Technical Study of the existing BRTS corridor for the last mile connectivity and pre-feasibility of potential electrification of the corridor in Rajkot

August 2018
About the team

**ICLEI - Local Governments for Sustainability** is the world's leading association of more than 1000 metropolises, cities, urban regions and towns. ICLEI South Asia - the South Asian arm of ICLEI - Local Governments for Sustainability, aims to build and serve a regional network of local governments to achieve tangible improvements in regional and global sustainability through local initiatives. Over 13 years, ICLEI South Asia has emerged a strong and vibrant local government association with a membership base of over 70 cities.

**S G Architects** was established in 2006, and provides consultancy services in the field of sustainable urban transport including public and non-motorised transport. We provide expertise in research, planning and implementation for all forms of sustainable urban transport projects, including developing toolkits, guidelines and other resource material.

**SNZ** is an experienced and independent engineering, planning and consulting company. We are successful in traffic planning, traffic management, environmental planning, civil engineering and road construction, railway technology and railway systems, supply and disposal buildings, structural engineering, basic and specialist foundation engineering, building conservation, project management and construction management. Our company is divided into three departments - traffic planning, configuration and construction / value retention. SNZ has been ISO 9001 certified since 1997.
Objective:
Identify a feeder solution to increase the ridership and explore electrification of the BRT network

Task 1:
Compare the potential of different feeder modes to attract ridership in favor of BRT

Task 2:
Plan the selected feeder network

Task 3:
Plan the BRT Operations for resultant increase in ridership

Task 4:
Propose an Electrification plan for BRT Network

STAGE 1
INTERMODAL SHIFT
Probability of shift from one mode to another

BRT RIDERSHIP INCREASE

2018 → 2023 → 2028
CUMULATIVE TRIPS
Time dimension – Land use changes, smart city ABD, population increase

STAGE 2
ELECTRIC MOBILITY PLAN
Objective: Identify a feeder solution to increase the ridership and explore electrification of the BRT network

Task 1: Compare the potential of different feeder modes to attract ridership in favor of BRT

Task 2: Plan the selected feeder network

Task 3: Plan the BRT Operations for resultant increase in ridership

Task 4: Propose an Electrification plan for BRT Network

STAGE 1

- Task 1: Compare the potential of different feeder modes to attract ridership in favor of BRT
  - Walk
  - Shared Auto
  - RMTS
  - Cycle
  - Auto Rick.
  - Car
  - 2 Wheeler

- Task 2: Plan the selected feeder network
  - Access Distance
  - Journey Time
  - Journey Cost
  - Trip Numbers
  - Avg. Speed
  - Per Km. Cost
  - O – D

- Task 3: Plan the BRT Operations for resultant increase in ridership
  - Zones & Modes of Interest
  - Network Plan
  - BRT Ridership

- Task 4: Propose an Electrification plan for BRT Network
  - LITERATURE Potential Feeder
    - Walk
    - Shared Auto
    - RMTS
    - Bicycle Sharing
    - E-Rickshaw
    - Hybrid BRT
    - + BRT
About Rajkot City

- **Fourth largest city** in the state
- Managed by **Rajkot Municipal Corporation (RMC)**
- **RMC Area** - 104.85 sq.km; **Population of RMC** - 1.29 million (1.75 metropolitan 2018)
- **Population Growth Rate** – 3.3%
- **Rajkot Urban Development Authority (RUDA) Area** - 686.30 sq.km
- **Per Capita Trip Rate (including walk)** - 1.30 trips/day
- **Per Capita Trip Rate (excluding walk)** - 0.81 trips/day

- **Average Trip Length (ATL)** - Within 4 km
- **Trip Purpose** - Work 53%
  Education 26%
- **High mode share of NMT** - 48%
  & **Motorized two wheelers** – 35%
- **Trips in the city are made largely by** walking and two-wheelers
- City has informal though very **strong IPT presence**.
About BRTS

- **Rajkot** is proposed with **BRTS network of total 63.5km**
- Out of 63.5kms, **10.7 km BRTS corridor i.e. from Gondal Road to Jamnagar road is operational along a section of ring road**.
- **Rajkot BRT** was planned in **2007-09** by Urban Mass Transit Corporation (UMTC), SGArchitects (SGA) and BPS Architects for Rajkot Municipal Corporation (RMC).
- **First BRT in the country, designed with semi-signalised roundabout junctions**

**Corridor Details**

- **Closed BRTS, Length - 10.7km, ROW - 45m**
- **No. of Stations - 18, Daily Ridership - 11000 - 24000 (August 2017)**
- **The corridor is designed with**:
  - 2 vehicular lanes
  - Continuous cycle track
  - A parking lane
  - Continuous and barrier free footpath along the length of the corridor
  - Dedicated bus lanes
About RMTS

- **Rajkot** has a city bus - **Rajkot Municipal Transport Service (RMTS)**
- Operated by "Special Purpose Vehicle" (SPV) called **Rajkot Rajpath Ltd (RRL)**
- 60+6 Marco Polo Midi Buses with 32 seating capacity and
- 30+3 Tata Standard Buses with 42 seating capacity
- 57 planned routes (44 operational)
- Out of 57 (planned) routes, 31 routes are intersecting BRTs corridor
Literature Review

- **Last Mile Connectivity Study.** Author: Gresham Smith and Partners in collaboration with Sprinkle and vhb for PCID, Atlanta city.
- **First Last Mile Strategic Plan & Planning Guidelines.** Authors: Los Angeles County Metropolitan Transportation Authority & SCAG, Los Angeles.
- **Last Mile Connectivity (LMC) For Enhancing Accessibility of Rapid Transit Systems.** Author: Chidambara, Department of Urban Planning, School of Planning and Architecture, New Delhi, India
- **First mile-Last mile, Intermodalism, And Making Public Transit More Attractive.** Author: Steven Polzin, Blog Post, PLANETIZEN.
- **First/Last Mile Strategies Study.** Author: FEHR & PEERS and NELSON NYGAARD
- **Access-egress and other Travel Characteristics of Metro users in Delhi and its Satellite Cities.** Author: Rahul Goel and Geetam Tiwari, TRIPP, IIT Delhi.
- **Case studies and best practices of electric mobility in developing countries:**
  - Electric bus market in India
  - Electric bus market in other developing countries
- **Case studies and best practices in electrification of last mile modes**
  - PubliBike (bike sharing)
  - Mobility (car sharing)
- **Case studies and best practices in electrification of BRT fleet**
Data Collection

• **Study Area:** limited to the BRT corridor – Data collected on corridor and on routes intersecting the corridor

• **Secondary Data:** operational data for RMTS and RRL
  - Route-wise Ticketing Information: Origin, Destination, Boarding, Alighting – RMTS, RRL
  - Speed Analysis Data – RMTS, RRL
  - Fare Matrix – RMTS, RRL
  - Route wise time schedule – RMTS, RRL
  - Route length, bus stop location and spacing – RMTS, RRL
  - Fleet Operational Characteristics: Bus length, Fleet size, Daily distance per vehicle, Operating hours and Frequency, EPK, CPK - RMTS, RRL
  - Present and future electricity sources and distribution infrastructure

• **Primary Data:** surveys were conducted on the corridor including junctions and BRT stations
  - Sample Size: 833 O-D at junctions and 196 O-D on BRT Corridor
  - This included origin-destination (O-D) surveys through interviews,
  - Traffic surveys through videography and
  - Average speed data (on Rajkot Road network) by different modes using hand held (mobile) GPS devices
  - Willingness to use BRTS - Perception survey
## Secondary Data Findings (RMTS & RRL)

<table>
<thead>
<tr>
<th>Particulars (31 RMTS Routes, 1 BRT Route)</th>
<th>RMTS (City Bus)</th>
<th>RRL (BRT)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average</td>
<td>Range</td>
</tr>
<tr>
<td>Route length (Km)</td>
<td>16.28</td>
<td>6.29 (R 27) to 31.76 (R 9)</td>
</tr>
<tr>
<td>Dist. between stations (m)</td>
<td>560</td>
<td>370 to 918</td>
</tr>
<tr>
<td>Passenger trip length (km)</td>
<td>6.43</td>
<td>3.34 (R 27) to 11.44 (R 9)</td>
</tr>
<tr>
<td>Occupancy</td>
<td>18.30 (0.57%)</td>
<td>1.58 to 46.79</td>
</tr>
<tr>
<td>Routes per station</td>
<td>2.7</td>
<td>1 to 27 (Tikon Bagh)</td>
</tr>
<tr>
<td>Boarding per day</td>
<td>44.6</td>
<td>0.35 (53 quarter) to 1886 (Tikon Bagh)</td>
</tr>
<tr>
<td>Alighting per day</td>
<td>46.6</td>
<td>0.35 (53 quarter) to 1603 (Tikon Bagh)</td>
</tr>
<tr>
<td>Boarding per trip</td>
<td>1.43</td>
<td>0 to 22.11 (Ghanteshwar R 20)</td>
</tr>
<tr>
<td>Alighting per trip</td>
<td>1.39</td>
<td>0 to 25.81 (Ghanteshwar R 20)</td>
</tr>
<tr>
<td>Average op. speed (Km/h)</td>
<td>18.32</td>
<td>11.86 (R 41) to 21.57 (R 9)</td>
</tr>
<tr>
<td>Fare Structure (Rs./km)</td>
<td>1.0</td>
<td>0.7 to 5.0</td>
</tr>
<tr>
<td>Route Headway (minutes)</td>
<td>70(26 at stop)</td>
<td>38 (R 1,27) to 136 (R 20)</td>
</tr>
<tr>
<td>Fleet Size</td>
<td>99</td>
<td></td>
</tr>
</tbody>
</table>
Primary Data Findings

Traffic count estimation for Peak hour and daily traffic data
- Peak traffic period (on BRTS corridor) – 7:30 AM to 8:30 AM

Average Speed of Modes other than Bus
- Peak traffic period (on BRTS corridor) – 7:30 AM to 8:30 AM

Traffic volume intensity on BRTS corridor
Primary Data Findings

Composition of Traffic and Trips by Mode on the BRT Corridor

Mode-wise trip in peak hour

- Cycle: 2%  
- 2 wheeler: 4%  
- 4 wheeler: 2%  
- Auto: 24%  
- Bus: 38%  
- BRTS Bus: 9%  
- Pedestrians: 23%

Mode-wise PCU in peak hour

- Cycle: 1%  
- 2 wheeler: 7%  
- 4 wheeler: 30%  
- Auto: 19%  
- Bus: 1%  
- BRTS Bus: 2%  
- LMV: 9%  
- Trucks: 20%

Willingness to use BRTS Perception survey

- 61% - ‘BRTS station is far from their origin and destination’ - not preferring BRTS as a mode of transport.
- 36% - ‘High Speed – low journey time than other mode’ - they prefer BRTS as a mode of transport.
- More than 50% - more people can use BRTS if waiting time for BRTS is reduced.

For preferred last mile connectivity option:

- About 44% - opted for RMTS as the most preferred last mile connectivity mode.
- 19% each - for walk and auto rickshaw
- 11% - cycling as the preferable last mile connectivity mode.
Primary Data Findings

Last mile connectivity modes used by current BRT commuters

- Majority of commuters -77% (first mile) & 71% (last mile) – walk to BRT station
- 10% commuters use city bus as the mode for first mile connectivity
- 11% commuters use shared auto as the mode for last mile connectivity

Trip Purpose for Modes other than RMTS bus

BRT Buses

Allmodes (other than buses)

<table>
<thead>
<tr>
<th>Mode/Feeder</th>
<th>Average Trip length (ATL) - Modes other than Bus</th>
<th>Average Trip length (ATL) - BRT Commuters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walk</td>
<td>2.24km</td>
<td>5.6 km</td>
</tr>
<tr>
<td>Bicycle</td>
<td>4.37km</td>
<td>--</td>
</tr>
<tr>
<td>Shared Auto</td>
<td>9.06km</td>
<td>7.1 km</td>
</tr>
<tr>
<td>Auto</td>
<td>7.19km</td>
<td>6.67 km</td>
</tr>
<tr>
<td>Car</td>
<td>8.01km</td>
<td>6.6 km</td>
</tr>
<tr>
<td>2W</td>
<td>6.98km</td>
<td>6.47 km</td>
</tr>
</tbody>
</table>

Average trip length of BRT commuters is 6.04 km
Primary Data Findings

**Land use analysis**

- Majority of land use - Residential - nearly 80% (500m both side of the corridor)
- Land use along the corridor - nearly 40% - majorly Mixed (residential + commercial)
- The land use along the corridor is favorable for shorter and non-motorized trips.
Primary Data Findings

**Locational Data**
- TAZ with approximately 600m-1200m x 600m-1200m, Total zones - 193 zones
- O-D Other than bus – Min. data points - 0; Max. data points - 88 (zone 109)
- BRT O-D - at all 18 BRT stations interviewed – Minimum data points from a zone - 0, Maximum data points from a zone – 23 (from zone – 66, 81, 88, 109 and 144)
Analysis and Modelling

INTERMODAL SHIFT

Access Dist.
Journey Time
Journey Cost

Probability of Shift

- Distance to corridor
- ROUTE - Ratio of dist. on corridor to total trip length
- Speed
- Wait time
- Access time & cost
- Interchange time & cost

Walk
Shared Auto
RMTS
Cycle
Auto Rick.
Car
2 Wheeler

Walk
Shared Auto
RMTS
Bicycle Sharing
E-Rickshaw
Hybrid BRT

Sample projected to population
Analysis and Modelling
TEMPORAL GROWTH OF TRIPS

Land use plan in 2023
Land use plan in 2028

POPULATION INCREASE + GROWTH IN TRIP RATE + LANDUSE

ABD Area
SMART LANDMARKS IN ABD
Mode wise Zones of Interest (Walk and Bicycle sharing)

2018
Important Zones:
• KKV
• Raiya chowk
• Metoda village

2023
Important Zones:
• KKV
• Raiya chowk
• Metoda village
• Hospital chowk
• Raiya Road

2028
Important Zones:
• KKV
• Raiya chowk
• Metoda village
• Hospital chowk
• Raiya Road
• Nageshwar Park

2018
Important Zones:
• Raiya Chowk
• Raiya road
• Hospital chowk
• Tikon bagh

2023
Important Zones:
• Raiya chowk
• Raiya road
• Hospital chowk
• Tikon bagh
• Dhebar chowk

2028
Important Zones:
• Raiya chowk
• Raiya road
• Hospital chowk
• Tikon bagh
• Dhebar chowk
• KKV
• Gondal
• Punit Nagar
POTENTIAL SHIFT (ESTIMATES)

Mode wise Zones of Interest (RMTS and Hybrid)

2018
Important Zones:
• KKV
• Raiya chowk
• Raiya road
• Hospital chowk
• Gondal

2023
Important Zones:
• KKV
• Raiya chowk
• Raiya road
• Hospital chowk
• Gondal
• Ramdevpir chowk
• Tikon bagh

2028
Important Zones:
• KKV
• Raiya chowk
• Raiya road
• Hospital chowk
• Gondal
• Ramdevpir chowk
• Tikon bagh
• Metoda
• Nageshwar park

2018
Important Zones:
• KKV
• Raiya chowk
• Raiya road
• Hospital chowk
• Tikon bagh
• Metoda
• Gondal
• Tikon bagh

2023
Important Zones:
• KKV
• Raiya chowk
• Raiya road
• Hospital chowk
• Gondal
• Ramdevpir chowk
• Tikon bagh
• Metoda
• Nageshwar park

2028
Important Zones:
• KKV
• Raiya chowk
• Raiya road
• Hospital chowk
• Gondal
• Ramdevpir chowk
• Tikon bagh
• Metoda
• Nageshwar park

2018
Important Zones:
• KKV
• Raiya chowk
• Raiya road
• Hospital chowk
• Tikon bagh
• Metoda
• Gondal
• Tikon bagh

2023
Important Zones:
• KKV
• Raiya chowk
• Raiya road
• Hospital chowk
• Gondal
• Ramdevpir chowk
• Tikon bagh
• Metoda
• Nageshwar park

2028
Important Zones:
• KKV
• Raiya chowk
• Raiya road
• Hospital chowk
• Gondal
• Ramdevpir chowk
• Tikon bagh
• Metoda
• Nageshwar park
Mode wise Zones of Interest (Shared 3W and E-rickshaw)

**2018**
- Important Zones:
  - Raiya road

**2023**
- Important Zones:
  - KKV
  - Raiya chowk
  - Raiya road
  - Gondal
  - Ramdevpir chowk
  - Tikon bagh

**2028**
- Important Zones:
  - KKV
  - Raiya chowk
  - Raiya road
  - Gondal
  - Ramdevpir chowk
  - Tikon bagh
  - University road

**University road**

**Tikon bagh**

**Potential Shift (Estimates)**
Mode wise Network Plan and Salient Features

Proposal for Potential NMT Network Plan

- Network length – 12 km (42km including minor streets).
- Right of Way: Max. – 30m; Min. – 24m
- Footpath width – 1.8m to 2.5m (either side)
- Segregated cycle track: 2.2 - 2.5m (both side)
- Stretches having space constrains –
  - 3 to 4m wide common cycle track-footpath or
  - 1.2 to 1.5m wide painted cycle lanes along with traffic calming.
- Cycle tracks and Bicycle sharing stations integration.
- Cycles with carriers for bike sharing service
- Total shift to BRTS–

<table>
<thead>
<tr>
<th>year</th>
<th>Bicycle Sharing (daily pass. trips)</th>
<th>Pedestrian Infa. (daily pass. trips)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2018</td>
<td>781</td>
<td>533</td>
</tr>
<tr>
<td>2023</td>
<td>1176</td>
<td>680</td>
</tr>
<tr>
<td>2028</td>
<td>2260</td>
<td>841</td>
</tr>
</tbody>
</table>
**Proposal for Potential Hybrid BRT Network Plan**

**Two proposed routes:**

<table>
<thead>
<tr>
<th></th>
<th>Route A</th>
<th>Route B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Route length</td>
<td>8.9 km</td>
<td>18 km</td>
</tr>
<tr>
<td>Expected shift:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(2023) 1082</td>
<td>(2023) 640</td>
</tr>
<tr>
<td></td>
<td>(2028) 1443</td>
<td>(2028) 899</td>
</tr>
<tr>
<td>Avg. Operational speed</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(2023) 17.62</td>
<td>(2023) 17.76</td>
</tr>
<tr>
<td></td>
<td>(2028) 17.2</td>
<td>(2028) 17.6</td>
</tr>
<tr>
<td>Avg. Occupancy (%)</td>
<td>80%</td>
<td>30-45%</td>
</tr>
<tr>
<td>Headway (minutes)</td>
<td>13 to 22 min</td>
<td>24 to 29 min</td>
</tr>
<tr>
<td>EPK</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(2023) Rs. 19.2</td>
<td>(2023) Rs. 8.4</td>
</tr>
<tr>
<td></td>
<td>(2028) Rs. 19.2</td>
<td>(2028) Rs. 10.8</td>
</tr>
</tbody>
</table>

**Total fleet requirement:** 9 (2018), 11 (2023) and 14 (2028) MIDI BUSES (ELECTRIC)

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**Mode wise Network Plan and Salient Features**

- **Total fleet requirement**:
  - 2018: 9 Fleet
  - 2023: 11 Fleet
  - 2028: 14 Fleet

### Potential Hybrid BRT Network Plan

- **Route A**
  - Route length: 8.9 km
  - Expected shift: 840 trips (2018), 1082 trips (2023), 1443 trips (2028)
  - Avg. Operational speed: 18.35 km/hr (2018), 17.62 km/hr (2023), 17.2 km/hr (2028)
  - Avg. Occupancy (%): 80%
  - Headway (minutes): 13 to 22 min
  - EPK: Rs. 19.2

- **Route B**
  - Route length: 18 km
  - Expected shift: 504 trips (2018), 640 trips (2023), 899 trips (2028)
  - Avg. Operational speed: 18.37 km/hr (2018), 17.76 km/hr (2023), 17.6 km/hr (2028)
  - Avg. Occupancy (%): 30-45%
  - Headway (minutes): 24 to 29 min
  - EPK: Rs. 7.2

---

**Notes**

- **Proposal for Potential Hybrid BRT Network Plan**
- **Two proposed routes**:
- **Route A**:
  - Route length: 8.9 km
  - Expected shift: 840 trips (2018), 1082 trips (2023), 1443 trips (2028)
  - Avg. Operational speed: 18.35 km/hr (2018), 17.62 km/hr (2023), 17.2 km/hr (2028)
  - Avg. Occupancy (%): 80%
  - Headway (minutes): 13 to 22 min
  - EPK: Rs. 19.2

- **Route B**:
  - Route length: 18 km
  - Expected shift: 504 trips (2018), 640 trips (2023), 899 trips (2028)
  - Avg. Operational speed: 18.37 km/hr (2018), 17.76 km/hr (2023), 17.6 km/hr (2028)
  - Avg. Occupancy (%): 30-45%
  - Headway (minutes): 24 to 29 min
  - EPK: Rs. 7.2
Potential RMTS Network Plan

- Total 8 routes identified – 2, 5, 7, 16, 26, 27, 40 and 57 (having maximum potential to shift).
- Average headway – 20 minutes.
- Fleet requirement: additional 18 midi buses (includes 10% reserve).
- Locating RMTS bus stops within 75m of the BRTS with good quality pedestrian infrastructure.
- Fare integration between RMTS and BRTS (2023 onwards)
- Redevelopment of 9 Junctions
- Private vehicle parking regulations and restrictions (for horizon year 2023 and 2028).
- Total shift –
  - 884 daily passenger trips (2018),
  - 1260 daily passenger trips (2023)
  - 1573 daily passenger trips (2028).
Mode wise Network Plan and Salient Features

**Proposal for Potential E-rickshaw Network Plan**

- **E-rickshaw route length** – 7.8 km
- **Average commuter trip length** – 1.5km.
- **Average occupancy** – 50% (4 seater vehicle)
- **Fleet utilization** – 70%

<table>
<thead>
<tr>
<th></th>
<th>In 2018</th>
<th>In 2023</th>
<th>In 2028</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total shift to BRTS (trips)</td>
<td>254</td>
<td>446</td>
<td>552</td>
</tr>
<tr>
<td>Daily trips by E-rickshaw</td>
<td>1270</td>
<td>2230</td>
<td>2760</td>
</tr>
<tr>
<td>Fleet Requirement (nos.)</td>
<td>11</td>
<td>21</td>
<td>27</td>
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<tr>
<td>Avg. Headway (minutes)</td>
<td>14.7</td>
<td>8.4</td>
<td>6.8</td>
</tr>
<tr>
<td>Avg. Operational Speed (km/hr)</td>
<td>8</td>
<td>7.6</td>
<td>7.22</td>
</tr>
<tr>
<td>EPK (Rs.)</td>
<td>Rs. 7</td>
<td>Rs. 7</td>
<td>Rs. 7</td>
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</tbody>
</table>
## Impact on BRTS Ridership and Fleet Requirement

<table>
<thead>
<tr>
<th>Feeder Network/Mode</th>
<th>2018</th>
<th>2023</th>
<th>2028</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walk</td>
<td>533</td>
<td>680</td>
<td>841</td>
</tr>
<tr>
<td>Cycle</td>
<td>781</td>
<td>1176</td>
<td>2260</td>
</tr>
<tr>
<td>Hybrid BRTS</td>
<td>1345</td>
<td>1722</td>
<td>2342</td>
</tr>
<tr>
<td>RMTS</td>
<td>884</td>
<td>1260</td>
<td>1573</td>
</tr>
<tr>
<td>E-Rickshaw</td>
<td>254</td>
<td>446</td>
<td>552</td>
</tr>
<tr>
<td>TOTAL Passenger trips shift</td>
<td>3796</td>
<td>5284</td>
<td>7567</td>
</tr>
<tr>
<td>Current BRTS corridor Pass. trips</td>
<td>21109</td>
<td>26175</td>
<td>32297</td>
</tr>
<tr>
<td>TOTAL Including feeder Pass. trips</td>
<td>24905</td>
<td>31459</td>
<td>39864</td>
</tr>
</tbody>
</table>

### Fleet Requirement BRTS Buses (nos.)
- **In 2018**: 13
- **In 2023**: 16
- **In 2028**: 21

### Avg. Headway (minutes)
- **2018**: 6.7 min
- **2023**: 5.3 min
- **2028**: 4.2 min

### Expected Trip shift

<table>
<thead>
<tr>
<th>Year</th>
<th>4W</th>
<th>2W</th>
<th>3W</th>
<th>Shared3W</th>
<th>RMTS</th>
<th>Cyclist</th>
<th>Pedestrians</th>
</tr>
</thead>
<tbody>
<tr>
<td>2018</td>
<td>31%</td>
<td>33%</td>
<td>3%</td>
<td>3%</td>
<td>32%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>2023</td>
<td>34%</td>
<td>30%</td>
<td>3%</td>
<td>3%</td>
<td>33%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>2028</td>
<td>43%</td>
<td>26%</td>
<td>3%</td>
<td>3%</td>
<td>28%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

- **Maximum trips expected to shift from** – Shared 3W (in all 3 years)
- **Least shift from** – RMTS, Pedestrians and Cyclists (in all 3 years)

- **Headway expected to reduce further** – introduction of hybrid BRTS fleet.
- **No change in average EPK** – as no change in fare, occupancy or commuter trip length.
- **Average per km subsidy** – expected to remain unchanged.
- **Potential in exploring 12m long e-buses in BRT (proposed) fleet**
Feeder Demand – Other Key Findings

- Passenger Trips in the city (million): $2018\ 2.3 \rightarrow 2023\ 2.8 \rightarrow 2028\ 3.2$
- Passenger Trips crossing BRT (million): $2018\ 0.8 \ (34.5\%) \rightarrow 2023\ 1.0 \ (36.1\%) \rightarrow 2028\ 1.4 \ (41.1\%)$
- Potential shift (Passenger trips): $2018\ 7400 \ (0.32\%) \rightarrow 2023\ 10900 \ (0.39\%) \rightarrow 2028\ 16000 \ (0.48\%)$
- Planned shift (Passenger trips): $2018\ 3800 \ (0.17\%) \rightarrow 2023\ 5300 \ (0.19\%) \rightarrow 2028\ 7600 \ (0.23\%)$
- % of Passenger trips added to BRT: $2018\ 18.0\% \rightarrow 2023\ 20.2\% \rightarrow 2028\ 23.4\%$
- Total shift to feeder: $2018\ 32700 \ (1.4\%) \rightarrow 2023\ 46700 \ (1.7\%) \rightarrow 2028\ 65300 \ (2.0\%)$
- % of feeder (Passenger) trips shifted to BRT: $2018\ 11.6\% \rightarrow 2023\ 11.3\% \rightarrow 2028\ 11.6\% \ (2\% \text{ to } 40\%)$
Financing feeder infrastructure development and integration

**Proposed feeder options to BRTS**

- **Walk**
- **Bicycle sharing**
- **Hybrid BRTS**
- **RMTS**
- **E-Rickshaw**
- **Shared 3W**

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### Walk and Cycle Feeder –
- Estimated cost for only 12 km major streets – 60 Crore
- Estimated cost for 42 km including minor road network development – Rs 130 to 148 crores (@0.6 to 6 crore per km)
- Two possible financing mechanisms:
  - Sale of additional FAR
  - Increase in property tax

### Hybrid BRTS –
- Subsidy required – cost of Rs. 20 to 23/km.
- Operations of routes – Private operator with concession agreement

### RMTS services –
- Integrating RMTS and RRL
- Aggregating routes in to a single larger contract (in long term planning)
- Shift to hybrid or electric buses – reduce the CPK
- Cost of developing junctions – 50 lakh to 1.0 crore
- Introducing Corporates and public sector undertaking – for maintenance of the junctions

### E-rickshaw –
- No finance required from government.
- Provide land for charging stations with subsidized electricity and parking required from government.

### Shared 3W –
- No significant potential
**Electrification Plan**

- **Electrification of BRT corridor and City Bus Service** is feasible – Combination of fast and slow charging (end of trip and overnight) can help reduce cost
- **Multiple synergetic effects** in collaboration of electrifying the BRT corridor and city buses, such as:
  - Shared use of charging infrastructure
  - Shared use of bus maintenance
  - Joint procurement - less expensive costs per unit

- **Electrification of rickshaws** promoted by providing parking & charging infrastructure closer to BRT stops and main attraction points
- **Flat topography** – added advantage
- “Bharat EV standards” recommends prioritize AC charging stations in short term – beneficial scheme for low power requirement of e-rikshaws

- **Electric BRTS/City Buses**

- **E-rikshaws**
  - e-bike: bicycle with integrated electric motor
  - e-bike (rechargeable batteries) speed - 25 km/h (slow e-bikes) to 45 km/h (fast e-bikes).
  - e-bikes integration with bike sharing system is reasonable for:
    - stations having commuters around 5 - 15 km away from the station and
    - where PT or IPT service not available
  - Existence of safe and attractive bike routes is a prerequisite

- **Electric Bicycles**

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**Electric BRTS/City Buses**

**E-rikshaws**

**Electric Bicycles**
<table>
<thead>
<tr>
<th>S.No</th>
<th>Parameter</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><strong>Measure</strong></td>
<td>Length, Width, Height, Door width, Seats (passengers + driver), Capacity, Height (from ground)</td>
<td>12m, 2.55m, 3.5m, 1.2m, 32+1, 70 pax, 1.2m</td>
</tr>
<tr>
<td>2</td>
<td><strong>Performance</strong></td>
<td>Max. speed, Reverse speed, Deceleration, Autonomy (min.)</td>
<td>70km/h, 5km/h, 5m/s², 200km (without fast charge) 100km with 6h</td>
</tr>
<tr>
<td>3</td>
<td><strong>Electric Motor</strong></td>
<td>Model</td>
<td>Central/hub</td>
</tr>
<tr>
<td>4</td>
<td><strong>Electric System Energy</strong></td>
<td>Battery type, Capacity, Power consumption, Lifetime, Load capacity (after 5 years), Fast charge (+ autonomy 17-20km per charge), Slow charging (full)</td>
<td>Lithium, 70kWh, 1.5kWh/km, 5years, 8%, 5-10min, 6h</td>
</tr>
</tbody>
</table>
### Electric Bus specifications (BRT)

<table>
<thead>
<tr>
<th>S.No</th>
<th>Parameter</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Guarantee</td>
<td>Warranty</td>
<td>15 years</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Electric bus warranty</td>
<td>500,000km or 5 years</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tires</td>
<td>1,20,000km</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Use without overhaul</td>
<td>8 years</td>
</tr>
</tbody>
</table>

### Charging Station specifications

<table>
<thead>
<tr>
<th>1</th>
<th>Technical Features</th>
<th>Frequency</th>
<th>Power (Fast)</th>
<th>Power (Standard)</th>
<th>Number of protected poles (Fast)</th>
<th>Number of protected poles (Standard)</th>
<th>Type (by location)</th>
<th>Installation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>50hz</td>
<td>40/22kW</td>
<td>22/7.4kW</td>
<td>1 P+N</td>
<td>3 P+N</td>
<td>Outdoor/Indoor</td>
<td>On ground</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2</th>
<th>Dimensions</th>
<th>Exterior dimensions</th>
<th>1500x330x200</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Weight (Maximum)</td>
<td>45 kg</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3</th>
<th>Environmental Conditions</th>
<th>Operating temperature</th>
<th>-25 to +50c</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Storage temperature</td>
<td>-40c to +80c</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Relative humidity</td>
<td>&lt;95%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Maximum altitude</td>
<td>2000m</td>
</tr>
</tbody>
</table>

| 4    | Guarantee (Warranty)   | Disclaimer of warranty | 24months    |
Next Steps

Out of six feeder modes evaluated, five have potential to attract trips in favor of BRT. Expected shift after integration will result in additional trips on BRT Network:

• 3800 daily Passenger trips (in 2018),
• 5300 daily Passenger trips (in 2023) and
• 7600 daily Passenger trips (in 2028).

In order to achieve this the following next steps need to be planned and undertaken:

1. **Use of E-rickshaw** - a ring corridor linking University & Raiya road – 11 e-rickshaw to be inducted in the first phase, along with adequate charging infrastructure.

2. **Eight RMTS routes** - high potential to serve as feeder to BRT and carry additional passengers – 18 midi diesel buses may be inducted on these routes to reduce the headway to 20 minutes.

3. **BRT Routes** - Additional buses to be inducted to cater to Trunk BRT and two proposed hybrid/mix BRTS routes (2018) - 5 electric standard buses (currently under process) and 6 electric midi buses with possible:
   • fast charging stations at one or both terminating ends of each route/corridor.
   • standard chargers 50% (of total fleet of buses) - overnight charging at the depots
Next Steps (contd.)

4. **Redevelopment of intersections on BRT corridor** – along with at least 100m length of the cross roads

5. **Bicycle sharing plans** – Raiya Road, University Road, Kalawad Road and the core area around Moti Tanki Chowk

6. **High quality pedestrian and cyclist infrastructure** (core area of Moti Tanki Chowk, Raiya Road, University Road and Portions of Kalawad Road)

7. Initiate development of **parking policy** & its enforcement plan

8. As a long term strategy, **development of road map towards integration of RRL and RMTS** as an overarching regulator of all public mode of urban transport – including integrated fare and scheduling.
Thank you