Research at IITB on MSRTC
Operations and the Way Ahead

Transport Team, GISE Hub, IIT Bombay
Outline

- Public transport as a societal service
- Analysis of MSRTC Operations
- Digital Geography framework
- Data Analysis of Shahapur Depot
- Social Value Analysis
- Plan for Future Work
- Way ahead
Public Transport in Rural India

https://india.uitp.org/articles/mobility-in-rural-india
What does the census say on transport

Crucial for women, students and informal workers
Backbone of regional economy and society

https://india.uitp.org/articles/mobility-in-rural-india
Repeated Losses

### MSRTC counts its losses

KOLHAPUR: The state transport corporation is finding it difficult to stay on course with a cumulative net loss of Rs 2712 crore in last five years.

The Maharashtra State Road Transport Corporation (MSRTC) is one of the largest public transport utilities in India having fleet of 68,000 active buses and 60 lakh daily passengers. But it has been suffering from financial losses due to expenditure on salaries, fuel and passenger tax charged by the state government.

**Rising fuel costs compels corporation to increasing MSRTC bus fares by 18%**

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>तपशील / Particulars</th>
<th>वाहतूक सेवा उपलब्ध असलेल्या खेड्यांची टक्के वारी</th>
<th>Percentage of Villages served</th>
<th>वाहतूक सेवा उपलब्ध असलेल्या लोकसंख्येची टक्के वारी</th>
<th>Percentage of Population served</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>घेट /</td>
<td>74.48</td>
<td>3 (30906)</td>
<td>75.53</td>
<td>31341</td>
</tr>
<tr>
<td></td>
<td>Direct</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>ढ ते 5 कि.मी. पर्यंत /</td>
<td>15.72</td>
<td>6 (6524)</td>
<td>15.11</td>
<td>6 (6269)</td>
</tr>
<tr>
<td></td>
<td>Upto 3 Kms.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>5 ते 8 कि.मी. दरम्यान /</td>
<td>5.61</td>
<td>2 (2328)</td>
<td>5.42</td>
<td>2 (2247)</td>
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<tr>
<td></td>
<td>Between 3 to 5 Kms.</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>5 ते 8 कि.मी. दरम्यान /</td>
<td>2.57</td>
<td>2 (1067)</td>
<td>2.44</td>
<td>2 (1014)</td>
</tr>
<tr>
<td></td>
<td>Between 5 to 8 Kms.</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>8 कि.मी. पर्यंत /</td>
<td>1.61</td>
<td>2 (668)</td>
<td>1.50</td>
<td>2 (622)</td>
</tr>
<tr>
<td></td>
<td>Beyond 8 Kms.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

MsRTC
Repeated Losses

Yet nowhere comparable to railways!
## Railway vs MSRTC

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Railway</th>
<th>MSRTC</th>
</tr>
</thead>
<tbody>
<tr>
<td>People travelling</td>
<td>2%</td>
<td>10%</td>
</tr>
<tr>
<td>Connectivity</td>
<td>Main cities</td>
<td>75% villages</td>
</tr>
<tr>
<td>Charge per km</td>
<td>0.48</td>
<td>1.5</td>
</tr>
<tr>
<td>Subsidy by govt as a fraction of income</td>
<td>105%</td>
<td>18%</td>
</tr>
</tbody>
</table>

ST is responsible for more societal service than railway
Previous work: Analysing Regional Public Transport
One Depot at a time

- Understanding the MSRTC operations
- Field visit to depots (Shahapur, Sinnar)
- GIS Analysis
- Analysis of ETIM and ABC data
- Connectivity to school (case of Dolkhamb, Shahapur)

Previous MoU and Data Agreement
The MSRTC operations

- Bus Schedule Management: Designing schedules based on the public traffic of the roads.
- Selection of Manav-Vikas buses: based on the schools and students on that routes.
- Creation of new routes: Based on Supply And Demand
- Crew Management: Crew Management is mostly done by the Traffic controller and Depot manager.
- Real Time Vehicle Tracking: Location of Bus vehicles can be tracked on real time basis.
- ETIM/ABC Analysis: based on the number of tickets issued, category of routes, revenue collected, determine profitability of the routes and their status (A, B or C)
System Approach

Master Data

ETIM

TRAFFIC

FORM IV

ABC

DEPOT MANAGER

ACCOUNTING

WORKSHOP

10
Analysis of MSRTC Operations (Traffic)

Datasets used
- Form 4
- Master data
- ETIM data
- ABC data
- Census data
- Schools
- UDISE data
- Socio-economic data

Questions to be addressed
- What are the current routes and trips? Can they be visualised in GIS format?
- How many passengers travel through a particular route? How many (on an avg) board at a particular stop?
- What is the time table at a given stop? - Needs a framework to model the operational data
- Which services are essential for schools and colleges? Which services provide connectivity to remote villages?
- If a service is not generating any revenue and the depot decides to stop it, How to know if it is essential for school students or not? - Needs a method of social value accounting
Analysis of Data

Related to Operational Aspects of Depot

- Analysis of the routes
- Analysing ridership on routes
- Analysing ticket issue patterns on routes
- Analysing punctuality of trips
- Day-wise analysis for a month’s data
- Survey at the depot to understand the functioning

Related to Social value provided by ST

- Identifying the main Hubs in the region
- Identifying the points of social interests i.e. schools, weekly markets, govt offices, colleges, industry/MIDC etc.
- Surveying such points to understand the requirements of the passengers
- Maintaining standard OD pairs
MSRTC’s GIS portal

Available data
- National and state highways
- Locations of depot, terminal, offices
- Data useful for overall management and aggregated at the central, regional, depot level e.g. avg ridership, total km covered, avg km of tyres, pass numbers, total passengers etc

What is not available
- Actual MSRTC route network
- Locations of destinations
- Data required for local depot level analysis and planning e.g. locations of stops, avg passengers boarding at a stop, current running status/ location of the bus, locations of points of public interest like schools, weekly markets etc

The solution should integrate the current available data structure of MSRTC and provide extra features as per requirements
How many trips pass through a given location? Do dense areas have more trips? How many villages and population is covered? Can riders know where is my bus?

Requires connecting geography and schedule!

- Digital Geography is a representation of all MSRTC operational data like (ABC analysis, ETIM analysis) through a GIS-based graphical interface.
- Helps in better decision making based on visuals.

Solution: We use a Graph Structure. Digital Geography!
Details of Digital Geography

● Edges and nodes from OSM data
● MSRTC stops and route network mapped on the OSM data
● Details of service in form 4 mapped on the stops and routes network
● ETIM data to understand profitability of a route

Network Layer of Shahapur using Digital Geography Framework
Route Timings

Timings for each node on the route. Estimated time to reach the node and other details.
### All-route timetables at all points: (Kinhavli)

<table>
<thead>
<tr>
<th>serviceid</th>
<th>route_no</th>
<th>s_eng</th>
<th>s_s_eng</th>
<th>d_eng</th>
<th>s_d_eng</th>
<th>arrival</th>
</tr>
</thead>
<tbody>
<tr>
<td>S-81557</td>
<td>54239</td>
<td>KINHAVALI</td>
<td>KINV</td>
<td>SHAHAPUR</td>
<td>SHPR</td>
<td>10:25:00</td>
</tr>
<tr>
<td>S-81252</td>
<td>87315</td>
<td>KINHAVALI</td>
<td>KINV</td>
<td>ASNOLI</td>
<td>ASNLIN</td>
<td>10:40:00</td>
</tr>
<tr>
<td>S-81253</td>
<td>17536</td>
<td>KINHAVALI</td>
<td>KINV</td>
<td>APATE</td>
<td>APTE</td>
<td>11:35:00</td>
</tr>
<tr>
<td>S-81605</td>
<td>54236</td>
<td>KINHAVALI</td>
<td>KINV</td>
<td>SHAHAPUR</td>
<td>SHPR</td>
<td>12:20:00</td>
</tr>
<tr>
<td>S-81255</td>
<td>17536</td>
<td>KINHAVALI</td>
<td>KINV</td>
<td>APATE</td>
<td>APTE</td>
<td>12:30:00</td>
</tr>
<tr>
<td>S-81365</td>
<td>83073</td>
<td>KINHAVALI</td>
<td>KINV</td>
<td>SOGAON</td>
<td>SOGAONST</td>
<td>12:30:00</td>
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<td>S-81952</td>
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<td>KINV</td>
<td>SHAHAPUR</td>
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<td>15:05:00</td>
</tr>
<tr>
<td>S-81843</td>
<td>83037</td>
<td>KINHAVALI</td>
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<td>KHRPTA</td>
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<td>KINV</td>
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<td>KINHAVALI</td>
<td>KINV</td>
<td>AASANGAON</td>
<td>ASNGN</td>
<td>18:20:00</td>
</tr>
<tr>
<td>S-81563</td>
<td>12720</td>
<td>KINHAVALI</td>
<td>KINV</td>
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<td>ASNGN</td>
<td>19:00:00</td>
</tr>
<tr>
<td>S-81387</td>
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<td>KINV</td>
<td>SHAHAPUR</td>
<td>SHPR</td>
<td>21:35:00</td>
</tr>
</tbody>
</table>
Dynamic Tracking and evaluation
Classification of Routes

- Based on economic outcomes/revenue
  - Type ABC classification of MSRTC
- Based on number of currently running Trips
- Based on Social importance
  - Last mile connectivity for remote villages
  - Routes for schools (Manav Vikas Buses and other school routes)
  - Routes that connect facilities like Bank, Mandi, Weekly Market, colleges, hospitals etc
Classification of Hubs

Hubs based on number of trips per day

Hubs based on presence of social points of interest

Khardi village falls in level 0 hub but it has a secondary school, college, hospital and railway station. There is a scope for more trips between Khardi and neighbouring villages.
Punctuality

<table>
<thead>
<tr>
<th>Trip Status</th>
<th>No of ETIM</th>
<th>July Trip</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>As scheduled (10-20 mins)</td>
<td>2767</td>
<td></td>
<td>23.04</td>
</tr>
<tr>
<td>As scheduled (within 10 mins)</td>
<td>5359</td>
<td></td>
<td>44.63</td>
</tr>
<tr>
<td>Cannot say late/early (9-12 hrs)</td>
<td>63</td>
<td></td>
<td>0.52</td>
</tr>
<tr>
<td>Cannot say late/early (more than 12 hrs)</td>
<td>25</td>
<td></td>
<td>0.2</td>
</tr>
<tr>
<td>Early</td>
<td>830</td>
<td></td>
<td>6.91</td>
</tr>
<tr>
<td>Early by 1-2 hrs</td>
<td>118</td>
<td></td>
<td>0.98</td>
</tr>
<tr>
<td>Early by 2-4 hrs</td>
<td>58</td>
<td></td>
<td>0.48</td>
</tr>
<tr>
<td>Early by 5-8 hrs</td>
<td>125</td>
<td></td>
<td>1.04</td>
</tr>
<tr>
<td>Late</td>
<td>2254</td>
<td></td>
<td>18.77</td>
</tr>
<tr>
<td>Late by 1-2 hrs</td>
<td>306</td>
<td></td>
<td>2.54</td>
</tr>
<tr>
<td>Late by 2-4 hrs</td>
<td>81</td>
<td></td>
<td>0.67</td>
</tr>
<tr>
<td>Late by 5-8 hrs</td>
<td>21</td>
<td></td>
<td>0.17</td>
</tr>
<tr>
<td>Total</td>
<td>12007</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- No record when the trip started or ended.
- Based on ETIM time-stamps.
- Analysis for starting stops!

GPS Based Time-Stamping Essential. Guidance to passengers too!
Ridership - Path Analysis

Shahapur-Pune service

1. Empties at Thane. Very few passengers take the longer journey.
2. Serves Padgha and intermediate people to reach Thane railway station. Serves as a Thane -Pune service thereafter
3. Average ridership at 22 is not GOOD.
Trip-wise occupancy

<table>
<thead>
<tr>
<th>route_no</th>
<th>trip_no</th>
<th>max_occupancy</th>
<th>weighted_avg_occupancy</th>
<th>std_dev</th>
<th>sitting_occupancy</th>
<th>standing_occupancy</th>
<th>dept_time</th>
<th>from_cd</th>
<th>till_cd</th>
<th>kilometer</th>
<th>abc_status</th>
<th>utilization</th>
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<tbody>
<tr>
<td>17526</td>
<td>00S81143</td>
<td>58</td>
<td>22.70</td>
<td>5.20</td>
<td>27.90</td>
<td>33.11</td>
<td>8:40:00</td>
<td>ASANGAON</td>
<td>GUNDE</td>
<td>41.8</td>
<td>B</td>
<td>μ</td>
</tr>
<tr>
<td>17526</td>
<td>00S81998</td>
<td>65</td>
<td>9.47</td>
<td>4.25</td>
<td>13.72</td>
<td>17.97</td>
<td>19:15:00</td>
<td>ASANGAON</td>
<td>GUNDE</td>
<td>41.8</td>
<td>C</td>
<td>γ</td>
</tr>
<tr>
<td>75002</td>
<td>00S81310</td>
<td>69</td>
<td>14.96</td>
<td>7.35</td>
<td>22.30</td>
<td>29.65</td>
<td>19:20:00</td>
<td>ASANGAON</td>
<td>JUNAVANI</td>
<td>28.8</td>
<td>C</td>
<td>β</td>
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<tr>
<td>75003</td>
<td>00S81311</td>
<td>54</td>
<td>17.99</td>
<td>7.32</td>
<td>25.30</td>
<td>32.62</td>
<td>5:50:00</td>
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<td>28.8</td>
<td>C</td>
<td>β</td>
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<td>00S81234</td>
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<td>11.26</td>
<td>4.60</td>
<td>15.94</td>
<td>20.63</td>
<td>18:05:00</td>
<td>JUNAVANI</td>
<td>ASANGAON</td>
<td>28.8</td>
<td>C</td>
<td>γ</td>
</tr>
<tr>
<td>92740</td>
<td>00S81868</td>
<td>73</td>
<td>19.92</td>
<td>11.21</td>
<td>31.12</td>
<td>42.33</td>
<td>16:30:00</td>
<td>GUNDE</td>
<td>ASANGAON</td>
<td>41.8</td>
<td>C</td>
<td>β</td>
</tr>
</tbody>
</table>

Guide discrepancy between ABC and ridership - pass-holders?
Drive bus size and capacity utilization
New datasets formed, many corrections attempted.

New tables:
1. Day-wise analysis of ETIM data.
2. Monthly schedule for all ETIM machines.
3. Average ridership of a trip.

For example, here is the Ridership on 3rd July, 2019 for a trip 00581428 on route SHAHAPUR-MAHULI:

New attributes added:
1. Trip number from ETIM is added to ABC.
2. Number of passengers in ETIM.
3. Punctuality of a trip over a month.
4. Accuracy of a route

Bus traffic Analysis
Social Value Analysis

Shahapur taluka - ST network and schools
Analysing a school at Dolkhamb

- Dolkhamb is level 1 hub (11 trips per day)
- There is a road connecting Chondhe Kh., Gandulwad, Talwade to Dolkhamb but it has no bus service
- There are 4 services between Shahapur - Chondha

Brown lines indicate road network, yellow lines show ST routes
- What is the catchment of school?
- Are there buses to suit the school schedule?

**Not too good!**

<table>
<thead>
<tr>
<th>Bus Timings</th>
<th>School Timings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start Timing</td>
<td>Origin</td>
</tr>
<tr>
<td>08:30 AM-09:45 PM</td>
<td>Shahapur</td>
</tr>
<tr>
<td>12:00 PM-01.15 PM</td>
<td>Shahapur</td>
</tr>
<tr>
<td>03:30 PM-04.45PM</td>
<td>Chonda</td>
</tr>
<tr>
<td>04:15 PM-05.30 PM</td>
<td>Shahapur</td>
</tr>
</tbody>
</table>
So how are students coming to school?

<table>
<thead>
<tr>
<th>Village Name</th>
<th>Distance (Village Centroid to School) (in km)</th>
<th>Travel Mode Choice</th>
<th>Distance from bus/road network to school</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Village centroid to bus/road network</td>
<td>Bus/road network</td>
<td>Distance from bus/road network to school</td>
<td>Village centroid to road</td>
</tr>
<tr>
<td>Jambulwad</td>
<td>0.408</td>
<td>7.203</td>
<td>0.103</td>
<td>Walk</td>
</tr>
<tr>
<td>Ranvihir</td>
<td>2.482</td>
<td>2.085</td>
<td>0.103</td>
<td>Walk</td>
</tr>
<tr>
<td>Bhinar</td>
<td>1.057</td>
<td>3.732</td>
<td>0.103</td>
<td>Walk</td>
</tr>
<tr>
<td>Kharade</td>
<td>0.603</td>
<td>2.218</td>
<td>0.103</td>
<td>Walk</td>
</tr>
<tr>
<td>Talwade</td>
<td>0.836</td>
<td>4.745</td>
<td>0.103</td>
<td>Walk</td>
</tr>
<tr>
<td>Malad</td>
<td>1.887</td>
<td>6.981</td>
<td>0.103</td>
<td>Walk</td>
</tr>
<tr>
<td>Dehene</td>
<td>2.287</td>
<td>11.569</td>
<td>0.103</td>
<td>Walk</td>
</tr>
<tr>
<td>Hinglud</td>
<td>1.042</td>
<td>7.219</td>
<td>0.103</td>
<td>Walk</td>
</tr>
<tr>
<td>Panchghar</td>
<td>0.410</td>
<td>10.207</td>
<td>0.103</td>
<td>Walk</td>
</tr>
<tr>
<td>Chondhe Bk.</td>
<td>1.250</td>
<td>13.303</td>
<td>0.103</td>
<td>Walk</td>
</tr>
<tr>
<td>Chondhe Kh.</td>
<td>3.799</td>
<td>13.303</td>
<td>0.103</td>
<td>Walk</td>
</tr>
</tbody>
</table>
Case study at Chiplun depot and DBJ college

Students from chiveli, talsar and tamhan mala use other modes of transport as ST does not reach on time.
Improving Ridership

- Standard O-D pairs - field surveys
  - Educational trips, trips for work, trips for markets
- Focus on institutions - schedule, volumes, institutional analysis
- *Where is my bus - improving information and punctuality*
- Improving operational matters - roads, depot amenities, analysing competition

Social Value Accounting

- Development of a standard demand-side map
  - Census, population, institutions, hubs
- Route classification and ridership analysis
- Incorporation of concessions into CB analysis
- Responsive schedules and timetables
- Improving standard communication with stakeholders
Plan for future work

Improving Routine Analytics

● Depot and Route analysis - Coverage and profitability

Improving Ridership

Starting on Social Value Accounting

Mapping Operational Problems of MSRTC using the DG framework

● Longer-term Optimization and Support

Core Data Backbone

● GIS representation of network and operations
● Supplementary data - census, socio-economic, education etc.

Scaling up for Multiple Depots
Mapping Operational Problems

How many buses are needed to serve a time-table? How can these be clubbed into schedules?

- Affects both Quality of Service as well as efficiency
- How much is the gap between trips? Can that be reduced?
- Can trip-links be done dynamically in case of delay?

Converting MSRTC’s optimisation and management decisions into the Network Layer framework of Digital Geography
Scaling Up

Example for Rajapur (Ratnagiri)

Understanding the inter-depot/ long route services

Considering all the Depot and a few important towns in each tehsil as hubs

Addition of inter-tehsil routes and trips

Separate optimising methods with these inter-tehsil/ inter-depot routes

Resource allocation (i.e. allocation of bus services and crews) between depot level services and long route services
Way Ahead

- Detailed analysis of 4-6 medium and small bus depots
- Standard case-study format, accessible to regional colleges (Unnat Maharashtra Abhiyan, HTE)
- New analytic frameworks for accounting
- IT support to operations side - integration of separate IT systems
- Immediate - permission to visit depots, gather data and conduct surveys, Point of Contact, renewal of data MoU, renewal of collaboration MoU
## Resources (1 year MoU)

<table>
<thead>
<tr>
<th>Task</th>
<th>Charges</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Analysis of 3 bus depots</td>
<td>8 person-months/depot (Rs. 12 lakh per depot)</td>
<td>Rs. 36L</td>
</tr>
<tr>
<td>2. Standard case study development and Training program</td>
<td>Rs. 4 lakh + Rs. 3L per workshop (2 workshops)</td>
<td>Rs. 10L</td>
</tr>
<tr>
<td>3. Routine IT support and analytics</td>
<td>Rs. 5L per month (2 full-time and 2 students)</td>
<td>Rs. 60L</td>
</tr>
<tr>
<td>4. Big Ticket Items - Two M.Tech. Project Fellowships, with 1 year support in year 3.</td>
<td>Rs. 15L*2</td>
<td>Rs. 30L</td>
</tr>
</tbody>
</table>

+ 20% IITB overheads + applicable 18% GST (?)
Thank you