# Smart Data for Performance Monitoring of City-Bus Services - A Case Study of Ahmedabad

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# Introduction

Background of the study | Why the study is necessary

# Service Quality Perspectives

- **Operator**: Focus on operational efficiency .
- **User**: The two major areas of concern are service availability, and service delivery (i.e., comfort and convenience).
  - Spatial availability
  - Temporal availability
  - Information availability
  - Capacity availability
- **Society**: Transit services benefit community by reducing air and noise pollution, by reduction parking and traffic congestion and by providing a mode of travel for those users who can't afford a private mode as well.

**SERVICE AVAILABILITY**

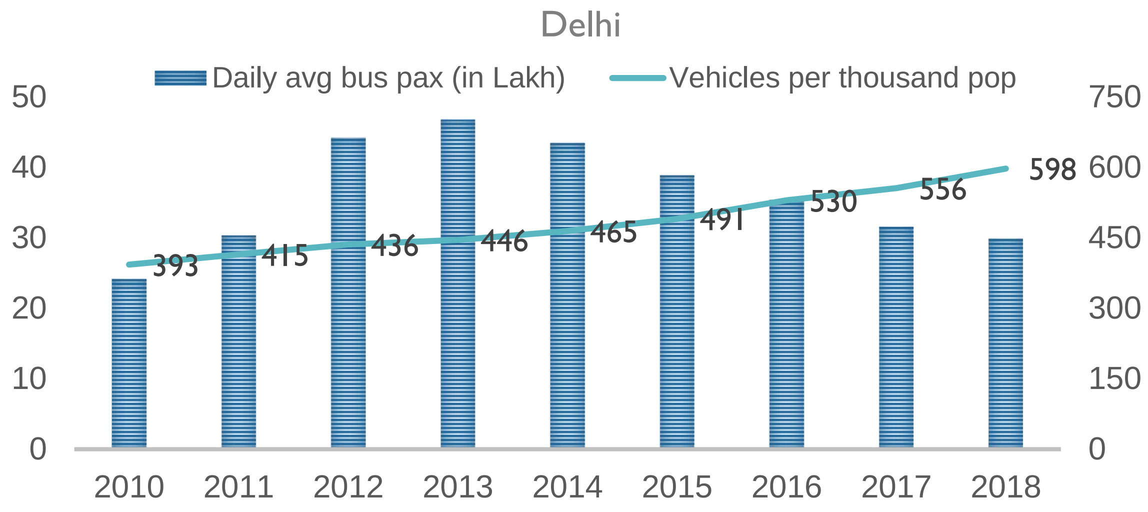
- Extent of service area covered
- Minimum/ maximum distance between routes
- Service frequency
- Span of service
- Stop location and accessibility

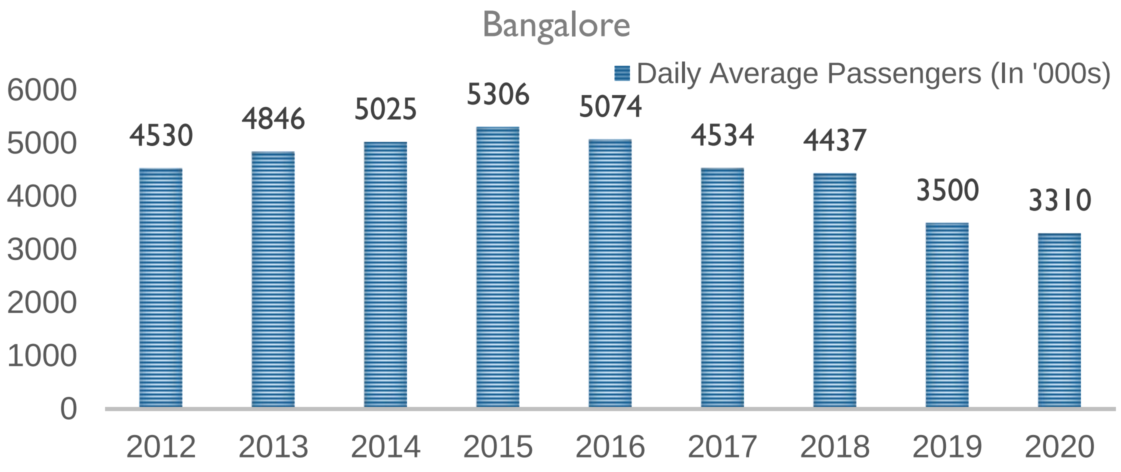
**SERVICE DELIVERY**

- Vehicle load
- On time performance/ schedule adherence
- Speed
- Customer amenities
- Safety
- Passenger complaints and passenger satisfaction.

*Source: TCRP report 88*

# Problem Statement




**Typical KPIs used in India**

**Physical Performance**

- Depots
- Schedules added and operated
- Vehicles added, scraped and held
- Effective km/day
- Fleet utilization
- No. of breakdowns/10,000 km
- Rate of accidents/ lakh km
- Manpower & fuel productivity

**Financial Performance**

- Effective km
- Traffic revenue
- Non traffic revenue – govt reimbursement and commercial revenue
- Cost of operation
- EPKM
- CPKM

- There is decline in bus ridership resulting in loss in revenues across the country due to the deteriorating quality of infrastructure and services as expressed by passengers.

- This in turn prevents the transport agencies from upgrading their systems.

- The emphasis of the performance assessment is from operator's viewpoint with all the indicators focused on assessing operational and financial performance of the services alone.

*Source: Operational Statistics of DTC, Economic Survey Of Delhi, 2018-19, Statistica, BMTC, State Transport Undertakings - Profile and Performance, CIRT*

# Research Question and Objective

**Aim** : To develop a framework for monitoring performance of city bus services through user's perspective using smart data

**Objective :**

01
- To understand various performance evaluation and monitoring processes adopted by transport agencies

02
- To identify indicators focused on operator, user and larger societal perspectives.

03
- To review to what extent user specific indicators are being measured to monitor performance.

04
- To study the various performance measures that can be evaluated and monitored using smart data

**Methodology :**

**Literature study :** Identifying research papers to establish
- Need of the study
- Recommended indicators
- How Big Data can be used for performance monitoring

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Data collection – **Ahmedabad** on
- parameters identified for selected routes
- Format, sources and methodology used by AMTS and AJL

↓

Assessing gaps in the current practice by measuring performance using selected indicators from literature study and using the ones by authorities

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Highlighting what needs to change and how it can be changed by providing recommendations and way forward

**Scope and Limitation:**
- Sample routes for both city buses and BRTS are selected for Ahmedabad and route analysis on user focused measures have been undertaken using smart data.
- Indicators are selected keeping in mind the type of smart datasets available

# Literature Review

What are the various indicators used for assessing performance globally | Best practices

# Performance Indicators – Global practices

## Performance indicators

### Ridership
- Ridership by mode
- Pax trips/km
- Ratio of ridership to population growth
- Passenger per capita

### Cost Efficiency
- Pax per vehicle km
- Pax per vehicle hr.
- OPEX per pax
- Operating expense per vehicle revenue mile
- Fuel economy

### Asset Management
- Age of fleet by vehicle type
- Percent of vehicle useful life remaining
- Number of mechanical failures
- Distance between vehicle failures

**Operator’s Perspective**

### Availability
- Total service hours provided versus total hours needed to meet. transit demand
- Average days per week that transit service is available.

### Quality of services
- On-time performance by mode.
- Rate of injuries and/or fatalities involving transit vehicles.
- Ratings of public transportation system.

**User’s Perspective**

### Community
- % non-single-occupant vehicle commuters
- Auto vehicle trips reduced
- Energy savings
- % of fleets using clean or alternative fuels

**Society’s Perspective**

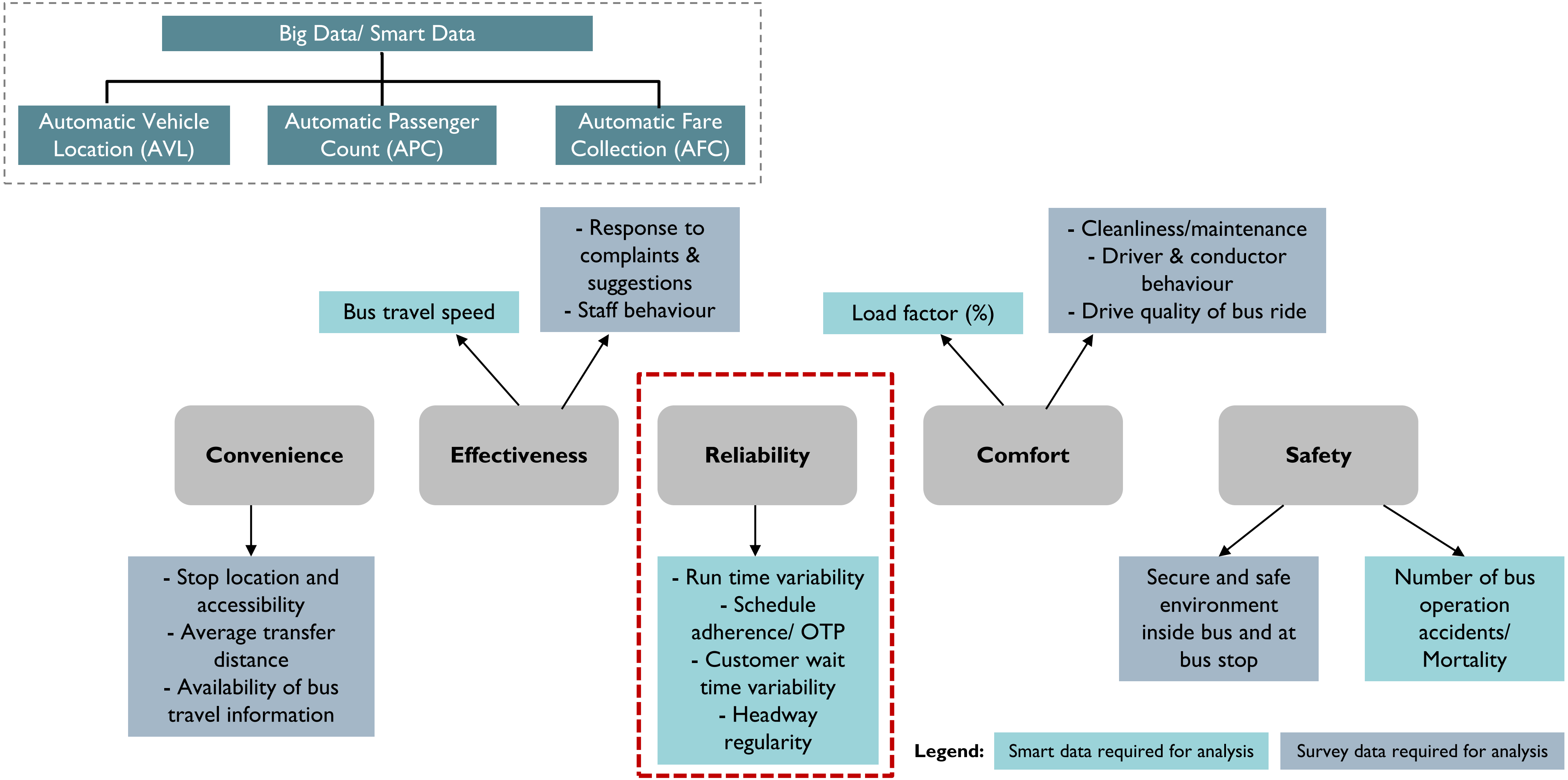
*Source: Best Practices In Evaluating Transit Performance, Florida Department of Transportation, 2014*

# Service Quality Dimensions (User's Perspective)

| | | |
|---|---|---|
| 1 | Reliability | Unreliable services amount to extra waiting time for passengers to reach the destination at a particular time. Passengers perceive wait time as twice of in-vehicle time |
| 2 | Comfort | It is the physical comfort perceived through the design or the measures taken to create ambient conditions. |
| 3 | Safety | It includes actual safety from crime or accidents, which results in the feeling of security |
| 4 | Accessibility | Measure used to calculate distance among different areas and to analyze the convenience to reach destination from origin with respect to the transportation system. |

*Source: TCRP report 34, TCQSM 3rd edition, TCRP report 113, TCRP report 47, TCRP report 215, Service Quality In Public Transport, Understanding User And Non-user Perspectives : A Case Of Ahmedabad, Reliability Of Public Transportation System : Case Study Of Ahmedabad , Patel H.M, 2017, Analyzing Reliability And Comfort In Public Transport Services, Panchal, P 2018*

# User Perspective Dimensions using Smart data




*Source: An Assessment of Alternative Bus Reliability Indicators, Bus Operation Monitoring Oriented Public Transit Travel Index System and Calculation Models, Bus Service Performance Analysis, TCRP 34*

# Importance of the selected indicators under Reliability (dimension)

| Selected Indicator | Why it is selected | Its importance |
|---|---|---|
| **On time performance** | Used by all transport agencies to measure reliability. AMTS and AJL also uses it | It is important for passengers who refer to timetable for travel to plan out their trip |
| **Runtime difference and consistency** | It provides an understanding of the average travel time taken. It is measured by both AMTS and AJL | Run time consistency shows the variation in in-vehicle time which would affect headways. |
| **Headway regularity** | It provides an understanding on whether bus bunching is occurring and its effect on wait times and on time performance | Irregularity in headway causes variation in crowding in buses. Maintaining regular headways prevent bus bunching and reduces average wait times |
| **Bus Trajectory** ***(linked to headway regularity)*** | It helps to identify the points where bus bunching occurs. | Related to headway regularity and explains how the route operates. |
| **Customer wait time** | Most important indicator from a user's perspective as wait times are affected by on time performance and headway regularity | Users chooses public transport depending on the average waiting time spent by him at a stop. |

*Source: Bus Operation Monitoring Oriented Public Transit Travel Index System and Calculation Models, TCRP report 34, TCQSM 3rd edition, Service Quality In Public Transport, Understanding User And Non-user Perspectives : A Case Of Ahmedabad, TCRP report 47, TCRP report 215, Reliability Of Public Transportation System : Case Study Of Ahmedabad , Patel H.M, 2017, Analyzing Reliability And Comfort In Public Transport Services, Panchal, P 2018*

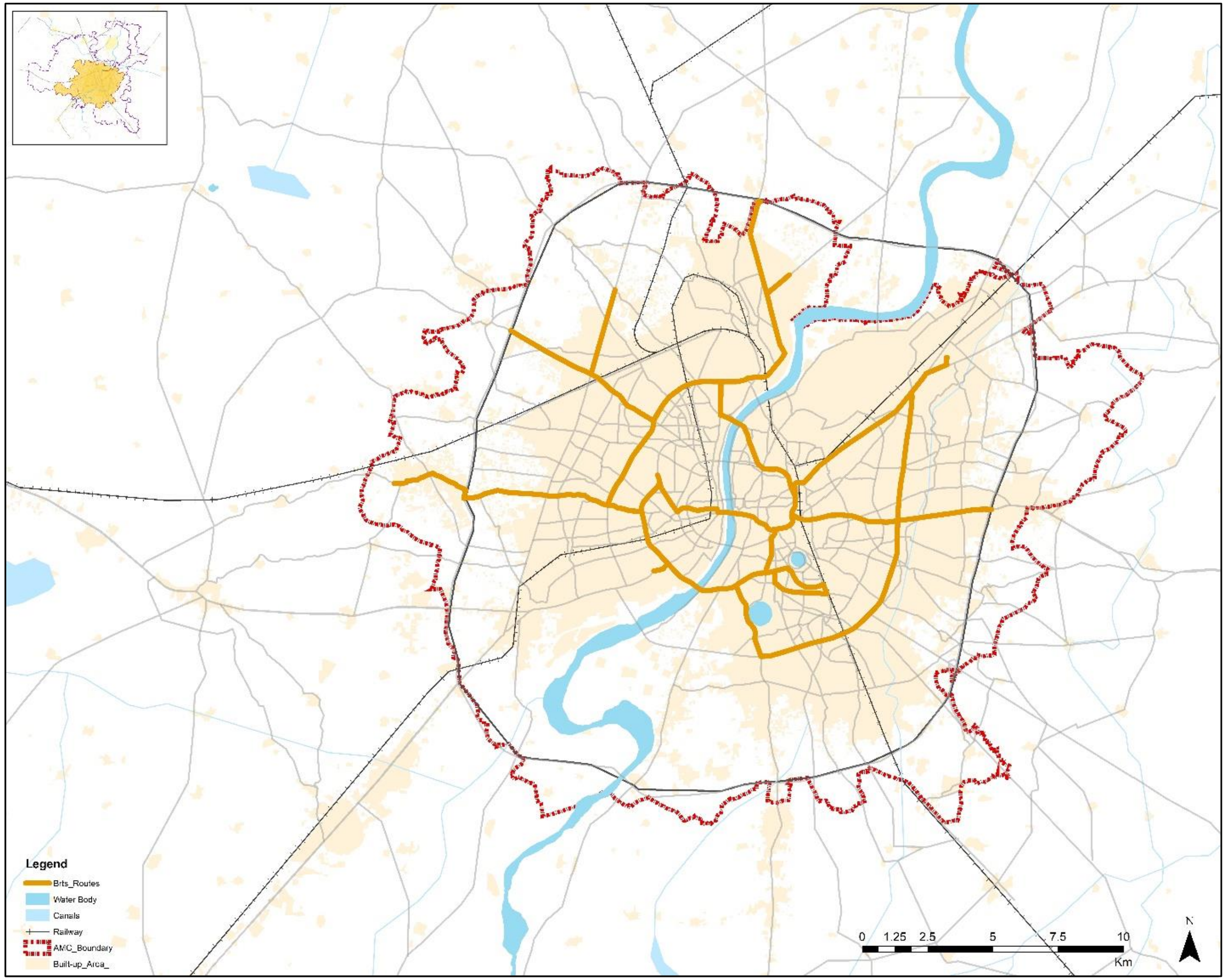
# Selected method to measure the indicators under Reliability (dimension)

| Selected Indicator | Definition | Method to measure and author | Why it is selected |
|---|---|---|---|
| **On time performance** | Measures how well actual arrival and departure times are adhering to scheduled arrival and departure times. | % of trips (Various transit operators) | AMTS and AJL uses this method, and it is easily relatable with other indicators |
| **Runtime difference and consistency** | Runtime difference is the difference in actual and scheduled runtimes and runtime consistency is the distribution of actual runtimes over a period of time along a particular route | Average runtime difference in mins = average scheduled runtime - average scheduled runtime (Cham, 2006)<br>$C_v$ = σ/mean of actual run time (Liu & Sinha, 2007) | AMTS and AJL uses similar calculation.<br>Can be easily related with other indicators. Helps to understand the consistency of service |
| **Headway regularity** | Headway is the time taken between 2 vehicles at the same point along a route. | Cv = σ/mean of actual run time (Cham, 2006) | Easier to compare with wait time |
| **Bus Trajectory**<br>***(linked to headway regularity)*** | Trajectory shows the movement of vehicle along a route to identify points where bus bunching occurs | Graph is plotted using cumulative distance over cumulative time for a particular line direction. Each coloured line represents a bus that appears. (TRB, 2006) | Helpful for getting a sense of how the route operates.<br>It can help to understand the phenomena of bus bunching. |
| **Customer wait time** | Time taken by users waiting to board the bus along a route | EWT = AWT-SWT<br>=½ of actual headway - ½ of scheduled headway, where,<br>(Liu & Sinha, 2007) (TRB, 2006) | Used by Transport for London (TfL) |

# Case City Profile - Ahmedabad

Public Transport Scenario | Routes chosen

# Case City - Ahmedabad




The city has a total area of 483 sq.km with an estimated population of 69.1 lakhs and an average density of 143 pph in 2021.

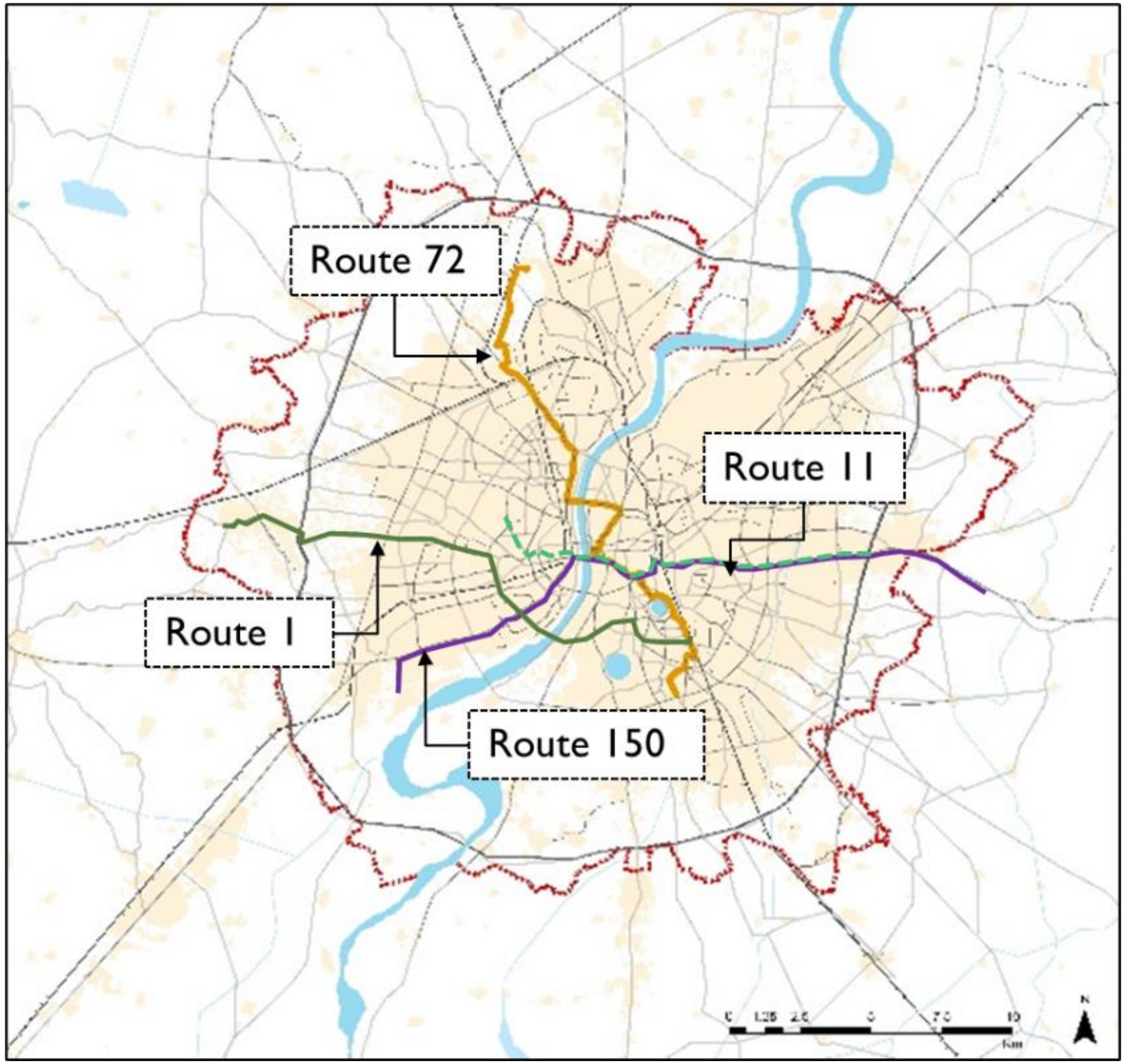
The city offers two public transport systems to meet the transport needs of the city – AMTS and BRTS. The city is also providing metro services; however, it is not fully functional.

Network length of AMTS – 792 km with a fleet size of 684.

Network length of BRTS – 89 km with a fleet size of 260.

The ITMS is implemented for both AMTS as well as BRTS and both systems have separate control rooms to manage the system operations based on real time data collected.

# Routes chosen for analysis




### Criteria for Selection of Routes

- Coverage. Routes that connected N-S and E-W locations were selected
- Ridership: High and low ridership routes were selected

| Route | OD of route | No. of bus stops | Route length | Headway | Buses on route | No of trips | Ridership |
|---|---|---|---|---|---|---|---|
| 150 | Sarkhej Gam-Chinubhai Nagar | 69 | 26 | 6 | 18 | 127 | 6900 |
| 72 | Sahyadri Bunglows-Godrej Garden City | 66 | 22.5 | 8 | 9 | 100 | 6100 |
| 1 | Maninagar-Ghuma Gam | 34 | 19.5 | 5 | 13 | 321 | 31632 |
| 11 | Odhav Ring Road to LD Eng College | 25 | 14.7 | 15 | 14 | 131 | 19459 |

# Analysis

KPIs by AMTS and AJL | Route wise Analysis using chosen indicators

# KPIs by AMTS and AJL

| Indicator | Category | AJL | AMTS |
|---|---|---|---|
| **Comfort –** *Ride quality* | Service | Speeds are only monitored (low priority) | 1. Drive above speed limits (medium priority)<br>2. Speed violation incidents (low priority) |
| **Comfort** | Infrastructure | Unclean vehicles at the start of first trip in the morning , malfunctioning passenger door, loose/ missing passenger door (low priority) | 1. Unclean buses at the start of first trip in the morning (medium priority)<br>2. Loose handrails, roof grabs/rails (low priority) |
| **Reliability -** *Runtime difference* | Schedule/ Service | - | - |
| **Reliability –** *Schedule adherence* | Schedule/ Service | 1. Missed stops (low priority)<br>2. Stoppage at points not designated (low priority)<br>3. Arrival for a shift ≯10 min late and delay ≯ 20 min beyond at the end of the shift (low priority) | 1. Non completion of trips (low priority)<br>2. Non stoppage at points (high priority)<br>3. Starting trip 5 mins early to scheduled time (low) |
| **Reliability –** *Dwell time* | Schedule/ Service | Stopping at bus station for longer than authorized by authority (low priority) | - |
| **Reliability –** *Route level* | Schedule/ Service | - | 1. Deviating from route issued by AMTS (medium)<br>2. Non availability of buses for any shift (medium) |
| **Reliability** | Infrastructure | - | 1. Equipments not working or kept off (medium)<br>2. Non selection of trip in DDU* (low priority) |
| **Safety** | Service | - | Loss/ tampering with recordings in the complaint book (medium priority) |

Driver Display Unit*

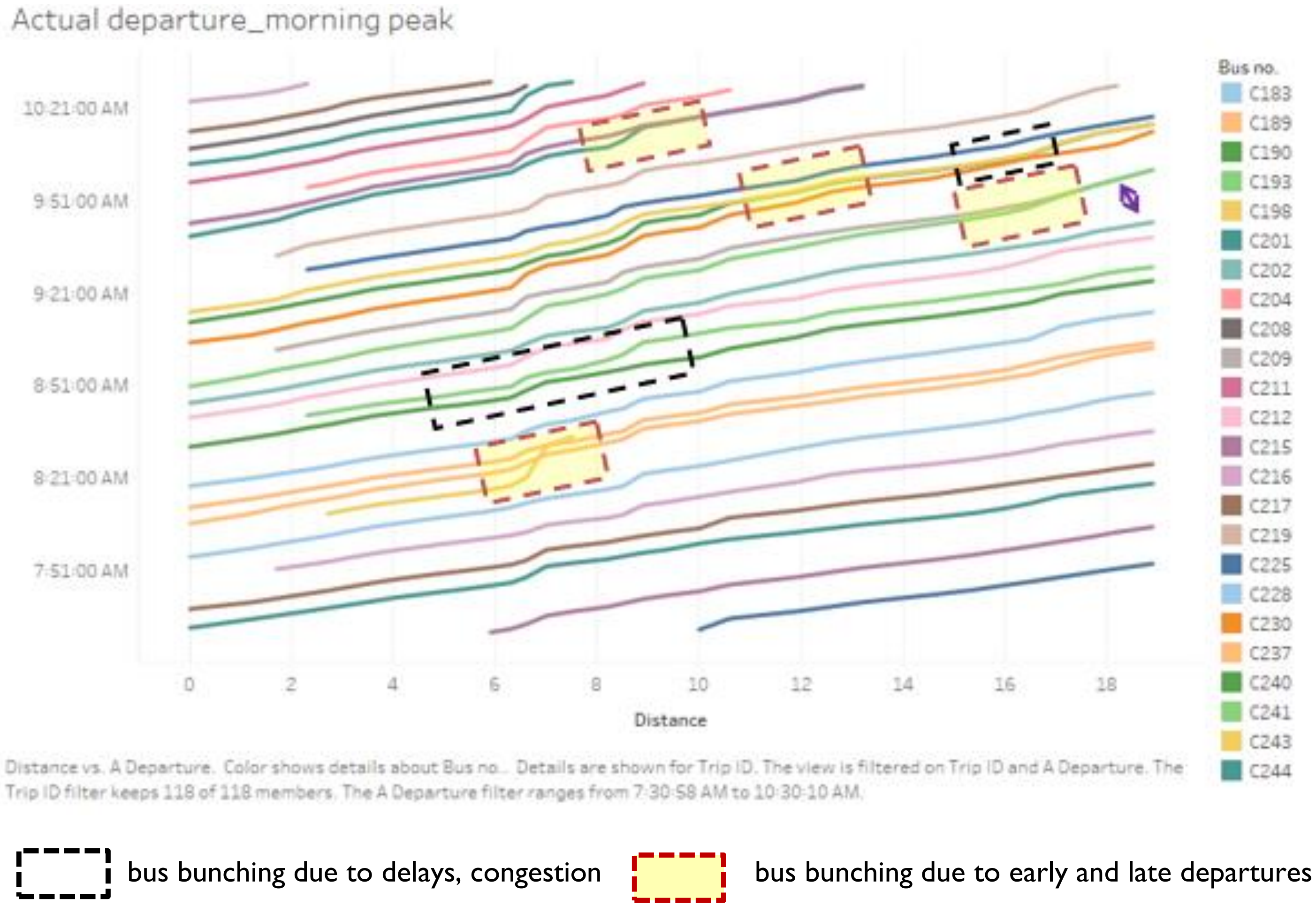
Both operators only monitor the service at a route level and not stop wise. Penalising start and end of the trips doesnot enforce that service will be reliable for users.

# Performance results using operator’s KPI and KPI from literature study

<table>
<tr><th>Selected Indicator</th><th>AJL</th><th>AMTS</th><th colspan="5">As per literature for routes 72,150,1,11</th></tr>
<tr><td rowspan="4">Schedule adherence/ On time performance</td><td rowspan="4">Only monitors missed stops, stoppage of buses at designated points and delay for start of trip ≯10 mins,<br>delay for end of trip ≯20 mins<br><br>Time band used : -5 to + 10 mins<br><br>If buses arrive within this time band, then the service is considered to be on time</td><td rowspan="4">Only monitors missed stops, stoppage of buses at designated points and starting trip 5 mins early to scheduled time<br><br>Time band used : -5 to + 10 mins<br><br>If buses arrive within this time band, then the service is considered to be on time</td><td colspan="5">Time band used is an issue as the headway for the routes are 10 mins and the time band is for 15 mins.</td></tr>
<tr><td>Time band – On time</td><td>72</td><td>150</td><td>1</td><td>11</td></tr>
<tr><td>AJL/AMTS<br>-5 to 10 mins</td><td>17%</td><td>6%</td><td>72%</td><td>24%</td></tr>
<tr><td>TfL<br>-2.5 to 5 mins</td><td>6%</td><td>3%</td><td>49%</td><td>14%</td></tr>
<tr><td>Arrival at last stop – Early vs Late</td><td>Not measured</td><td>Not measured</td><td colspan="5">If OTP is less than 70%, then the service is highly unreliable</td></tr>
<tr><td>Runtime difference and consistency</td><td>Not measured</td><td>Not measured</td><td>Runtime consistency – Coeff. Of variation (all trips)</td><td>2.7</td><td>1.9</td><td>0.5</td><td>0.2</td></tr>
<tr><td>Customer wait time</td><td>Not measured</td><td>Not measured</td><td colspan="5">If the value is greater than 0.74, then most vehicles are bunched</td></tr>
<tr><td>Headway regularity</td><td>Not measured</td><td>Not measured</td><td>Headway regularity- Coeff. Of variation (peak trips)</td><td>0.96</td><td>1.25</td><td>2.44</td><td>1.49</td></tr>
</table>

AJL and AMTS only monitors the start and end of the trip, which doesnot necessarily indicate that the service is reliable. On monitoring other factors, it can also be seen that the service is highly unreliable as majority of the users have to wait beyond the acceptable range, thereby also reducing comfort.

# Headway regularity- Bus Trajectory




Bus Trajectory for route 1 during morning peak hours

- To understand the bus bunching effect extensively, and how buses move along the route and to understand how delays affect the bus operations.
- Bus trajectories are plotted for morning peak hour and evening peak hour using actual departure - cumulative distance over cumulative time.

Observations

- Particularly in route 1, it can be observed that there is higher wait time for passengers when bus bunching is not present, which is marked using violet arrows
- Time band used by AMTS and AJL - 72 % of the trips are on time, but bus bunching occurs at stops.
- Using TfL time window - 49% of the trips are on time - justifies trajectory plot.
- Hence, time band taken must be carefully selected, and that AMTS and AJL must revise their time bands.

# Conclusion

Recommendations and Way Forward

# Conclusion and Recommendations

The indicators that are currently being used is only giving partial information. The indicators identified from literature study can be easily used to monitor performance using smart data as seen.

The recommendations that can be provided to AMTS and AJL are as follows:

- Time window for measuring on time performance should be narrowed down to a time band of -2.5 minutes to +5 minutes
- Headway regularity along with customer wait time should be measured at stop-level, using the same methodology in the study to understand the effect on users.
- Run time consistency should be measured for all the routes as reaching destination on time and maintaining average travel times are major concerns of a passenger

As a way forward, this methodology

- Can act as a guiding document for operators to analyze large smart datasets to monitor performance for all the routes.
- Can be used to study specific indicators like crowding and ride quality using APC and other datasets available.
- Can be used to develop a tool where smart data is easily available and can be computed without much effort for the user specific indicators to analyze the system at route level, stop level and even vehicle level.

# THANK YOU !