training

programmes are known to have better operational efficiency and performance levels. Part 3 of the guidebook talks of the training and capacity-building needs of city bus agencies; it provides detailed guidelines on the categories of staff to be trained, proposes training modules with their ideal durations, class sizes, and the topics to be taught, suggests the frequency of conducting trainings, and lists the expected outcomes. It also includes a list of topics for induction and re-orientation training. These trainings attempt to cover the needs of the various categories of staff ,and can be adapted by a city bus agency based on the staff and resources available to them. The schedules proposed have been designed to ensure that each employee gets the opportunity to undergo training at least once a year.



1. Introduction

The prime objective of public transit agencies is the provision of efficient and cost-effective services. Service planning and monitoring form the key components in achieving this goal. Towards this end, it is necessary to set up proper service design standards and clearly define the performance monitoring systems.

2. Definitions

The technical terms used in this document often have varying usage across geographies. This section lists the specific meanings of such terms to facilitate a common understanding and the effective use of this document.

- **Average Passenger Trip Length:**

Also called Average Trip Length (ATL), this is the average distance travelled by passengers on the transit system.

$$\text{Average Trip Length (km)} = \frac{\text{Sum of Individual Passenger Trip Lengths (kms)}}{\text{Number of Passengers}}$$

* Individual passenger trip lengths may be obtained from the ticket data provided by the Electronic Ticketing Machine database

- **Cycle Time¹:** This is the total time taken by a

bus to complete one round trip, including the layover and recovery times at both ends of the trip. It is the time gap between two consecutive starting times of the same bus from the same origin. Cycle times can vary at different times of the day due to varying traffic conditions.

- **The Deadhead Operation of a bus:** The time taken and the distance the bus travels in no-revenue mode, i.e. during which no passengers are picked-up, is called the deadhead operation of a bus. This is typically when a bus travels between the bus depot/parking lot and the

¹ Also referred to as the “round-trip-time”, or “RTT”.

origin origin/last stop of the bus stop of the trip, or when it heads towards a maintenance facility within or outside the depot, during trips to the regulatory authorities for getting roadworthiness certification, and/or for any purpose other than the scheduled revenue-earning operations. It is also commonly referred to as “dead kilometres” or “dead hours”.

- **Downtime:** The time when a bus is not in operation for any reason, including awaiting repairs or maintenance, waiting for the crew, etc.
- **Dwell Time:** The scheduled stop times at a bus stop for alighting and/or boarding of passengers is called the dwell time.
- **Frequency:** The number of buses passing a point along a route within a given unit of time is called the frequency of the bus. It is usually expressed as number of buses/hour. Headway (below) is the inverse of frequency.
- **Headway:** The time interval between two consecutive buses running in the same direction on the same route is called the headway. It is usually expressed in minutes. Frequency is the inverse of headway.
- **Layover:** Often determined by labour agreements or similar regulations, a layover refers to the amount of time allocated to the bus crew to rest, or take a break between trips². Layover time, ideally, has to be provided at a

bus terminal, depot, or any other location that has basic staff amenities like toilets, shaded rest areas, seating, drinking water, etc.

- **Mode-Share:** The percentage of person trips catered to by a certain mode of transport such as private cars, buses, walking, etc., compared to the total person trips that occur in the area under consideration is called the mode-share.
- **Occupancy Ratio (OR):** The ratio of passengers carried, versus the passenger capacity of the bus is called the OR. Also commonly called the “load factor”, it is calculated as follows:

$$\text{Occupancy Ratio (OR)} = \frac{\text{Sum of The Individual Passenger Trip Lengths}}{\text{Passenger Capacity of Bus} \times \text{Service Distance}}$$

- The OR can be calculated for an individual trip or for a specific period. The most common usage of OR is the value averaged over a whole weekday.
- **Passenger Capacity:** The capacity of a bus is calculated very differently in different types of services and geographies. In cases of regional/long-distance bus services, the passenger capacity is counted as the number of seats/berths in a bus; for urban bus services, standing during transit is considered acceptable, and is counted under passenger capacity. Typically, in city buses, the passenger capacity of a bus is considered to be 150% of the number of seats in the bus. However, with new seating

² Also occasionally referred to as the “recovery time”.

configurations coming up primarily to allow for more standing space in buses, the same principle may not hold.

For the purposes of CRUT, the capacity of the standard 12 metre-long bus and the 9 metre midibus are to be taken as 60 and 40 passengers respectively. An Occupancy Ratio (OR) greater than 1.00 indicates crowding, whereas an OR of 65% means that all the seats are occupied.

- **Passenger Kilometres:** The sum of the individual passenger trip lengths for the time duration under consideration (usually over a day, but sometimes over a set of trips) is called passenger kilometres.
- **Recovery Time:** The time built into the schedule, usually at a terminal/stop at the end of the trip, to take care of the en route variations in trip time, and ensure an on-time departure for the next trip. In cases of long-distance travel, recovery time can also be provided at the intermediate stops (the same is not advisable in case of city bus services).
- **Revenue Kilometre:** The number of kilometres of service on bus routes available to passengers for travel. This excludes the dead kilometres. It is typically calculated per route, or for the route network, or per bus per unit period (like a day).
- **Revenue Hours:** This refers to the number of scheduled hours of service provided by a bus,

typically calculate per route that passengers can avail for travel. This time excludes the deadhead hours, but includes the layovers and the recovery times. In India the revenue kilometre is more commonly used to measure this.

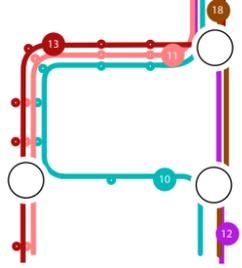
- **Route:** A route is the specified path taken by a bus, along which the passengers are picked up or allowed to disembark. It is usually designated by a number and/or a name.
 - **Schedule:** The schedule is the operation timetable for a bus or crew. It refers to a document given to the bus operator and the bus driver, which specifies
 - the starting point of the bus, and
 - the starting and ending times for each revenue trip, through specified time points
- Ideally, a schedule contains a detailed summary of the timetable including, but not limited to,
- Vehicle deployment hours (from starting time to the ending time)
 - Dead time
 - Revenue kilometres
 - Dead kilometres
 - Schedule ID, etc.
- **Schedule Efficiency:** The ratio of revenue generated to the total distance traversed by a bus is called the schedule efficiency. This parametre helps to track the extent to which a schedule is able to avoid dead kilometres. This can be aggregated by route, by depot, or by the whole fleet.
 - **Short Turn:** A route truncated at an

intermediate point instead of travelling the full length originally specified is called a short turn. This mechanism is often used to provide additional capacity/frequency in a specific segment of the route where the passenger demand is higher.

- **Time point:** These are designated locations/stops along a route used to guide the driver to keep to the time schedule. Typically, a bus can arrive before, but not leave earlier than the scheduled time from these locations.
- **Total Distance:** The total number of kilometres a bus travels, including revenue kilometres, deadheads, and for maintenance/servicing.

- **Turn-back:** The physical location along a route where a short-turn trip turns and starts service in the opposite direction is called the turn-back. This could be an off-street facility, or just an intersection along the route that facilitates the turning of the bus. In case of the latter, either the last stop before the turn, or the first stop after the turn needs to have holding space to park the bus until it is time for the next trip.
- **Vehicle Hours:** The total number of hours travelled by a bus, including those for revenue kilometres, layover time, and deadhead travel.





3. Transit System Planning

For any city to serve the mobility needs of the public and serve as a backbone for sustainable economic growth, making provisions for mass transit is a critical service.

City bus operations are an extremely complex and labour-intensive service. Further, due to various externalities and on-transit costs, it suffers from being financially unviable. Planning is critical to ensure efficiency in the system.

Transit system planning can be classified into three broad categories:

- I. Infrastructure planning
- II. Services planning
- III. Performance monitoring

All these categories are interdependent, and must be engaged with simultaneously. Each is presented in detail in the following sections.

3.1 Transit Infrastructure Planning

Transit infrastructure planning is a macro-level exercise. While this may not require frequent revisions, the execution and maintenance of the same do require attention on an ongoing basis.

The following is a list of essential services. Each component plays a critical role in providing efficient and effective public transport services that cater to the mobility needs of the passengers. The subsequent sections detail out the underlying principles, the quantum and functionality of each.

- I. **Bus fleets** – for transporting passengers
- II. **Bus depots** – for parking, maintenance and staff amenities
- III. **Bus terminals** – for convenient interchange between routes, and staff changeovers
- IV. **Bus stops** – for passenger pick-up and drop
- V. **Intelligent Transportation System** – for data collection and operational efficiency

3.1.1 Bus Fleets



The bus fleet is the very first and basic requirement of a mass transit service. Various considerations apply in determining the bus fleet for a city. Here are two simple methods for planning the quantity and type of bus fleets, depending on pre-decided policies and objectives.

This method is primarily for estimating the minimum fleet for which the other supporting infrastructure is to be planned. A method for determining the exact fleet size has been presented later in the document.

Calculating the Minimum Operational Bus Fleet Requirement – Method 1: The Supply Side

The first method of fleet estimation is based on supply-side parameters, such as the route networks intended to be served by public transport, and the intended minimum frequency of service as per policy. The function is as follows:

$$\text{Minimum Bus Fleet} = \frac{\text{Network Route length (km)} \times \text{Frequency of Service (buses/hr)}}{\text{Average Peak Hour Speed (km/h)}}$$

- **Network Route Length:** This is the total length of road network intended to be served by the city bus service, measured in both directions in kilometres.
For example, if the transit service needs to cover 100 km of road network in the city, of which 15 km is constituted by one-way streets, then the network route length to be used in this function is calculated as: $(100 - 15) * 2 + (15) * 1 = 185 \text{ km}$
- **Frequency of Service:** The frequency of bus service will vary across the road network, depending on passenger demand. In this method, the average minimum service standard frequency during the peak hours is considered.
For example, if the policy is to operate a bus every 3 minutes on the service network, then the frequency of service is 20 buses per hour. However, if more detailed information on the service frequencies at the different links of the transit network becomes available, then the

minimum fleet requirement can be calculated individually, and then summed up to arrive at the minimum fleet requirement for the region.

- **Average Peak Hour Speed:** This refers to the average speed of traffic on the route network during the peak hours. If detailed data (the

individual link speeds of the network) is available, the same can be calculated individually.

The transit speed should account for buses stopping to pick-up and drop-off passengers along the route.

A Sample Calculation:

- The city of Bhubaneswar has 180 km of arterial and sub-arterial road networks. Considering that the bus routes will span across this network, and assuming that all of them are two-way roads, the total network length comes to 360 km.
- Adhering to CRUT's vision of achieving 40% mode-share, let us assume a convenient bus service that operates every 2 minutes, indicating that the frequency is 30 buses/hour.
- Consider the average peak-hour speed to be 18 km/hr.

Hence, the minimum operational bus fleet =

$$\frac{360 \text{ km} \times 30 \text{ buses / hr}}{18 \text{ km / hr}} = 600 \text{ buses}$$

- It should be noted that this method does not take the demand aspects into consideration, and hence does not allow for determining the size of the buses.

Calculating the Minimum Operational Bus Fleet Requirement – Method 2: The Demand Side

The demand side method of assessing fleet requirements is a little more complex, and needs inputs on the general travel patterns in the city. The function for fleet determination is as follows:

Minimum Pax³. Capacity =

$$\frac{\text{Motorised Trips} \times \text{Intended Mode-Share} \times \text{Avg. Trip Length (km)}}{\text{Avg. Daily Revenue Distance of a Bus (km)}}$$

Minimum Operational Bus Fleet =

$$\frac{\text{Minimum Passenger Capacity}}{\text{Pax. Capacity of Bus} \times \text{Expected Occupancy Ratio}}$$

- **Motorised Trips in the Service Area:**

This variable indicates the total demand existing in the area for motorised modes of travel. It is the product of the total population of the region and the average per-capita number of trips made by motorised modes. This information is usually sourced from household travel surveys conducted in the region.

For example, consider Bhubaneswar city, with a population of about 1 million. According to the estimates of the *Bhubaneswar City Bus Modernisation Plan (2018)*⁴, the average per-capita motorised trip rate is 0.74/day (this figure is expected to rise in the future). Hence,

the total daily motorised trip demand of the city is estimated to be 0.74 million trips/day.

- **Mass Transit Mode-Share:** This refers to the intended percentage of motorised trips serviced by public transport. CRUT's near-term vision is to achieve a 40% mode-share by the city bus system. Hence, using the estimated number for the total motorised trips in Bhubaneswar (0.74 million trips/day), the total daily travel demand to be addressed by the bus system in the city = 0.74 million trips x 40% = 2,96,000 trips
- **Average Trip Length (ATL):** This is the average distance travelled by people in the region through availing motorised trips. This information

³ "Pax", in this context, refers to "a passenger".

⁴ The detailed project report for the *Bhubaneswar City Bus Modernisation Plan*, UMTC, May 2018

can be sourced from household travel surveys. It should be noted that public transport trips are usually longer than those using private vehicles. Hence, it is ideal to use the ATL for public transport trips wherever possible.

- **Average Daily Revenue Distance:** The estimated average distance for which a city bus is available per day for passenger service, not

including the dead kilometres.

For example, if a bus is intended for operation throughout the day (typically for 10 to 12 hours), and if the route network has an average speed of 18 km/hour in the peak hours, the average daily distance for the bus is between 180 and 230 km in a day.

A Sample Calculation:

Given that

- Motorised trips in Bhubaneswar city = 0.74 million
- The intended mode-share for bus services = 40%
- The average trip length of transit passengers = 10.21 km
- The daily average revenue distance of a bus = 200 km
- The passenger capacity of a bus = 40 Pax (assuming all 9 metre midibuses)
- The planned occupancy ratio = 70%

Then, the minimum operational fleet =

$$\frac{740,000 \text{ Trips} \times 40\% \times 10.21 \text{ km}}{200 \text{ km} \times 40 \text{ pax/ bus} \times 70\%} = 540 \text{ buses}$$



This method assumes that the demand is spread uniformly across the day, which does not happen in practice. Considering slower travel speeds and higher demand during the peak hours, the actual minimum operational fleet needed would be 10–15% higher.

While the supply-side method identifies that a minimum operational bus fleet of 600 would be required in order to meet the service standard headway of 2 minutes across the arterial and sub-arterial networks of the city, the demand-side assessment suggests that fleets of midibuses will suffice to meet the traffic demand at the time of the study.

The actual operational bus fleets for a city should anticipate the network characteristics and the travel demands of the near future. The current trend in Indian cities points to a steadily rising per-capita trip rate due to various socio-economic factors, and this has the potential to increase travel demands significantly, even if the population of the region remains stable.

The network travel speeds during the peak hours are worsening due to the same factors. For example, if the average peak hour speed of buses reduces from 18 km/hour to 16 km/hour, then the operational fleet requirement will increase to 675, and severely and adversely impact the cost of transit operations. Transit agencies need to be watchful of such changes in the environment, and work closely with the local governments to mitigate the impacts of the same through improved intersection design, optimising the transit signal priority, providing dedicated bus lanes in congested sections, and by applying travel demand management measures (such as restricting parking and the movements of private vehicles).

Spare Bus Fleets

The computations presented earlier in this section were to determine the size of fleets that are deployed into service each day. In order to facilitate routine preventive maintenance of the fleets, and to account for possible breakdowns or accidents, it is necessary to maintain additional buses or spare fleets.

Compared to regional operations, city bus

operations usually need to reserve more of their fleet as spare, as these experience a higher rate of wear-and-tear and minor accidents. While a well-managed and well-maintained city bus fleet will typically have 5% buses as spare, transit agencies can bring this down to 3% by streamlining their maintenance practices. Most city bus systems in India have 5–10% of their fleets out-of-service for maintenance at any given time (10% is indicative of poor upkeep).

$$\text{Total Bus Fleet} = \frac{\text{Operational Bus Fleet} \times (100)}{100 - \text{Spare Fleet (\%)}}$$

A Sample Calculation:

Consider a fleet of 100 buses. After being in operation for about 5,000 to 6,000 km, in addition to undergoing routine checks after the end of the scheduled operations every night, each of these buses need comprehensive preventive maintenance once a month.

Assuming 25 working days a month for the maintenance crew, 4 buses will have to be removed from service each day so that each bus can be inspected once a month, rendering 4% of the fleet as spare. In an extremely efficient and well-planned system, the maintenance manager may be able to stagger the maintenance of the buses such that 2 of them are inspected in the morning schedule and the other 2 in the evening, thereby needing to reserve only 2% of the fleet as spare.



Additionally, one bus always needs to be reserved in the depot, ready to be deployed into service in case of a breakdown/accident of an operational bus. Thus, the total bus fleet needed in this case can be calculated as follows:

$$\text{Total Bus Fleet} = \frac{600 \times (100)}{(100 - 5)} = 632 \text{ buses}$$

Many technical considerations can come into play while procuring the bus fleet, especially mechanical and safety-related choices that depend upon the terrain, the weather conditions, the type of fuel used, the emission standards, costs, etc. Those are outside the scope of this document. However, from the planning perspective, the following need to be considered:

- The physical dimensions of the bus should

be chosen, keeping in view the road widths and the turning geometry along the route network.

- The height of the first step (from the ground level) to the entry and exit doors of the bus should preferably be the same for different bus models in the fleet. This facilitates level-boarding, and helps in designing the bus stops for disability access.

3.1.2 Bus Depots

A bus depot is one among the most essential infrastructures necessary for operating a city bus system, and is abuzz with activity round the clock. Keeping in mind the peaking nature of public transit operations, the numbers, location, and size of depots must be planned to enable friction-free movement of buses within the depot, accessibility to routes, optimal managerial effectiveness,

maximum utilisation of facilities and resources, minimisation of dead mileage operations, etc.

This section details the various functions of a bus depot, and the basic principles for determining the optimal number and size of depots.

The Location of a Bus Depot

The prime consideration for the location of a bus depot is its accessibility to/from the main urban roads, and its proximity to/from the terminal points of the route network. The depot location should help to minimise the dead kilometres. Ideally, there should be no dead kilometres; this can happen if the depot is located at the route's end, i.e. if an integrated depot-cum-terminal facility is developed. In order to limit the dead kilometres to 5% of the total distance travelled by a bus, a bus depot should be located within 2-3

km of the route serviced by the fleet.

The bus depot is also the hub of all transit-related activities, and is accessed by hundreds of staff and officers daily. It is critical to locate the depots centrally, especially in cities which do not have extensive organised transit operations, and where only a few depots exist. Since it is extremely difficult to find large parcels of land in developed cities, it is prudent to earmark spaces (even if these spaces are less than optimal) uniformly distributed across the service area.



The Number of Bus Depots

There are two key criteria for deciding the number of bus depots required in a city:

- **The Number of Buses in the Fleet:** A rule of thumb is to have one depot for every 100 buses in the fleet. This has been estimated by balancing the costs of setting up a depot and limiting the deadhead for the buses.
- **The Extent of the Route Network:** Increasing

deadheads result in severe operational expenses. Hence a depot should be planned within 2.5 km of the point of origin/destination of the buses. Assuming a nearly uniform radial distribution of the service area, this translates to having a depot for every 20 sq. km of the same.

Example: Considering the data from the earlier example of Bhubaneswar,

- The city requires a minimum of 635 buses – which roughly translates to 7 depots.
- The spread of the city – starting from Khurda to Nandankanan – is about 150 sq. km. By the second principle, the city needs about 8 depots to limit the deadheads and for optimal fleet operations.

The Size and Functionality of a Bus Depot

The various functions served by a bus depot and some generic planning considerations for the same are discussed below.

- **Parking & Maneuvering:** A basic function of a depot is to provide a secure parking space for the fleet. A standard bus requires about 56 sq. m of area for parking, while a midibus requires only 41 sq. m. About 7,500 sq. m and 6,000 sq. m respectively of additional

space is required, for maneuvering across the depot, fuelling, cleaning, repairs and parking. For a standard-sized fleet of 100 buses, parking and maneuvering will require about 5,600 sq. m and 7,500 sq. m of depot space respectively. To avoid dust and the formation of potholes, the entire parking and maneuvering area of a depot should be strengthened and paved, preferably with cement concrete hardstanding.

- **Fleet Maintenance:** A robust maintenance



infrastructure along with a well-trained maintenance crew is the backbone of a good city bus system. Urban operations involving frequent stops and starts entail extensive wear-and-tear of buses, and require rigorous monitoring of the mechanical, electrical and structural elements to ensure safe and reliable operations. It calls for well-equipped and extensive workshop infrastructure not only for day-to-day repairs, but also for scheduled preventive maintenance, periodic road worthiness certification, etc. A rule of thumb is to have one inspection pit for every 20 buses and one repair bay for every 50 buses in the fleet.

- **Fuelling:** To avoid additional trips (dead kilometres) for refuelling, it is useful to have a dedicated fuel-storage and dispensing system in a bus depot. It also helps to ensure that fuel quality standards are met, and malpractices like fuel pilferage, short supply, etc are avoided. Digitally equipped fuel-dispensing systems also provide online data about the quantities of fuel supplied to each bus. Fuel stations need to have a storage capacity sufficient for about 5–7 days. The installation of fuel stations requires safety measures and permissions, which should be adhered to, based on guidance from the oil marketing companies.
- **Washing & Cleaning:** Internal and external cleanliness of the buses help to build the brand value of the public transport system. Generally,

automated pressurized water and/or mechanised brush-type cleaning systems that are able to wash the bus exterior faster are used. Although washing the exterior takes only about 3 minutes, the process of picking the bus from the parking bay, completing the washing and sending the bus back to parking may take anywhere between 8–12 minutes. The placement of the automatic washer should be such that it facilitates a smooth and easy movement of the bus during entry and exit, and expedites the process. The number of washing systems can be decided upon and procured after considering the overall washing cycle time per bus and the availability of buses for washing. A heavy-duty vacuum cleaner needs to be provided for internal cleaning, esp. of the bus floor.

- **Building Space:** Secure building space should be designed for:
 - Storing spare parts and equipment
 - Staff amenities such as rest areas, changing rooms, lockers, toilets, etc.
 - Training facilities
 - Office space for assigning staff duties, cash handling, etc.
- **Staff Vehicle Parking:** The depot should have open space for staff vehicle parking. A depot

with 100 buses typically employs 550 to 650 staff working in three shifts. Assuming that most of the staff use two-wheelers, this amounts to a requirement of nearly 700 sq. m of open parking space.

- **Security Post:** The security post in a bus depot plays an important role in recording vehicle dispatch/in-shedding information, as well as

for other parameters defined in the Service Level Agreement. The design of the security post should take these into consideration.

Depot Space Allocation Summary: For a fleet of 100 standard 12 metre-long buses, a typical bus depot requires 6 acres of land area, distributed amongst the various activities as presented in *Table 1*.

Table 1: Space Requirement for Various Activities in a Bus Depot

Depot Component	Area Required (acres)
1. Bus Parking	1.38
2. Bus Maneuvering	1.85
3. Engineering	1.25
4. Office Space	0.35
5. Staff Parking	0.17
6. Peripheral Green Space	1.00
TOTAL:	6.00

3.1.3 Transit Terminals



Transit terminals are to passengers what bus depots are to buses. They facilitate the termination/starting of routes, as well as the boarding-alighting and transfer of passengers between routes and/or modes of transport. Terminals of different sizes and with varying facilities may be developed to serve the needs of the public transit system, such as route cluster ends, route and/or mode transfers, crew changeovers, short-term idle parking of buses and other modes, etc. The facility usually includes other passenger and bus crew amenities as well, such as shelters, benches, bike racks, restrooms, and kiosks with schedules and maps.

The number or size of the transit terminals depends on the needs of the bus operations and the passengers. However, terminals should typically be developed where multiple routes cross, originate or terminate, at the mode/route transfer locations, or in places with heavy passenger activity.

The actual design of a transit terminal is beyond the scope of this document. However, some basic principles⁵ to consider while planning a bus terminus are:

- The platform width must be at least 1 metre, to enable a passenger flow rate of 25 persons/minute.
- The platform waiting area should afford at least 1 sq. m for every waiting passenger.
- Stairways should have a width of at least 1 metre, to enable a pedestrian flow rate of 20 persons/minute.

Additionally, the following features may be considered for the convenience of both the passengers and the crew:

5 From a presentation on "Bus Terminal Design", made by Srikanth Shastry (WRI India) to the North Eastern Karnataka Road Transport Corporation (NEKRTC). Gulbarga, May 2013.

• Passenger Conveniences

- Passenger waiting areas
- Drinking water facilities
- Toilets
- Park & ride
- Route & schedule information
- Feeder services (auto-rickshaws, bicycle rentals, etc.)

• Staff Amenities

- Revenue office
- Control room
- Staff resting area
- Canteen
- Adequate bus holding area

3.1.4 Bus Stops

Bus stops are the designated locations where passengers board and/or alight from buses. Some key considerations for deciding the location and size of bus stops are as follows.

The Location of a Bus Stop

- Bus stops should be close to the city's activity centres
- The most preferred locations for bus stops are at the midblocks. However, depending on the intensity of boarding/alighting, bus stops may need to be shifted away from the midblocks, more towards the intersections.
- It is important to maintain a minimum distance of about 50 metres between the bus stop and the junction, on the far-side of the

junction, in order to minimise blockages caused by bus bunching. Exceptions can be made to the above if passenger activity is predominant on the near-side of the intersection. In such cases, efforts should be made to provide off-street bus bays so that the buses do not block the left-turn lane.

- The stops along a route should be separated by a distance of at least 300 metres. Placing stops too close to each other leads to increased travel times and fuel consumption.

The Features of a Bus Queue Shelter (BQS)

- The passenger waiting area should afford at least 0.8 sq. m per passenger.
- The preferred dimensions of a bus shelter: 15 metre long X 2 metre wide for each bay.
- The design of the BQS should allow for the following:
 - The roof should extend such that the passengers are able to board the bus without being exposed to rain or heat
 - The floor level should coincide with the height of the first step of the bus to enable level boarding
 - There should be no obstructions on the sides of the BQS to enable passengers to have a clear view of approaching or departing buses
 - A BQS should facilitate easy access for persons with special needs
- A BQS should be adequately illuminated
- The name of the BQS and its unique ID must be prominently listed, and clearly visible from the buses and from outside
- Multiple bus bays would be required in case the frequency of the buses exceeds 40/hr.
- The BQS should have convenient pedestrian access from the nearest intersection or from the major traffic generators.
- There should be adjoining secure bicycle-parking space.
- A major BQS needs to be integrated conveniently with feeder services.
- Bus stops should have space for displaying advertisements so that additional revenue can be generated for the PT agency.

3.1.5 Intelligent Transportation Systems (ITS)

Data collection and monitoring are the key aspects of any transit service planning exercise. It is now a common practice to use ITS to capture, store and analyse various operational parameters. The following technology infrastructures are necessary for improving transit operations.

- **Automatic Vehicle Location System (AVLS):**

This is essentially a Global Positioning System (GPS) unit that is connected through a data connection to the control centre, and relays the location of the bus in real-time. Though the AVLS is primarily used for tracking the location of the bus and providing passenger information, this data is also useful in improving the scheduling and regularity of PT services. The monitoring of vehicle speeds, stop durations, etc. also helps to analyse driving behaviour.

Real-time information about bus locations also provides information on route behaviour, traffic holdups, etc. to facilitate timely diversion of other buses, thereby avoiding delays. The frequency of data capture may be decided based on the transit agency's needs, to avoid unnecessarily loading the system. Intelligent Transport Management Systems (ITMS) further provide event alerts to the control room/on-board passengers as per requirement.

On-board Passenger Information Systems (PIS) provide information about stops to the passengers en route, to facilitate alighting from the bus at the desired place. Route details are

also conveyed to those waiting at the bus stops by way of audio-visual displays on the bus gates.

In recent times, bus fleets come equipped with a Vehicle Health Monitoring and Diagnostic system (VHMD) that captures various drive-cycle and diagnostic information such as engine RPM, fuel consumption, tyre pressure, engine oil levels, brake pad condition, etc. It is possible to capture all these parameters in real time or post completion of the day's schedule, analyse driver behavior, and plan for preventive maintenance of the bus.

The AVLS deployed in city bus services in India typically captures GPS data, and real-time locations of the bus are updated every 10 seconds. However, for detailed travel-time studies or driver behaviour analysis, data needs to be captured at a frequency of one second or more.

- **Automatic Fare Collection Systems (AFCS):**

This term is commonly used for cashless, electronic collection of bus fare using smart cards, QR codes, mobile ticketing, etc. Hand-

held Electronic Ticket Vending Machines (ETVMs) are also commonly used in PT systems for on-board ticketing.

While AFCS is primarily used for passenger convenience, the data captured by the system can be used to analyse and evaluate travel patterns and trip chains.

Transit Signal Priority (TSP): TSP technology allows transit vehicles to be prioritised at traffic signals. This effectively reduces traffic delays at the intersections, thus improving the journey speed and fleet productivity.

There are a variety of technologies by which this can be achieved. While detailing these technologies is outside the scope of this document, it may suffice to know that these are relatively simple to implement and have high returns on investment.

Given the fast pace of developments in the

technology space, the possibilities of using technology in the transit sector are ever-increasing, at steadily reducing costs. At the same time, certain technology hardware is rapidly becoming obsolete. Hence it is advisable for the transit agencies to avoid procuring ITS equipment and hardware at their own cost, and instead, outsource the provision of specific requirements of service and outputs to vendors. In this model, the vendors bear the costs of procuring and maintaining the technology and the software components, and charge the transit company a monthly service fee for providing the required features and analytical tools.

For efficient use of ITS components, the compatibility of on-board ITS devices (both hardware and software), control room equipment and software, and communication systems and devices needs to be ensured.

3.2 Transit Service Planning

Service planning is the process of effectively using the elements of a PT system to address people’s travel needs in a convenient, comfortable, affordable, and safe manner. From the initial data collected about the network characteristics, population and density changes, ongoing ridership and transit trip times, transit planning has been emerging as a fascinating but complex field.

Service planning is an iterative process. To continually improve services, these iterations must entail an intense process of schedule revision, monitoring of schedule adherence, schedule dissemination for passengers, and impact assessment.

All this must be done in a manner that promotes both economic and environmental wellbeing.

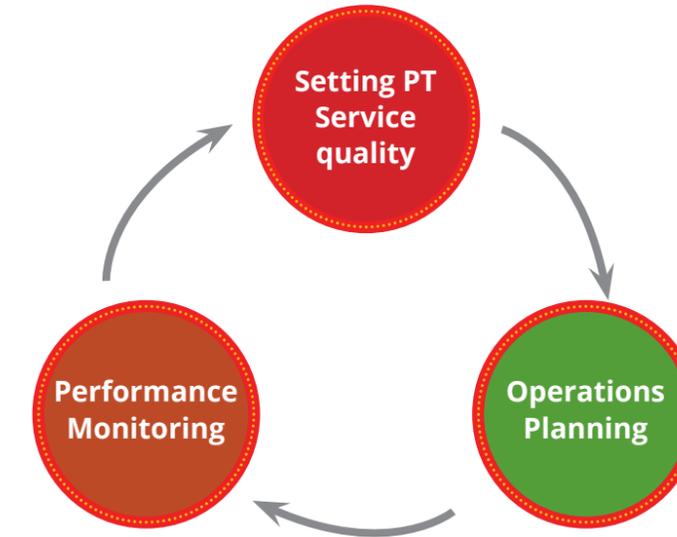


Figure 1: Iterative Process of Planning Urban Transit Services

3.2.1 Data Needs for Service Planning

Service planning is a data-intensive, analytical exercise. The first step to planning a transit service is to collect the following information:

- Population distribution (density) across the service area
- Demographic information – trip origins & destinations, the points of attraction and demand
- Road network details – road width, road type and function, pavement types, traffic volume (mode-wise), and travel speeds
- Available transit infrastructure – fleet size, age of the fleet, bus stops (locations, capacities, numbers), bus depots and terminals, etc.
- Transit user information – travel characteristics, travel demand patterns – spatial and

temporal; travel mode-share, the use of intermediate public transport (e.g. auto-rickshaws), routes, other socio-economic characteristics, etc.

- Labour laws, staff-union agreements on maximum duty cycles and overtime payments, etc.

This information can provide insights helpful in designing transit routes, the span and frequency of service, and pricing. Ideally, it should be possible to input all this data into a travel demand model that can then simulate the travel conditions and help decide upon the most effective transit service features to be adopted or retained. However, due to various reasons, the quality and extent of demographic and travel data available in Indian cities is extremely poor. This chapter describes some practical ways to think about designing and setting up a good transit facility.

3.2.2 Identifying the Transit Network

A city has many different types of roads based upon their physical and functional features, such as:

- The arterials and sub-arterials that function as the main roads, predominantly serving

through traffic

- The neighbourhood and collector roads that serve the trip-ends

In India however, the arterials and sub-arterials often perform hybrid functions due to the dense commercial developments along the roads.

These form the base road networks for PT, and are typically wider, multi-lane, at times separated by a divider, and carry a higher load of traffic. The collector streets are most suitable for IPT modes, and offer short-distance shared mobility with a high-frequency, small-sized fleet operating to and from passenger request-based origins/destinations.

The physical dimensions of a road, and the travel demand along it are the two main criteria that decide whether or not it qualifies as a part of the bus-based transit network. If the answers to all three following questions are positive, then the road link must be a part of the city bus transit network, and should be served by standard or midibus fleets.

1. Is the width of the paved road at least 10

metres (5 metres in case of a one-way street)?

2. Is the right of way of the road at least 15 metres (9 metres in case of a one-way street)?
3. Is the peak traffic along the road stretch greater than 800 persons/hour in a specific direction?

However, there are circumstances where certain roads have substantial demand that satisfies the traffic criteria specified above, but the available road widths are lesser than those required for bus operations. These should form a part of the Intermediate Public Transport (IPT) network, which operates at a high frequency and is served by smaller-sized, shared vehicles such as auto-rickshaws.

The *Bhubaneswar City Bus Modernisation Plan (2018)* has identified nearly 180 km of arterial and sub-arterial streets (Ref: Figure 2). All these roads satisfy the above criteria. A similar exercise needs to be conducted for the cities of Cuttack and Khurda, where the CRUT intends to operate its fleet. Such information on road widths and the right of way is usually available with the local authorities. Satellite maps freely available with various online mapping sites can also help in identifying such streets.

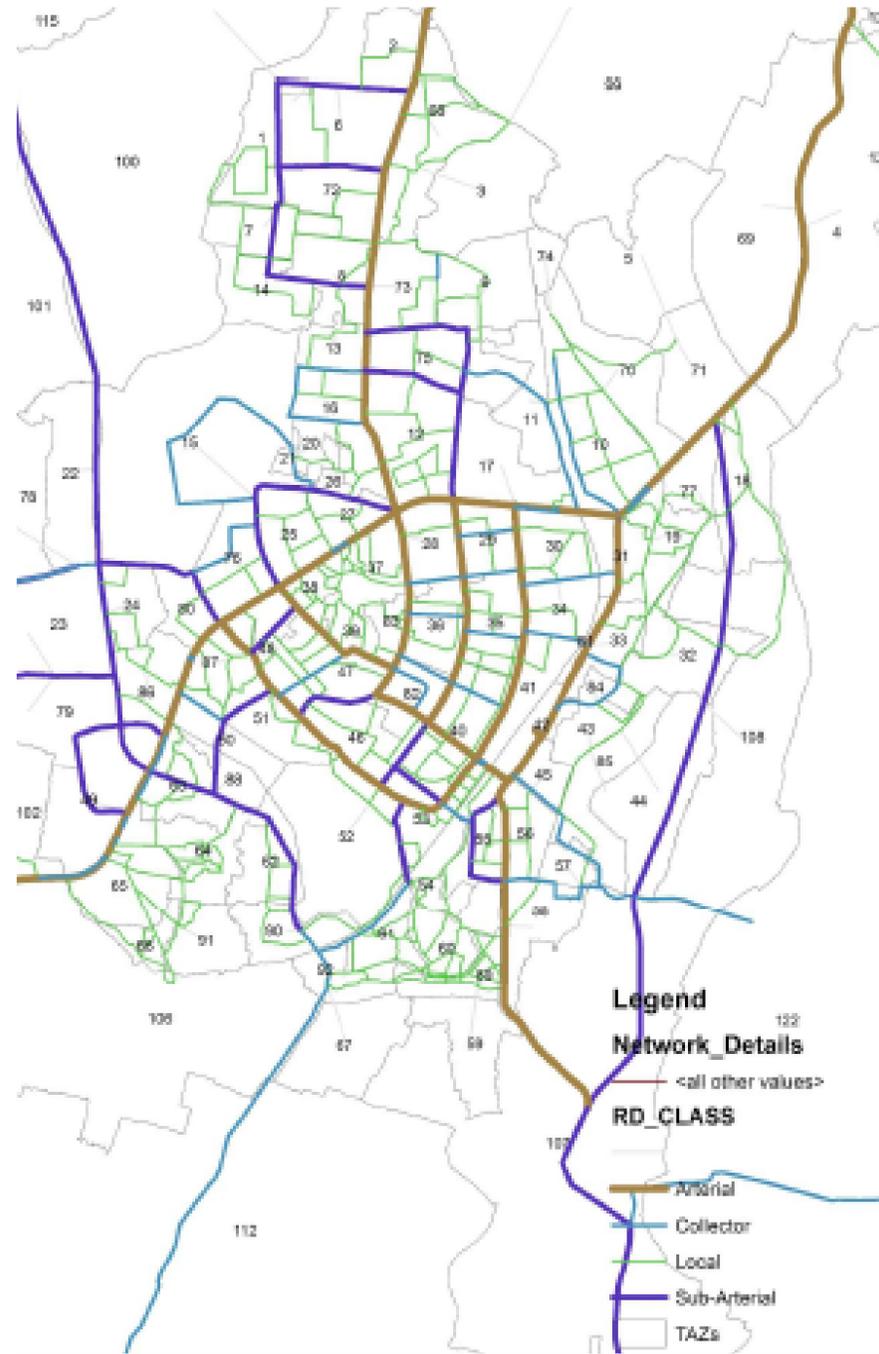


Figure 2: Hierarchy of Road Networks in BhubaneswarCity

It is necessary to conduct annual surveys to collect data on passenger traffic on these streets. Unlike in traffic counts where the number of vehicles is counted, for this analysis, the number of persons crossing a point should be counted. Drivers, taxi staff, auto-rickshaws, school buses and commercial vehicles should not be included in this statistic. This information may be available in comprehensive mobility plans for the city, which can be used if it is recent, or updated at regular intervals.

Whether or not to include a route in the PT network may be decided based on the route-wise

projected travel demand, road characteristics, and the adopted policy for providing PT services.

In view of the fast pace of growth of Indian cities and their transport infrastructures, road networks and new construction activities should be reviewed regularly, so that new segments can be added to the transit network. Bus services should preferably be launched early on along the new roads, to promote the use of public transport by the new settlers in the area. It is much more challenging to attract people to public transit after they get used to private vehicle travel.

3.2.3 Fixing Bus Stop Locations

Once the transit network is finalised, bus stop locations should be determined, based on the traffic generators and the attractions of the city. The location and design of the bus stops may follow the principles specified in the earlier section on transit infrastructure planning.

Note: Bus stop locations can be decided independently, or after finalising the bus routes.

3.2.4 Defining the Bus Routes

The process of transit planning so far has been relatively straightforward, and has required

review only a few times a year. In terms of analysis and the frequency of monitoring, the methods from hereon will increase in complexity, and the guidelines should be seen as experimentative rather than definite.

Identifying the Minimum Service Frequency on Individual Network Links

This step attempts to calculate the number of buses that should operate on each link/road/street of the transit network identified in the previous step. The minimum service frequency on a road link depends on the “person traffic volume” of the link and the service standard set for the area, where “person traffic” refers to the total traffic and not just the transit riders (i.e.,

Hourly Passengers = Hourly Person Traffic X Transit Mode-Share).

$$\text{Frequency of Service} = \frac{\text{Hourly Person Traffic} \times \text{Transit Mode-Share}}{\text{Capacity of Bus} \times \text{Planned Occupancy Ratio}}$$

This frequency of service, in theory, can be computed for each network link for every hour of the day, and also for weekday, weekends and holidays. However, accurately capturing such extensive data is nearly impossible. It generally suffices to assess the traffic along the network links for two periods – peak and off-peak. The level of passenger traffic can be estimated by collecting just 15 minutes of traffic data periodically.

A Sample Calculation:

Assuming that a 3-lane, two-way, undivided arterial road has a peak hour traffic of 3,000 persons/hour, and 2,100 persons/hour per direction during the off-peak hours.

Given that transit service is provided only on the prominent roads, to achieve CRUT's vision of an overall transit mode-share of 40%, the share of transit trips on the arterials will have to be higher, say by 20%, making the transit mode-share 48%.

From the previous example on fleet calculation, the planned occupancy ratio in the buses is 70%.

Thus, the frequency of service on the selected road link during peak hours =

$$\frac{3000 \times 48\%}{60 \times 70\%} = 34 \text{ standard buses/hour}$$

Similarly, the frequency of service during the off-peak hours will be 24 standard buses per hour.

*If the routes along this road are operated by 9 metre-long midibuses, the service frequency

There are two important points to note in this exercise:

- The choice of the size of the bus fleet depends on the minimum service standard decided by the city bus agency as a matter of policy. The higher the service frequency, the greater is the possibility of providing a more reliable service for the passengers. If the service standard is to provide at least one bus every 2 minutes in the peak hours, this standard can be satisfied by either the standard buses or the midibuses.
- It should also be noted that all the buses on this route segment do not belong to the same route, and will be going towards different destinations. Hence, the actual waiting time experienced by a passenger will depend on the number of different routes plying along a particular transit network link.

The transit service capacity may not always be exactly proportional to the person traffic along a street, especially in the case of a closely spaced grid street system.

Identifying the Major Traffic Generators

Apart from a few exceptions, travel in itself is not an end. People travel for a purpose: for work, for education, for entertainment, and so on. The next step in defining the bus routes is to identify the major traffic generators. These include the dense residential areas, the industrial clusters, government and private offices, the

regional transport hubs, the commercial centres, hospitals, schools, movie theatres, parks, etc. Figure 3 depicts some of the major activity centres of the city (the source of the image being the *Bhubaneswar City Bus Modernisation Plan*).

Once the activity centres have been identified, sample origin-destination studies should be undertaken to assess the quantum of travel demand that they generate, and identify their corresponding destinations. This exercise results in a demand-map with desire-lines indicating the direction of travel.

Insights for Route Design

The previous exercise provided the route planner with information on:

- The locations of various traffic generators and the transit stops closest to them
- The quantum of demand generated/attracted from these clusters
- The directions of these trips
- Estimating the frequencies of transit demand on the various links of the transit network
- The locations of the transit terminals which act as hubs and points of interchange

There are four distinct types of bus route designs, an optimised combination of which can be used to connect passengers to their destinations.

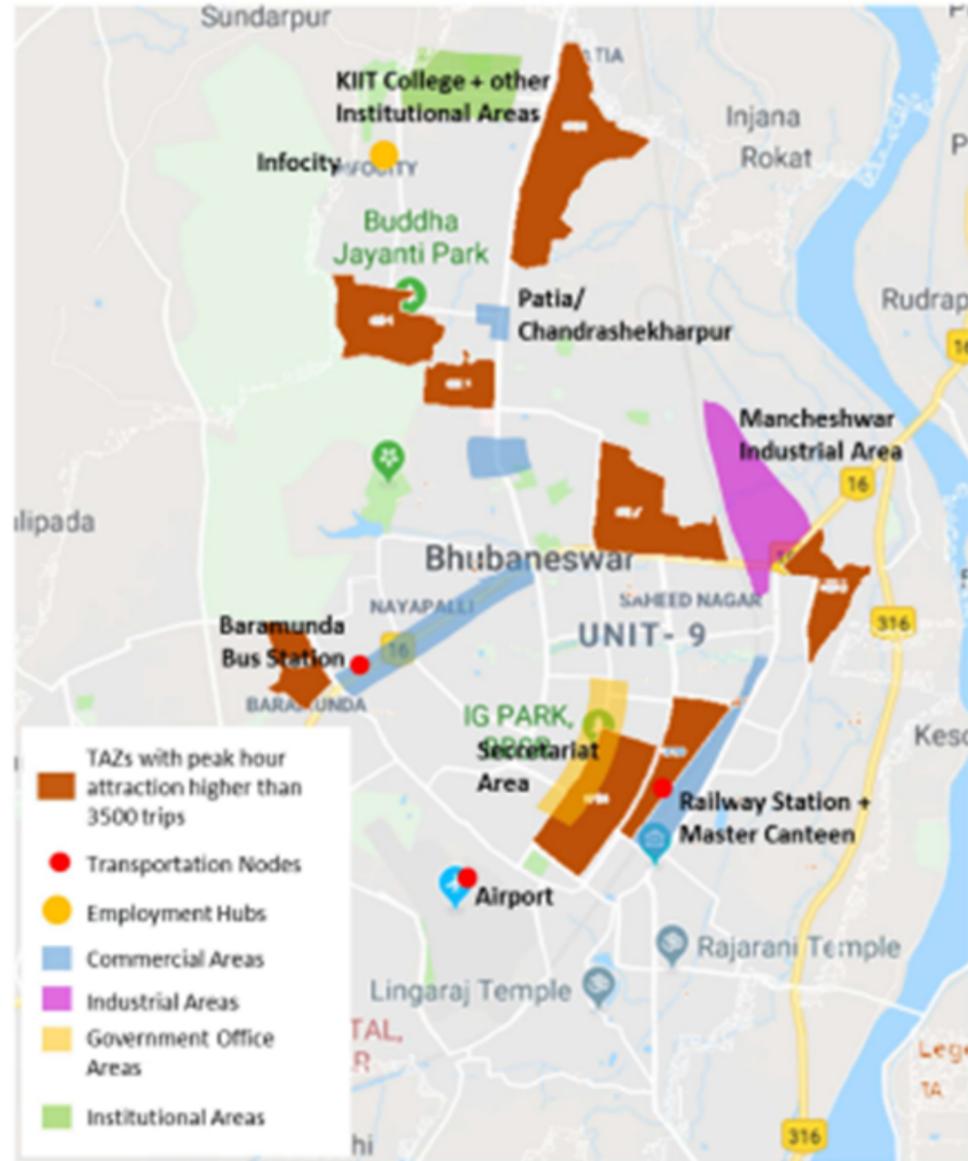


Figure 3: The major Activity Centres in Bhubaneswar City (Source: Bhubaneswar City Bus Modernisation Plan 2018 (UMTC))

- **Radial:** Routes focussed on passengers from remote clusters, which connect them to a major activity centre in the city.
- **Direct Connections:** These routes are designed to provide direct connections between two activity centres.
- **Hub & Spoke:** Most common in multi-modal transit systems, these routes are designed to culminate at the nearest transit hub, where the majority of passengers can transfer to another route to reach their destination. The hubs are connected with a high frequency of services.
- **Grid Pattern:** This approach focuses on connecting passengers across a grid pattern of high-frequency transit routes. It is designed such that every passenger can reach their destination by making one transfer. This is most suitable for cities having grid-type street networks.
- **Circular Routes:** These routes are commonly found in the core areas and along the inner ring roads of a city. They help to create intermediate connections for radial and direct connection routes.

From here on, route design will follow a method of intuitive trials. Since most trips originate at home, the plan is to start from the residential centres on the periphery, work inwards, and then repeat the process the centres in the reverse direction. The following is a very generic sequence of steps for designing a route from a

traffic-generating cluster:

- Estimating the transit demand from the cluster (40% of the total travel demand from the cluster)
- Identifying and plotting the destinations for these trips (from Origin–Destination surveys)
- Creating routes, following these guidelines:
 - Following as direct a route as possible. Deviations from the shortest route should be minimal, and undertaken only if justified by additional passenger activity. A general rule of thumb⁵ is that the additional travel time for all through passengers should not exceed ten minutes.

$$\frac{\text{Number of Through Riders} \times \text{Additional Travel Time}}{\text{Number of Riders Served by the Deviation}} \leq 10 \text{ minutes}$$

- The quantum of demand towards each destination will decide if a direct route is necessary for the destination, or if it is more optimal for passengers to make a transfer to another route at a transit terminal.
- If the cumulative demand for a route does not sustain the smallest-sized fleet with at least a 50% occupancy ratio and a headway lower than 10 minutes, then such passengers should be routed to a transit

⁶ Training Manual for Transit Service Planning and Scheduling (2015), Lehman Center for Transportation Research.

terminal from where they can make a transfer to their desired destination. There can be exceptions to this rule during non-peak hours or long-distance services.

- The route design needs to be such that most passengers do not need to make more than one transfer to reach their destinations.
- All routes should pass through or terminate at one of the transit terminals within the service area.
- Routes between two end nodes should be connected through various stops along the transit network.
- The fleet from each route must be mapped to bus depots nearest to the starting points.

Defining bus routes is not a very straightforward process. There are many factors that make this process challenging:

- The data necessary for making decisions is very arbitrary
- The fleet requirements on individual routes may not be possible with the total fleet strength available
- The fast-changing demographic conditions of the city due to new developments
- The demand, being a function of ticket price and other variables, is often hard to quantify, resulting in a mismatch between the actual ridership on the routes and the estimates made.

3.2.5 Scheduling

If route definition was a challenge, the process of scheduling is exponentially more difficult. The scheduling exercise must ideally consider all the following aspects in order to arrive at an optimal solution that navigates and balances all the constraints:

- Varying travel times – spatial and temporal variations
- Diverse demand patterns – imbalances in directional demand
- Differing passenger capacities of the fleets and their location at each point in time
- Labour laws limiting total hours of work, hours of continuous work, etc.
- Costs – minimum wages, overtime payments, fixed costs vs. variable costs, etc.
- Most city bus companies have too few buses in their fleet
- Crew salary costs in India are much less in proportion to the overall operations cost, as compared to Europe and America. Hence, optimising crew shifts is a much lower priority, and often ignored.
- The labour laws in India are not as stringent, allowing for some flexibility in the assignment of crew.
- Due to the wide variations in road conditions and fleet types in the Indian context, the process can be optimised by pairing the driver to the same bus and the same route to the extent possible.

During scheduling, variations (during holidays, peak hours, off-peak hours, etc.) need to be accounted for, and the frequencies at which these changes need to be made (road diversions, route changes, etc.) must be defined.

Nowadays, it is possible to use sophisticated software, not only to create schedules quickly, but also to assign buses and crew to each schedule, keeping in mind the bus maintenance schedules and the availability of the crew. In Indian cities however, except for a few pilot attempts to use software-based schedulers, scheduling is still being done manually. This is due to the following reasons:

- Technical software is usually very expensive

- This helps drivers familiarise themselves with the physical conditions along their routes. This improves safety and aids in improved fuel efficiency
- It also helps the drivers to take notice of the defects in their bus and pre-empt maintenance

A sequential rather than a simultaneous approach to scheduling the fleet and assigning the crew can significantly simplify the process.

In Bhubaneswar, the CRUT has engaged a private bus operator under a gross-cost contract (GCC). The responsibility of scheduling the fleet and assigning the crew rests with this operator. Though the complexity is reduced significantly, and the task of the planners is now limited to creating the timetables, a basic software may help in generating the timetables more quickly and efficiently.

Determining Fleet Sizes for Routes

The number of operational buses to be allotted to a route depends on:

- The hourly passenger demand during peak hours in the peak directions
- The cycle time of the route during peak hours
- The passenger capacity of the bus

The number of buses on a route can be calculated thus:

$$\text{Operational Fleet on a Route} = \frac{\text{Peak Hour Passenger Demand} \times \text{Cycle Time (hrs)}}{\text{Passenger Capacity of Bus} \times \text{Occupancy Ratio}}$$

As seen above, the fleet requirement is calculated for the peak-hour, peak-direction demand. In the off-peak hours, the demand for transit services is lower. The cycle time for the route also reduces, thus reducing the fleet required.

Static Scheduling

In the absence of any software, transit schedulers resort to simplifying the scheduling process and using ad hoc methods for creating a schedule. Some of the simplifications that make transit services look unplanned and unattended to, are as follows:

- Considering an average travel demand for the day
- Using fixed travel times for trips across the day
- Operating the same fleet size throughout the day
- Cancelling individual trips for introducing layovers

However, in larger cities with transit mode-shares higher than 20% (of all motorised trips), where travel time variations are very high, city bus agencies have resorted to a three-shift schedule instead of two shifts. The differences between the two are delineated below:

Two-Shift Schedule	Three-Shift Schedule
<p>In this approach, the full operational fleet is scheduled throughout the span of the service with the crew working in two shifts of 8 hours each:</p> <ul style="list-style-type: none"> • Morning Shift (8 hours between 4:00 am – 2:00 pm) • Evening Shift (8 hours between 1:00 pm – 11:00 pm) 	<p>The three-shift approach tries to optimise the travel time during the peak hours. In this approach:</p> <p>60 – 70% of the operational fleet is scheduled</p> <ul style="list-style-type: none"> • 30 – 40% of fleet operates in “a general shift”⁸ that covers the peak hours both in the morning and in the evening

Transit planners in the Indian context commonly refer to the three-shift system as a “dynamic schedule” and the two-shift system as a “static schedule”. Whether a shift is “dynamic” or not, depends on

the number of environment variables that the scheduling process takes into consideration. The essence of true “dynamic” scheduling is presented in the next section.

Static Scheduling Sample – Single Shift:

Here is an example of a single-shift timetable of Route 225, functional under the BPTSL (The Bhubaneswar-Puri Transport Services Limited) between KIIT Campus and Museum Square, covering a distance of 17.2 km. The private bus operator under BPTSL used a single-shift schedule because of the non-availability of good drivers, and to reduce the operating costs. Five buses were plying on this route, and the corresponding timetables are shown in Table 2.

The same timetables can also be visually represented in the form of a graph (Figure 4). This allows for easy visual inspection and also helps to assess any errors in computation or copying. Some of the salient features of this schedule are as follows:

- Although presented in a format that may appear overtly simple, this scheduling has tried to account for some of the travel time variations during the course of the day.

⁸ This varies from city to city.

Table 2: Static Timetable of Route 225 with 5 Operational Buses

Route	Travel Time	
	Peak Hours	Off-peak Hours
225 Up: KIIT Campus – Museum Sq.	58 min	50 min
225 Down: Museum Sq. – KIIT Campus	57 min	51 min

Stop Name	Chainage (km)	Bus 1	Bus 2	Bus 3	Bus 4	Bus 5
KIIT CAMPUS	0.00			7:34 AM	7:57 AM	8:23 AM
MUSEUM SQUARE	17.13			8:28 AM	8:54 AM	9:21 AM
MUSEUM SQUARE	17.13	7:37 AM	8:07 AM	8:35 AM	9:04 AM	9:30 AM
KIIT CAMPUS	0.00	8:33 AM	9:04 AM	9:31 AM	10:01 AM	10:27 AM
KIIT CAMPUS	0.00	8:49 AM	9:15 AM	9:41 AM	10:07 AM	10:33 AM
MUSEUM SQUARE	17.13	9:47 AM	10:14 AM	10:39 AM	11:05 AM	11:27 AM
MUSEUM SQUARE	17.13	9:56 AM	10:22 AM	10:50 AM	11:16 AM	11:47 AM
KIIT CAMPUS	0.00	10:53 AM	11:17 AM	11:40 AM	12:08 PM	12:38 PM
KIIT CAMPUS	0.00	11:02 AM	11:32 AM	12:02 PM	12:33 PM	1:04 PM
MUSEUM SQUARE	17.13	11:52 AM	12:22 PM	12:52 PM	1:23 PM	1:54 PM
MUSEUM SQUARE	17.13	12:16 PM	12:46 PM	1:16 PM	1:45 PM	2:16 PM
KIIT CAMPUS	0.00	1:07 PM	1:37 PM	2:07 PM	2:36 PM	3:07 PM
KIIT CAMPUS	0.00	1:34 PM	2:04 PM	2:34 PM	3:04 PM	3:34 PM
MUSEUM SQUARE	17.13	2:24 PM	2:54 PM	3:24 PM	3:54 PM	4:24 PM
MUSEUM SQUARE	17.13	2:44 PM	3:14 PM	3:44 PM	4:14 PM	4:43 PM
KIIT CAMPUS	0.00	3:36 PM	4:05 PM	4:36 PM	5:05 PM	5:39 PM
KIIT CAMPUS	0.00	4:04 PM	4:34 PM	4:58 PM	5:24 PM	5:50 PM
MUSEUM SQUARE	17.13	4:54 PM	5:27 PM	5:56 PM	6:22 PM	6:49 PM
MUSEUM SQUARE	17.13	5:12 PM	5:37 PM	6:04 PM	6:30 PM	6:58 PM
KIIT CAMPUS	0.00	6:09 PM	6:34 PM	7:00 PM	7:27 PM	7:52 PM
KIIT CAMPUS	0.00	6:16 PM	6:42 PM	7:09 PM	7:36 PM	8:01 PM
MUSEUM SQUARE	17.13	7:15 PM	7:40 PM	8:03 PM	8:26 PM	8:50 PM
MUSEUM SQUARE	17.13	7:27 PM	7:51 PM	8:20 PM	8:40 PM	9:20 PM
KIIT CAMPUS	0.00	8:18 PM	8:42 PM	9:11 PM	9:32 PM	10:11 PM
KIIT CAMPUS	0.00	8:26 PM	8:50 PM			
MUSEUM SQUARE	17.13	9:16 PM	9:40 PM			



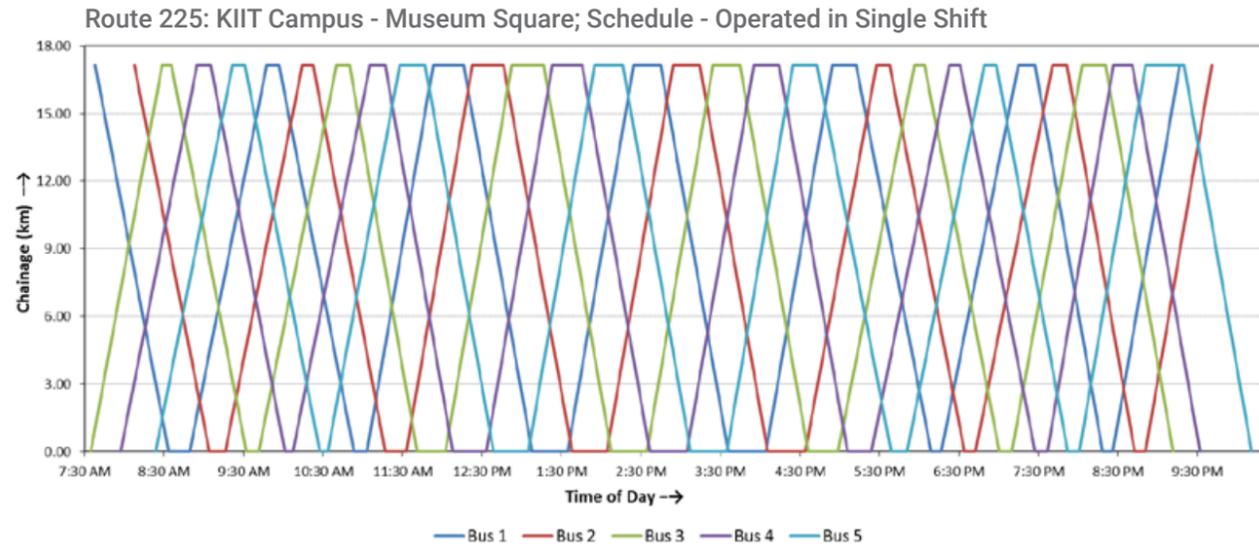


Figure 4: Visual Representation of the Timetable in a Space-Time Graph

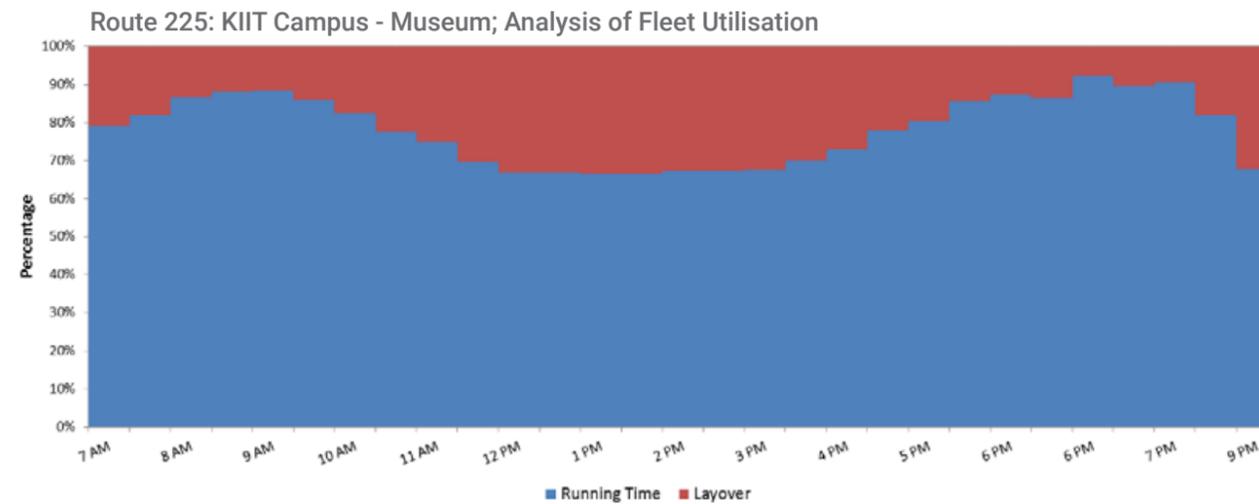


Figure 5: Schedule Visualisation – Fleet Utilisation Graph

- As there are only 5 buses operating with headways of 26 minutes in the peak periods – which is quite poor – the schedule attempts to maintain the same headway during the off-peak hours as well. This allows for longer layover times during the afternoons to ensure enough of a break for the crew to have their meal.
- Due to layovers and recovery time provisions in a schedule, not all the buses can be on the route throughout the operating hours. Another way to visualise the same timetable is with a focus on operational fleet utilisation (not including the spare buses) throughout the day (Figure 5).

This timetable attempts to mimic the peak and off-peak traffic conditions on an hourly basis, with the limited fleet available for service.

Transit schedules can be prepared in multiple ways. It is important to develop visual tools to help examine the output quality and identify better alternatives for the context under consideration.

Also, as seen here, Route 225 (Ref: Table 2) is operating at a reduced frequency of 2.3 buses/hour (26 minute headway). Unless operated absolutely per timetable, the passengers have no way of knowing if the next bus is arriving shortly or is further away.

Poor reliability naturally prompts passengers to choose other modes. Over a period, the passenger demand dwindles, and the service becomes financially unviable – which is what had happened with BPTSL.

Dynamic Scheduling

The more detailed the data points, the better the fleet estimates can be. However, in some circumstances, the fixed costs (infrastructure costs, insurance, permits, crew salaries, etc.) of transit provision may be very high compared to the variable costs (fuel and maintenance). In such cases, the transit scheduler needs high-quality, complete information on the individual cost components and the ticket revenue, and it makes sense to schedule a bus along a route every time the ticket revenue is found to be higher than the variable costs of bus operations.

To optimise the process, certain other factors also need to be carefully considered. For example, a bus can be allowed a layover only at a transit terminal or a bus depot with adequate infrastructure for the bus crew to refresh themselves.

A transit schedule can be “dynamic” in many ways, depending on a number of environment variables, such as:

- Variations in travel time
- Variations in travel demand along a route
- The cost components of bus operations
- Labour laws and crew-union agreements

At times, dynamic scheduling implies deciding the bus route and the end point of the trip in real time, based on the demand of the passengers

travelling in the vehicle, or of those waiting for a transit vehicle. This terminology primarily applies to shared taxi services rather than to high-capacity transit. Strategies like trip chaining can be used where a transit vehicle does not always operate on the same route, but is allocated different routes based on demand. The subsequent section provides further insight into the process.

Considering Travel Time Variations

A fundamental consideration for timetable preparation is the travel time between the stops along the route. Despite the fact that travel times vary significantly throughout the day, city bus agencies across the country continue to use a fixed cycle time to plan their schedules. This is because of the lack of accurate data, and the complexity of creating a schedule with varying travel times.

This has four clear consequences:

- The inability to keep to the timetable, and resultant stress for the bus drivers
- The bus service becomes unreliable for the passenger
- An excess of trips during the off-peak hours, as the drivers attempt to make up for the trips lost during peak hours
- Adverse impacts on revenue and costs

The above-mentioned points clearly emphasise the importance of recording travel times

accurately along the routes. Data from the AVLS can be used to capture this information routinely and also monitor it for variations over time, allowing for schedules to be modified accordingly. Where no prior AVLS data exists, web-based map sources can also help in collecting travel-time information. This however, may not be very accurate for short distances.

Traditionally, only two categories of time have been considered – peak and off-peak. But in present times, using spreadsheets and other computational tools, the travel time between any two stops can be tracked every half hour of the day, which again will vary across weekdays, in the weekends, and on holidays.

Also, two trips starting at the same time on the same route need not always take exactly the same amount of time. Such deviations in travel times for each pair of trip ends should also be recorded. This can help in determining the

recovery times required at each end of the trip, and provide enough time for the driver to start the next trip on time even if the previous trip is delayed. Recovery times can be kept equal to the standard deviation of the trip. However, when the deviations are large, the planners may limit the layover to 60% of the deviation.

When wide variations in travel time are observed within the same period of the day over a number of days, it is typically indicative of a few badly-calibrated traffic signals or poorly designed intersections. In such cases, the transit planner should examine the route data, and engage with the municipal engineers and traffic police to find a solution.

A sample format of a travel time data matrix is indicated in Table 3. Similar matrices can be created for all the adjacent stop pairs, so that the same can be used to interpolate the arrival time of the bus at intermediate time points.



Table 3: Travel Time Matrix along a route – an example from Bhubaneswar

TRIP START INTERVAL ⁹	05:00 – 06:30		06:30 – 07:30		07:30 – 08:30		08:30 – 09:30	
	Travel Time	Standard Deviation						
207 UP: NANDAN KANAN - AIRPORT	42 min	7 min	45 min	10 min	50 min	15 min	60 min	20 min
207 DN: AIRPORT - NANDAN KANAN	45 min	10 min	48 min	12 min	55 min	15 min	63 min	17 min
306 UP: KIIT CAMPUS - KALPANA	24 min	6 min	28 min	7 min	31 min	9 min	45 min	15 min
306 DN: KALPANA - KIIT CAMPUS	25 min	5 min	28 min	7 min	31 min	9 min	39 min	13 min
603 UP: SAI MANDIR - KALINGA VIHAR								
603 DN: KALINGA VIHAR - SAI MANDIR								
504 UP: B.P PARK (CTC) – BARAMUNDA								
504 DN: BARAMUNDA - B.P PARK (CTC)								

⁹ Time of the day when the trip starts from its origin.



A Sample Calculation

Consider the example of Route 207 from Table 3, extending from Nandankanan to the Airport, and covering a distance of about 21 km. Assuming a peak direction passenger demand of 300 passengers/hour in the early morning hours, and 400 passengers/hour in the morning peak hours (8:30 am to 10:30 am), the computation for this case will be as follows:

Sample Calculation: parametres	Morning Peak	Early Morning
Passenger demand (Pax/hr)	400	300
Cycle Time (hr)	= (60+20+63+17)/60	= (42+7+45+10)/60
Passenger capacity of Std. Bus	60	60
Estimated occupancy ratio (OR)	85%	60%
Fleet Required:	21 buses	15 buses
Service Headway:	7.6 min	6.9 min

It is worth noting above that though the fleet requirement during the peak and off-peak hours are vastly different (the OR does assume many standing passengers during the peak period though), the observed headway

during the off-peak hours (6.9 minutes) is much more comparable to that observed in the peak period (7.6 minutes). This is because of improved network speeds during the off-peak hours.

Route Optimisation – Creating Short Turns

Bus route planning in the Initial stages is based on various data estimates and assumptions. Once a schedule is designed and the buses start operating accordingly, the passenger ticket information provides rich insights on multiple aspects of passenger travel along the route. While it is common knowledge that passenger demand varies along a route, ticketing information can be used to understand the passenger load at various

points, and create variations in the route to adjust the bus supply accordingly. The following sections present some ways to assess whether such optimisations are possible.

Average Trip Length (ATL) Function: A simple way to assess if a bus route is optimally designed for passenger demand or not, is to compare the average passenger trip length along the route with the total route length (RL). Certain broad conclusions that can be drawn from this are:

	Range	Inference
If the Ratio of the Route Length to the Average Trip Length is	Between 1.0 and 1.2	<ul style="list-style-type: none"> This is indicative of a long- distance or contract bus service The route needs to be operated as a non-stop service.
	Between 1.2 and 1.8	<ul style="list-style-type: none"> The route has the potential to operate as a limited-halts, express service.
	Between 1.8 and 2.6	<ul style="list-style-type: none"> This indicates that the route is functioning optimally for the given demand. Monitoring should continue. A few buses may be operated as a limited-halts, express service.
	Between 2.6 and 3.3	<ul style="list-style-type: none"> May need to explore opportunities for creating short-turns for better frequency in the peak sections. A few buses can continue to operate along the whole length of the route.
	Above 3.3	<ul style="list-style-type: none"> In this situation, possibilities definitely exist for creating short-turns or bifurcations of the route -ends. For operational efficiency, the buses along the route can be divided into two or more categories: some operating along the whole route, as earlier, and some opting for short turns.

Boarding-Alighting Analysis:

Boarding-alighting analysis using ticketing data provides insights into the passenger activity along the route. In the cities, bus stops are usually located at short distances from each other. However, due to the nature of the route, it often happens that the passengers board or alight at

a few specific stops, and the other stops cater to a very insignificant portion of the ridership. This is often the case when the ratio of the RL to the ATL is between 1.0 and 1.8, but can also occur for values higher than that. In such cases, some buses can be operated as a limited-halts, express service.

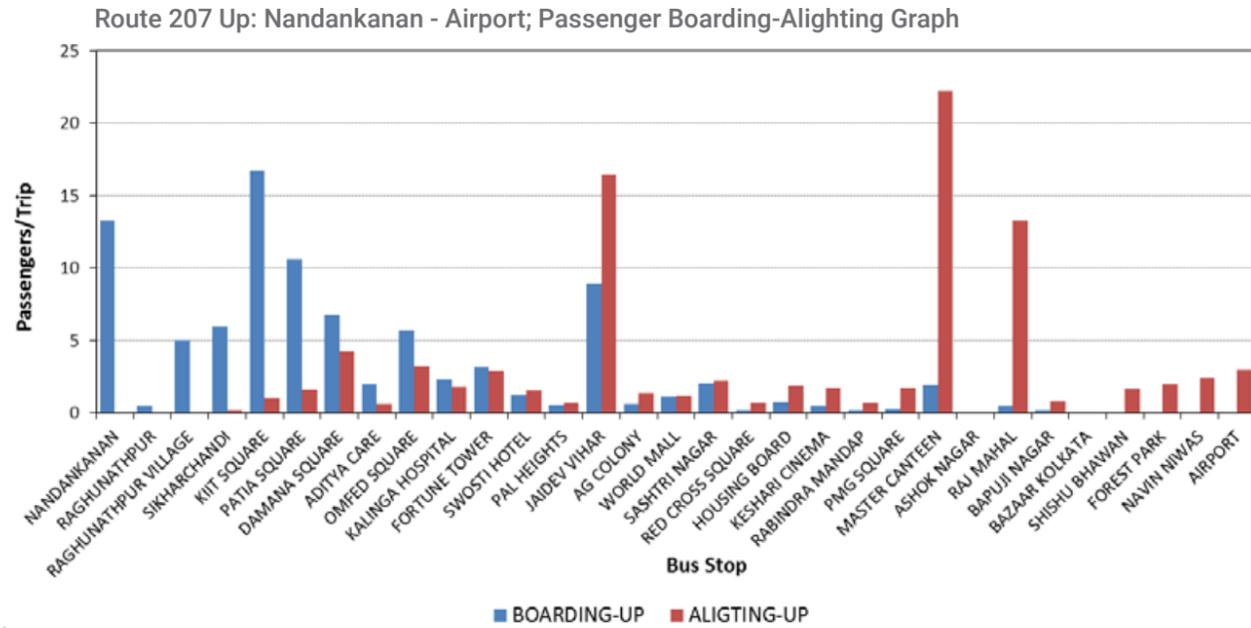


Figure 6: Boarding Alighting Graph

Figure 6 is a simple visualisation of the average boarding-alighting along route 207 on a weekday.

Graphical representations (as in Figure 6) make it easy to visualise the level of passenger activity at each bus stop along the route. The representation makes it clear that stops such as Raghunathpur, Bazaar Kolkata, Bapuji Nagar, Ashok Nagar, Rabindra Mandap and Red Cross Square are barely contributing any passengers to the route. Though Route 207 passes through these stops, these can be removed from the service-halt list, which will reduce the travel time of the bus and that of the passengers.

Load Curve:

The load curve is a visual representation of the number of passengers present in a bus at various points along the route. It is a cumulative representation of passenger boarding-alighting data and sectional loading.

As noted earlier, passenger demand is not constant along the route (except in cases where the ratio of RL to ATL is almost equal to 1.0). The load curve can vary across time-periods as well, and for creating optimal schedules, these should be studied separately.

The passenger load graph (Figure 7) uses the average trip ridership data from the boarding-alighting chart (Figure 6). This representation clearly shows that, compared to the remaining parts of the route, there is a higher passenger demand between KIIT Square and Master Canteen.

Hence, instead of operating the entire fleet along the whole route, it would be more efficient to operate a few buses specifically between KIIT Square and Master Canteen, while continuing to operate the remaining along the full length of the route. This strategy, which commits the full fleet neither to the short loop nor to the full route, can optimise the working of the transit network.

An example of such a schedule for Route 207, with single-shift operations, is shown in Figure 8. This schedule attempts to mix and match the route segments to achieve better connectivity for the passengers and also ensures higher frequency in the short-loop section.

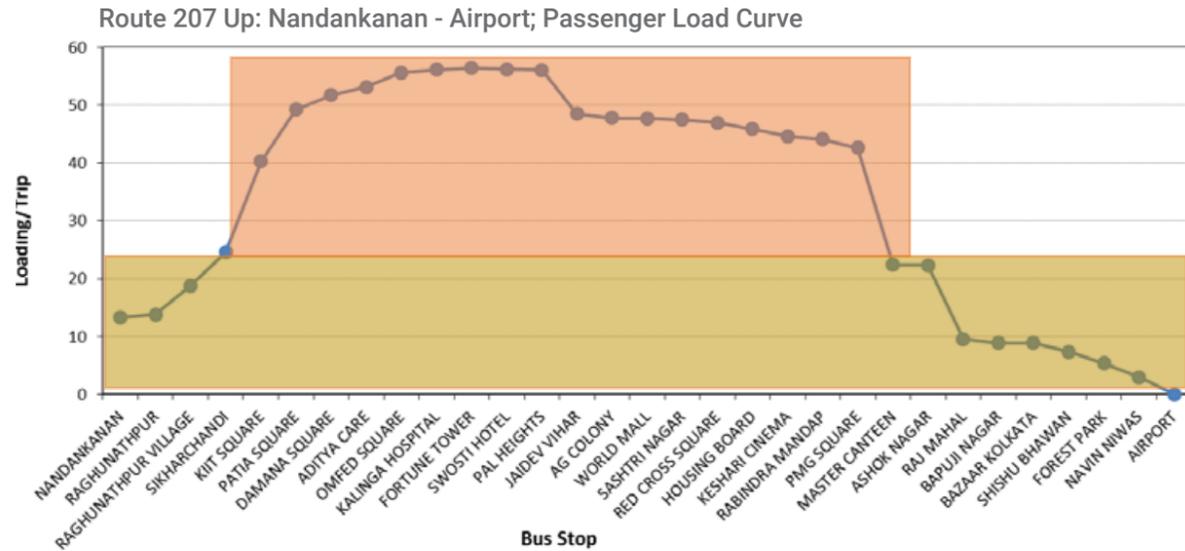


Figure 7: Passenger Load Curve of Route 207

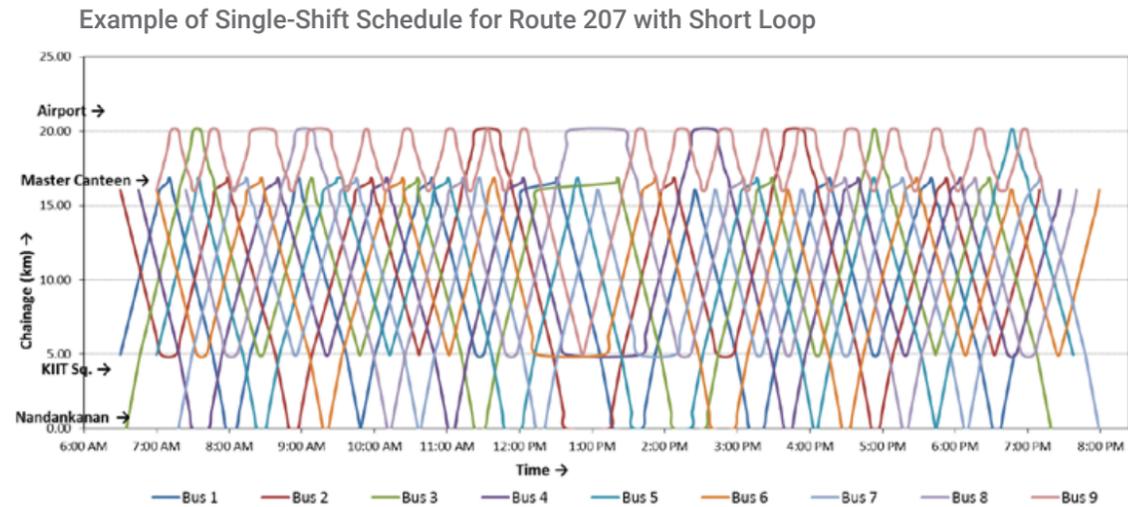


Figure 8: Timetable for Route 207 with a Higher-Frequency Short Loop

Here, every second bus starting from Master Canteen turns back at KIIT Square to offer a higher frequency of 4.5 buses/hour with a 13-minute headway between the two stops, compared to the frequency of 3.4 buses/hour with an 18-minute headway if all the buses had been operated along the entire route. Further, it can be seen that the stretch between Master Canteen and the Airport is being served by a separate shuttle service (Bus 9), along with a few trips starting from Nandankanan or KIIT Square.

Achieving Dynamic Scheduling

As observed above, “dynamic” schedules will most probably require operating different numbers of buses along a route at different times of the day. Given that peak and off-peak demand periods coincide for most routes in a city, a portion of the bus fleet will be out-of-service during the off-peak hours. If a two-shift schedule is planned spanning the entire day, then it becomes inefficient in terms of paying crew-salaries during the off-peak hours. Depending on the terms of payment for the crew, it may be more efficient to either hire a part-time crew for the peak hours alone, or use a general shift that covers both morning and evening peak periods. As seen from the examples in the short-loop sub-section, for a given set of constraints, a multitude of scheduling options exist. This makes the planning process more iterative than linear.

Using the above analysis, static schedules can be adjusted to take into account the varying travel speeds at different times of the day, and also the variations in passenger demand, in order

to achieve an optimal “dynamic” schedule that attempts to increase the reliability of the service and reduce the operational costs.

Other Considerations for Scheduling

As evident from the previous sections, despite attempts at simplification, fleet scheduling can be a complicated procedure. It helps to use available software to generate the schedule, so that data gathering, analysis, and monitoring of fleet operations can be optimised. The following are a few other factors worth considering while scheduling the fleet.

Overlapping Routes

This section, thus far, has dealt with the scheduling of buses along a single route. In a city, it is common for multiple bus routes to overlap along certain stretches of the transit network. Even though such routes may serve very different origin-destination pairs, such overlaps can be very significant. Ideally, the arrival of buses from

different routes in the overlapping section should be spaced uniformly. However, this becomes extremely difficult in a city environment where travel times can be highly uncertain. Even software may not really be helpful in this regard. If the time interval for the arrival of buses along a specific network link is greater than 10 minutes, efforts must be made to keep the headway uniform in the overlapping sections. Further, for assessing the extent of the overlaps, section loads need to be plotted route-wise, and the advisability of truncating the routes to avoid excess supply of PT needs to be evaluated.

The Adequacy of Transit Operations

The adequacy of service is assessed by comparing the route-wise supply with the location and time-based travel demands on each of the routes.

In section 3.1.1, while calculating the minimum operational fleet, the policy “frequency of service” on individual transit links had been identified. After deciding the schedules of all the bus routes, it is important to tally the combined service frequency of all the routes with the value identified earlier on the basis of the passenger traffic along the network link.

As clarified earlier, the frequency (or capacity) of a transit service may not necessarily match the travel demands along a network link, especially where roads exist near and parallel to one another. Transit passengers usually walk 300 – 500 metres to reach their bus stop. Thus, on certain specific

routes and/or during certain periods, there may be some gaps in the service, and the same may be identified for corrective measures. This check helps to verify if the complex route design and scheduling processes are in sync with the actual travel patterns observed in the city.

Low-Frequency Routes

While it is desirable to have a service frequency of no less than 30 buses per hour (with a headway of 2 mins) on all the major links of the transit network, some individual routes, especially those connecting the low-density areas, may not have enough passenger demand to operate buses with headways less than 10 minutes. In such cases, the transit agency should publish the exact timetable indicating the arrival of the bus. Such low-frequency routes should be closely monitored for schedule adherence, and the bus drivers need to be instructed not to leave the stops before time. Changes made to such schedules should be announced and publicised well in advance so as not to inconvenience the passengers.

Changing Timetables & Routes

Keeping the passenger base intact is a challenge, and so is the work of attracting new passengers from other modes. Making changes to the schedules randomly can confuse and frustrate the passengers. A well-operated transit agency is one that is disciplined and responsible in terms of tweaking its routes and schedules. A

good way to do this is to make changes on a specific day periodically (for example, the 1st day of every quarter) with adequate, prior notice communicated through the news media. This allows the passengers to know from beforehand when to check for schedule updates.

Maintaining Multiple Timetables for Every Route

Another aspect, often ignored by transit agencies, is the need to maintain multiple timetables (for weekdays, weekends, peak hours, off-peak hours, etc.) for a route where different fleet sizes operate. These may be useful, especially when there are disruptions. While all preventive maintenance measures must be taken to ensure that the fleet is available for operations every single day, and that there is adequate crew in attendance to ensure the prescribed operations, there is always a possibility of some unplanned interruptions. The usual tendency of transit managers in such cases is to skip one schedule, and continue to operate

the remaining fleet as per the timetable. However, this will most probably result in increased waiting times for the passengers at the bus stops. It is thus prudent to have multiple alternative timetables (each planned with fewer buses than usual, and a frequency allotted accordingly) prepared in advance, which can act as a contingency plan under such conditions.

For example, consider Route 207, operating with a fleet of 21 buses, scheduled to run with a uniform headway of 7.5 minutes in the peak periods. If on a particular day, the crew strength is only sufficient for 19 buses, then following the 21-bus timetable will lead to operations with an initial headway of 7.5 minutes, which after every 75 minutes, will suddenly double to 15 minutes. Passengers will find this wait time unacceptable. An alternative contingency plan -- such as a timetable for 19 buses -- will increase the headway only marginally to 8.3 minutes, thereby optimising the operations without inconveniencing the passengers noticeably..



3.2.6 Fare Structure

Another important aspect impacting the ridership of a transit service is its user tariff. Though detailed guidelines exist on the science of determining transit fares, the majority of these may not always consider the ground realities. Building consumer models based on price elasticity and price sensitivity could be data-intensive and yet not entirely accurate, just like the travel demand models themselves. Further, the user perception about transit fare is heavily dependent on the external policy and the regulatory and enforcement environments, which are rarely factored into the transit pricing models. Hence, it is highly recommended that transit pricing be approached as a subject of human psychology and social needs rather than one of economics.

An economic model of transit-fare pricing talks about the technical fare, i.e., the price at which the ticket revenue equals the cost of providing the service. However, this approach is flawed, as the model is a function of the ridership, which once again depends on the ticket price. This essentially means that the pricing of transit fares is an iterative process.

It should be noted here that the fixed costs of infrastructure (investments which undergo depreciation) constitute a major portion of the overall costs of the operations. Hence, the key to a successful transit system is to attract maximum ridership so that the infrastructure can be fully utilised. The service has to be priced such that the occupancy ratio is maintained at 70% or above.

Types of Fare Systems

There are three most popular types of fare systems:

- **Flat Fare:** This approach uses a single fixed fare for a passenger trip, irrespective of the distance of travel. It simplifies fare collection and is an attractive model for passengers travelling long distances.
- **Distance-based Fare:** In this approach, the transit fare is a function of the distance travelled by a passenger on the system. It

seems like a very fair way of pricing, but the ticket fares can become unaffordable for long-distance travels.

- **Telescopic Fare:** This model is a hybrid of both the above methods. In this approach, while the fare increases with distance, the rate of fare increase tapers off with distance. Thus, with increased trip length, passengers pay a lower price per unit distance, and after a certain distance, the fare reaches a constant. CRUT currently uses this model.

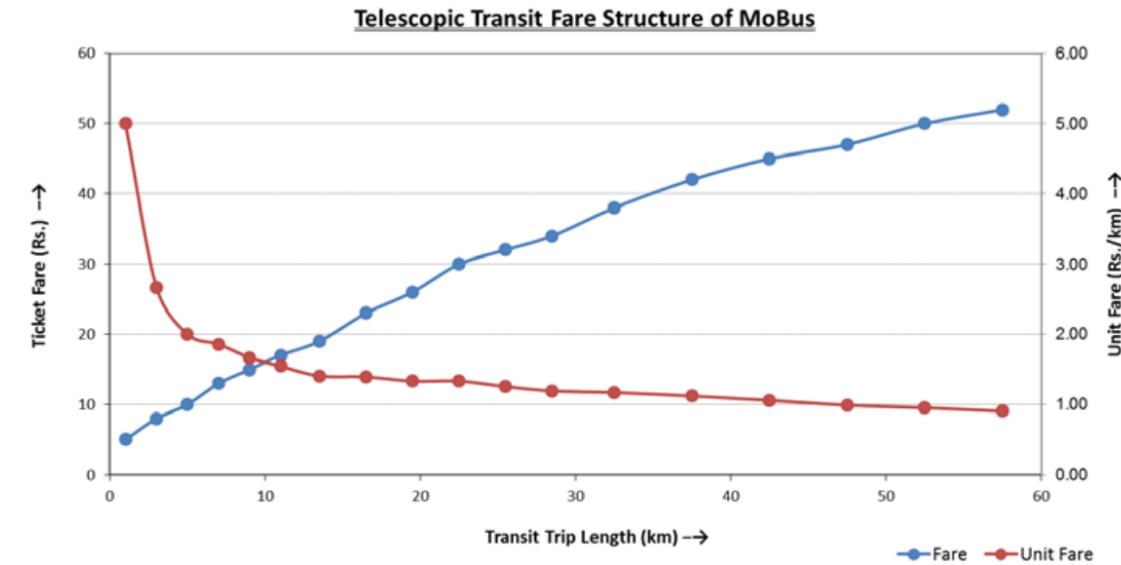


Figure 9: Bus Fares at CRUT

Fare determination, structuring, and revision is a detailed exercise and needs to be undertaken separately.

Strategies for Increasing Revenue

The key to improving the financial sustainability of a transit service is to focus on revenue maximisation rather than on increasing the ticket prices. This is possible by:

- **Achieving a Higher Occupancy Ratio:** The higher the ridership, the higher is the revenue collected.
- **Attracting Short-Distance Customers:** As seen in Figure 9, the fare per unit distance for passengers travelling shorter distances is almost twice as high as those travelling longer distances. It can

be extremely profitable for a transit agency to attract short-distance travellers.

- **Preventing Leakage:** Revenue leakage by way of ticketless travel is a major cause for the loss of revenue in a transit system. Strict policing and penalties on both passengers and ticket-issuers indulging in malpractices can help prevent such leakage.

While the last point above is an enforcement issue, the key to achieving the first two points is to operate a reliable and frequent transit service. The journey time for a short-distance traveller (less than 4 km of travel) using the transit service is about 10-15 minutes. Passengers usually do not like to wait for a bus for more than 10% of their journey time.

Taking these into account, the transit routes should be planned with high frequency and operated with uniform headways, using the scheduling techniques mentioned in the earlier sub-sections.

3.3 Transit Performance Monitoring

As emphasized earlier, transit management – both planning as well as ensuring service quality – requires continuous data collection and analysis. There are three essential functions of transit data:

- **Information Dissemination:** Providing passengers with real-time data on the arrival/location/passenger load of buses, through mobile applications and variable-message signs.

technologies in the past decade, transit agencies in Indian cities have largely automated the data collection process. Still, its utilisation continues to be very poor.
 - **Service Monitoring:** Post-processing of transit data to monitor bus operations and understand how it is impacted by any changes in its environment (by factors such as increasing traffic congestion, fare changes, service frequency changes, etc.)

Also, information dissemination essentially falls in the domain of communication and outreach, and this is a subject outside the scope of this document.
 - **Financial Planning:** Information on the costs, revenue, and benefits accrued are important for assessing the utility of the service, and in determining the provisioning of funds towards sustaining the operations and for future expansions.

This section focusses on service monitoring and the various Key Performance Indicators (KPIs) that should be routinely computed and tracked.
- Performance indicators for city bus transit systems can be broadly grouped into four intimately interrelated categories, each of which can help in drawing inferences about the various aspects of transit systems:

With the advent of the Intelligent Transportation System and improvements in communication

a) Technology performance indicators

- b) Demand-oriented indicators
 - c) Supply-oriented indicators
 - d) Indicators of fleet maintenance
 - e) Indicators of the quality of service (from the perspective of the users)
- This list is by no means exhaustive, and based on specific needs, more indicators can be added to the pool from time to time.
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3.3.1 Technology (ITS) Performance Indicators

Even a decade earlier, transit management was performed manually, and hence, except for financial indicators, all the data collected was restricted to random samplings. In recent times, most transit agencies use ITS for extensive capture of data for all aspects of the business. However, in India, ITS has not evolved to replace manual data-recording methods completely. Hence it is important to retain the manual records to randomly compare and verify the accuracy of the data captured using technology. Technological systems form the very backbone of data management. However, given the major investments that go into these, it is important to continually monitor the functioning and availability of such technologies. The KPIs as well as recommendations for benchmark standards for this aspect are presented here.

- **AVLS Availability:** The vehicle tracking system is a critical ITS infrastructure that provides real-time information to passengers as well as captures operational data, which in turn forms the basis for calculating the payments due to the private operator. Hence it is important to assess the reliability of the hardware and software placed in the buses. This KPI is measured in percentage (%) and is calculated as follows.

$$\text{AVLS Availability} = \frac{\text{Duration for which location data is transmitted in real time}}{\text{Total duration of transmission in the reporting period}} \times 100$$

It can be calculated for individual AVLS units, or aggregated for the entire fleet. At the fleet level, the benchmark should be 99.5%. For individual

buses, the data loss should be rectified within 4 hours of detecting a malfunction.

- **ETM Availability:** Ticketing is another critical activity and involves monetary transactions. Malfunctioning ETMs result in manual ticketing that is susceptible to fraud, and presents an auditing challenge. Though calculated in a

similar way to that of the AVLS availability function, this KPI has a higher benchmark at 99.75%, because:

- ETM malfunctions can be quickly replaced by a spare unit dispatched from the control centre, and thus, ensuring peak system operations becomes relatively easier.

3.3.2 Demand-oriented Performance Indicators

The entire purpose of establishing and operating a transit system is to serve the mobility needs of people such that public transport becomes the preferred mode of travel. The following KPIs help to assess the extent to which this objective is being met i.e. provide an indication of how successful the service is in attracting ridership..

- **Occupancy Ratio (OR):** As seen from the subsections on transit infrastructure planning, scheduling, and fare structures, the OR is a key statistic that summarises the level to which the transit service is able to satisfy the travel needs of the passengers.

$$\text{Occupancy Ratio} = \frac{\text{Sum of Individual Passenger Trip Lengths}}{\text{Passenger Capacity of Bus} \times \text{Service Distance}}$$

- **Benchmark:** 70% (minimum)
- **Notes:**
 - ◊ While the OR is a comprehensive demand

statistic, it is possible to create a schedule reflecting a high occupancy by removing off-peak services, which is not desirable. Hence, for a balanced assessment, this KPI should be complemented by other indicators.

- ◊ Additional fleet capacity should be directed into operation when the OR is greater than 85%.
- ◊ A reduced OR does not imply a lack of demand for transit. It indicates a mismatch between the planned supply and the demand- time-wise, geographically, economically, etc.

- **Ridership:** The total daily ridership and the average ridership per bus are statistics easily derivable from the ITS system. This information helps to understand the reach of the transit service and the variations in demand on a daily and seasonal basis.

$$\text{Average Ridership per Bus} = \frac{\text{Total Daily Ridership}}{\text{Total Number of Buses in Fleet}}$$

- **Benchmark:** 650 – 1800 passengers/bus
- **Notes:**
 - ◊ While ridership is a widely-discussed KPI, it holds little technical value in itself, as it counts one person making a transfer to complete a journey as two trips/passengers. Transit mode-share is a superior statistic to consider. However, ridership retains its importance owing to its ease of capture and easy communicability.
 - ◊ The “total number of buses” used in the above formula includes the spare buses.

- **Average Trip Length (ATL):** Since the advent of ETMs, this statistic has become easily computable. But it has often been undermined because of:
 - (a) The difficulty of calculation in the era of paper tickets

(b) The planner’s inability to fully comprehend its use

Although it may not be of significant value at the aggregate level, a route-wise ATL calculation is an important indicator for optimising routes and schedules (Refer to the table in the “Route Optimisation” section).

$$\text{Average Trip Length} = \frac{\text{Sum of Individual Passenger Trip Lengths}}{\text{Number of Passengers}}$$

- **Notes:**
 - ◊ A sudden reduction in ATL is indicative of revenue leakage by way of short-ticketing (passengers purchasing tickets for a shorter distance than their actual travel). However, such reductions in ATL can also happen when there is a sudden increase in ridership.
- **Revenue:** The revenue generated is an important focus for any transit agency as it directly impacts the sustainability and planning of the organisation. The earnings per kilometre of bus operations and average ticket prices are finer variations of this statistic.

$$\text{Earnings per Kilometre (EPKM)} = \frac{\text{Total Revenue}}{\text{Revenue Distance} + \text{Dead Kilometres}}$$

$$\text{Average Ticket Price} = \frac{\text{Revenue}}{\text{Ridership}}$$

Notes:

- ◇ For a given fare structure, the EPKM is directly proportional to the OR.
- ◇ The average ticket price is an important statistic indicative of affordability; the affordability of the service is inversely proportional to the average ticket price.

• **The Proportion of Digital Payments:** This statistic will become more and more relevant as mobile ticketing and smart-card-based cashless payment mechanisms gain prominence. Digital payments allow for ease of issuing tickets, and also reduce the chance of revenue leakage through bus conductors.

$$\text{Proportion of Digital Payments (\%)} = \frac{\text{Number of Cashless Tickets Issued}}{\text{Total Number of Tickets Issued}} \times 100$$

• **Benchmark:** 70% (minimum)

Notes:

- ◇ Digital payments can be made attractive and promoted by offering discounts even for occasional users of the transit system.

• **The Number of Ticketless Passengers:** This is actually a misleading statistic, as it essentially reports only the number of ticketless or short-ticket passengers apprehended by the ticket-checking squad conducting inspections at random. The actual number of ticketless travellers would be higher. The use of this indicator to assess a reduction in the number of ticketless travellers caught during random inspections can imply either:

- An actual reduction in ticketless travel
- The ticket checking squad not performing their job as intended

• **Transit Mode-Share:** The ultimate aim of the transit service is to capture a significant proportion of passenger trips within the city. Transit mode-share (and the improvement in transit modal-share over time) is an indicator of the success of the service.

$$\text{Transit Mode Share (\%)} = \frac{\text{Transit Ridership}}{\text{Total Travel Demand in the Service Area (trips)}} \times 100$$

• **Benchmark:** 40% (minimum)

Notes:

- ◇ This statistic cannot be inferred from the data captured by the ITS. The total travel demand in the service area is computed by

conducting household travel surveys from time to time.

• **Number of Complaints:** Passenger feedback is

another important metric, which can be tracked using the ITS system. The number of complaints received and resolved should be reported daily.

3.3.3 Supply-oriented Performance Indicators

This section lists the indicators that point to the quality and efficiency of the transit service. In the case of the CRUT (and other agencies working with a similar GCC model), where bus operations are managed by a private partner, it is important to monitor their work through these KPIs.

• **Average Revenue Kilometre (ARK):** While the OR is a key measure of transit performance, it is also possible to achieve a high OR by not operating the buses during the non-peak hours. This practice can have two detrimental effects:

- a. It restricts the mobility options of the passengers, especially during the early-morning and late-night hours, thereby increasing dependence on private motor vehicles, and slowly but steadily, leads people away from using the transit system.
- b. Reduced usage of the fleet results in wastage of investments (esp. the fixed infrastructural costs).

$$\text{ARK} = \frac{\text{Sum of Revenue Kilometres of All Buses in the Fleet}}{\text{Total Number of Buses in the Fleet}}$$

• **Benchmark:** 170 km/bus/day (minimum)

Notes:

- ◇ Dead kilometres should not be included while calculating this statistic.
- ◇ The “total number of buses” in the above formula includes the spare buses.

• **Average Dead Kilometres (ADK):** This indicator helps to understand the opportunity costs of insufficient infrastructure, inefficiencies in planning, and bus breakdowns. Transit

agencies in India commonly use a single statistic encompassing both revenue and dead kilometers, called “Average Fleet Utilisation. This is an incorrect practice as it does not reveal the level of efficiency within the system.

$$\text{Average Dead Kilometres} = \frac{\text{Sum of Dead Kilometres of All Buses in the Fleet}}{\text{Total Number of Buses in Fleet}}$$

- **Benchmark:** 10 km (maximum)
- **Notes:**

- ◊ In this equation, dead kilometres refer to the distance travelled by the bus during non-revenue service (as a part of the schedule prepared by the CRUT), and while returning to its depot in case of a breakdown.
- ◊ The distance covered by the bus to reach maintenance facilities, for refuelling, or for any other activity outside the schedule should not be included in the ADK.

- **Average Non-Scheduled Kilometres (ANK):** This category covers the distances traversed by a bus outside the schedule defined by the agency. If a private partner manages the bus operations, it is of utmost importance to track this metric separately to identify any fleet misuse at the earliest. The regulator is not liable

to pay for such travel.

$$\text{ANK} = \frac{\text{Sum of all Non-Scheduled Kilometres in a Day}}{\text{Total Number of Buses in Fleet}}$$

- **Benchmark:** 1 km (maximum)
- **Notes:**

- ◊ The distances covered by the bus within the bus depot outside the scheduled hours, for washing, cleaning and maintenance, are also a part of this statistic.
- ◊ The benchmark value for this metric depends on the availability of a fuelling station and maintenance facility within the bus depot.
- ◊ The sum of the revenue kilometres, dead kilometres and non-scheduled kilometres is equal to the total distance travelled by a bus or a fleet of buses.

- **Schedule Variation Index (SVI):** It is important to ascertain whether the buses are operating as per the prescribed schedule. The SVI indexes the variation from the scheduled time, and is also called the Schedule Adherence Index. There are various ways to measure the adherence to a schedule, and some can be very complex. A simple method has been

suggested here, to compare the performance over a number of days.

$$\text{SVI (minutes)} = \frac{\text{Sum of Deviation in Start Time of Individual Trips (in minutes)}}{\text{Total Number of Trips}}$$

- **Benchmark:** 1 minute
- **Notes:**

- ◊ Absolute values should be used to measure the deviation from the starting time of the trip. This means that if a bus starts 2 minutes earlier than scheduled, the deviation is 2 minutes and not -2 minutes.
- ◊ The benchmark value of 1 minute is set for the fleet as a whole. For individual trips, the deviation should not be greater than 20% of the trip time or half the headway of the route (whichever is smaller).
- ◊ While there are many ways to approach schedule adherence, CRUT needs to work on calibrating its benchmark.
- ◊ If a route or trip consistently fails to adhere to the schedule, there may be a need to redo the schedule using the new travel times.

- **Service Reliability Index (SRI):** While the SVI looks at schedule adherence from the planner’s perspective, the SRI helps to index the passenger’s experience with respect to the reliability of a particular route. The SRI should therefore be calculated separately for specific bus stops and routes, and not be combined across routes and stops. The SRI for a particular stop “s” and a route “r” in the transit system can be calculated as below:

$$\text{SRIs, } r = \frac{\text{Standard Deviation of Headways Observed at Stop 's' for Route 'r'}}{\text{Average Headway for Route 'r'}}$$

- **Benchmark:** 0.2 or 20% (maximum)
- **Notes:**

- ◊ Since there are many stops and routes in a transit system, the SRI should be regularly monitored for a sample set of stops with the highest passenger activity.

- **Bus Breakdowns:** The breakdown of a bus while on a route is an indicator of poor preventive maintenance by the bus operator, and also negatively impacts the passenger perception of the transit service. Bus breakdowns can be tracked using the ITS.

- Benchmark: 1 per a million kilometres of operation (maximum)
- **Accidents & Fatalities:** Passenger safety is of paramount importance to the transit service. Accident and fatality data may not be directly available from the ITS; the transit manager should coordinate with the traffic police and the health department to gather, track and report this information on a daily basis. This metric is an indicator of the poor driving practices of the bus crew.
 - Benchmark: 1 fatality per 10 million kilometres of operation (maximum)
 - Notes:
 - ◊ Further classifications of this category into minor injuries, severe injuries, fatal accidents, etc. will help to correctly assess the impact of corrective interventions.
 - ◊ The nature of the accident should be recorded in detail (like which side of the bus was hit, the environment variables, photographs, etc.) to facilitate analysis, fault-finding, and identify corrective action.
- **Average Journey Speed:** This is an indicator of the prevailing traffic conditions within the city. This value should ideally be tracked separately for different hours of the day for different zones in the service area. This KPI is not necessarily a reflection of the transit service itself, but is

more a representation of the transportation environment within the city. It can be used to negotiate with the city municipalities, and help in finding ways to improve transit service speeds, through interventions such as Transit Signal Priority (TSP) or exclusive lanes for buses.

$$\text{Average Journey Speed} = \frac{\text{Revenue Distance Covered in a Time Period}}{\text{Revenue Hours} - (\text{Layover} + \text{Recovery Time})}$$

- **Average Shifts per Bus Crew:** This is not a very commonly used statistic, especially when bus operations are outsourced to private partners. However, there are many instances of bus operators violating labour laws in terms of the maximum hours of continuous driving, etc. which could hurt transit safety. Given that the bus crew (drivers and conductors) assignments are logged in the ITS, this is an easy statistic to report every month. This metric also helps to understand the regularity and attendance patterns of the crew.
- **Average Service Duration of the Crew:** This parametre tracks the duration for which the crew is on the payrolls of the private operator. Higher attrition of crew has implications on safety, as well as on the costs of orientation and training. This report may be assessed every month.

- **Cost per Kilometre (CPKM):** This statistic indicates the total unit cost of providing transit services. Comparing this metric to the EPKM allows the transit managers to assess the sustainability of the service and explore ways to provide for the financial deficit. All the data necessary for calculating CPKM may not be available within the ITS, and may have to be calculated and reported separately. Some transit agencies only track the operating costs, treating the infrastructure investment as sunk costs, whereas some others look at the overall costs. It is recommended that the CRUT compute and track both the operating costs and the total costs. This parametre can also be tracked every month.

$$\text{Cost per Kilometre (CPKM)} = \frac{\text{Total Cost of Providing Transit Service}}{\text{Revenue Distance} + \text{Dead Kilometres}}$$

- **Service Coverage (SC):** Bus transit cannot reach every street in the service area, and passengers are expected to walk or use other modes to reach the nearest bus stop. Service coverage is an assessment of the level of coverage in the service area. It is defined differently in different places, the most common selection being an area that falls within 0.5 km of a bus stop in a transit network. In places with convenient

access to facilities, a larger coverage can be considered if the passengers are willing to walk to a bus stop from farther distances.

However, the above definition does not take the population density or the service frequency (an important factor influencing mode choice) into consideration, and hence does not provide an accurate picture. The following definition may be more appropriate for CRUT's purposes.

$$\text{SC} = \frac{\text{(The Population Within 0.5 km of a Bus Stop Served by at least 6 buses/hr)}}{\text{(Total Population of the Intended Service Area)}} \times 100\%$$

- Notes:
 - ◊ The formula essentially suggests excluding bus stops lacking an adequate frequency from being considered in the coverage area.
 - ◊ Calculating the service coverage requires detailed population density data, which is not necessarily available from the ITS.
 - ◊ Service coverage remains constant, and needs to be re-calculated with changes to bus schedules.

3.3.4 Fleet Maintenance Indicators

This last category under performance indicators tracks the quality of fleet maintenance. Given that the maintenance of the bus fleet is the responsibility of the private operator under the gross-cost contract model, data for some of the parameters may not be available with the ITS or the regulator. This section, therefore, only lists the parameters that require data readily available with transit agencies. Other parameters and their respective benchmarks may be obtained from the original equipment manufacturers supplying the products.

- **The Average Age of the Fleet:** The age of the fleet has implications on the quality and comfort provided to the passengers. The transit authorities should continually review the age of the fleet and put together a replacement plan along with the necessary financial allocations.
 - Benchmark: 4 years (maximum)
- **Fuel Efficiency:** Fuel efficiency is an indicator of the quality of driving, safety, the quality of bus maintenance, transit sustainability, and the environmental impact. This KPI has far-reaching implications for transit service, and can actually only be tracked by the bus operator. However, the ITS can capture fuel levels in the bus, and thereby estimate and report the fuel efficiency of individual buses, for individual drivers, for different types of buses in the fleet, and for different bus routes.

3.3.5 Indicators of the Quality of Service (from the perspective of the users)

In order to retain the existing ridership and attract new riders to the system, it is essential that transit agencies monitor the quality of their service using indicators that reflect user perception. Some of these include:

- Availability
 - Accessibility
 - Affordability
 - Reliability
 - Safety and security
 - Comfort, etc.
- Transit authorities should regularly evaluate their service performance on the above parameters through user-satisfaction surveys, and address the identified gaps.

3.3.6 Other Reports

Apart from the 24 KPIs listed in the previous sections, the ITS must provide reports for assisting in various other functions of the transit agency. These reports are primarily of two types:

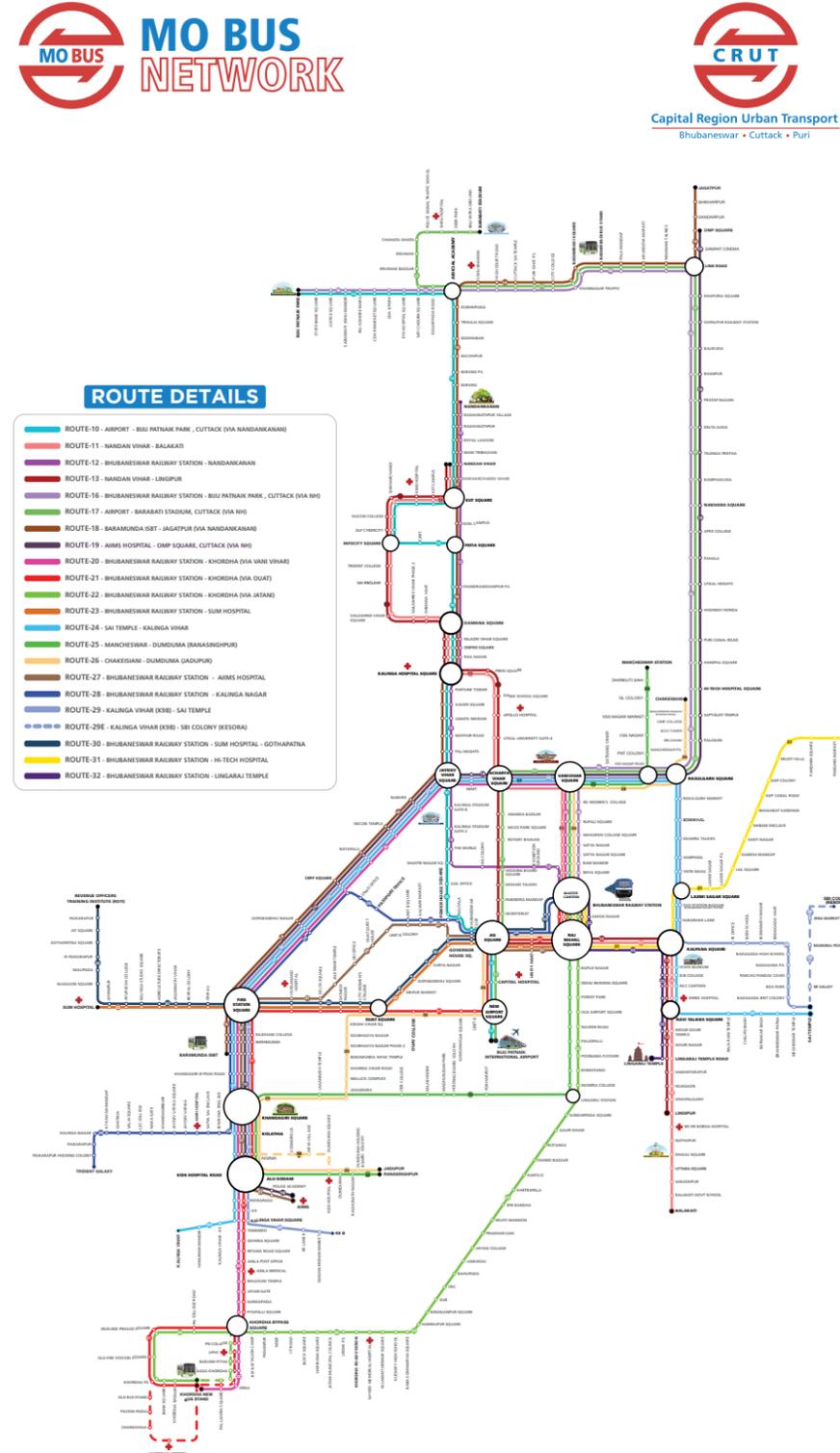
- **Transit Service Planning Reports:** As seen in the previous sections, service planning requires extensive amounts of data that needs to be structured to facilitate and improve scheduling. The following are some of the reports that are necessary in this regard:
 - Trip-Time Matrix
 - Boarding-Alighting Graph
 - Passenger Load Curve
 - Schedule Adherence Graph

Sample formats for the above reports have been provided in the section on transit schedules.
- **Safety and Regulatory Reports:** These reports have implications for passenger safety and the way in which transit services are perceived. Though the actual action items for this area are in the purview of the private bus operator, the ultimate liability falls with the regulator, and hence it is important to keep track, through:
 - Missed Stops Report
 - Over-speeding Report
 - Crew Working Hours Report
 - Route Permit Expiry Report
 - Insurance Expiry Report
 - Vehicle Fitness Expiry Report

3.3.7 Summary Notes

The number of KPIs and other reports and statistics can become overwhelming. Hence, these parameters should be presented in numerical values as well as have appropriate visual representations.

The ITS dashboard should also facilitate access to relevant data at various levels, based on the functions and purposes of the different officers of the transit agency. Although the essential KPIs to be evaluated will remain constant, the transit managers at the highest level may look only at the gross values, while the service planner may benefit from analysing the KPIs route-wise or stop-wise. Similarly, the depot manager may be more interested in assessing the KPIs for individual buses over a period of time. The ITS dashboards need to be designed to allow such flexibility of observing data, both at the macro and micro levels.



About the GIZ supported SMART-SUT Project

The Integrated Sustainable Urban Transport Systems for Smart Cities (Smart-SUT) project (August 2017 - July 2021) is jointly implemented by the Ministry of Housing and Urban Affairs (MoHUA) and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. The project works with the three Smart Cities - Bhubaneswar, Coimbatore, and Kochi, and their respective state governments, to promote low-carbon mobility, and to plan and implement sustainable urban transport projects in the fields of public transport, non-motorised transport and modal integration. It also supports urban transport agencies to set up the required institutional structures and processes, and enhance their capacities for efficient delivery of services. A consortium comprising GFA, WRI India and the Wuppertal Institute is supporting GIZ in the implementation of this project.



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