Road Safety and Bus Rapid Transit

- Workshop on Quantifying the Environmental, Social and Economic Benefits from Bus Rapid Transit Systems

A SPAD Academy & Asia LEDS Partnership Workshop
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- Binoy Mascarenhas, Manager, Urban Transport, EMBARQ India
- bmascarenhas@embarqindia.org
Why BRT?

Is it really safer?
India has the highest number of road fatalities in the world

140,000+

People killed on Indian roads in 2013

Source: National Crime Records Bureau (2009)
“Accidental Deaths & Suicides in India. NCRB”
Who are the vulnerable road users?

Share of road fatalities by type of vehicle (Year 2010)

The “other” vehicle involved: Case of Bangalore

Pedestrian fatalities

- Car / Jeep: 19%
- Bus: 16%
- Truck: 13%
- Autorickshaw: 14%
- Two-wheeler: 20%
- Others: 9%

Motorcyclist fatalities

- Truck: 28%
- Bus: 32%
- Hit a fixed object: 8%
- Van: 23%
- Autorickshaw: 16%
- Car / Jeep: 7%
- Others: 13%

In 16% & 23% of pedestrian & motorcyclist fatalities resp., the impacting vehicle is a bus.

Source: Bengaluru Road Safety & Injury Prevention Programme: Injury snapshots and activity profile – 2009 - NIMHANS
More data on city bus crashes

16% In Mumbai, 2012
15% In Chennai, 2008
12% In Bangalore, 2007

Proportion of fatal crashes that involved a bus
Who is most vulnerable in a bus crash?

Bangalore 2007 – BMTC buses

- Pedestrian: 18%
- Motorcyclist: 23%
- Bus occupant: 20%

Chennai 2008 – MTC buses

- Pedestrian: 25%
- Motorcyclist: 42%
- Bus occupant: 22%

Mode of victim in a fatal crash involving a bus

61% of all fatal crash victims in Bangalore and 89% in Chennai are from just these 3 groups!
Overcrowding is a big issue
Which wheel of the bus is most predominantly involved in run-over crashes?

Case of Chennai

Three main issues

- Overcrowded buses
- Left-rear side blind-spot
- Rear overhang

Activity at the time of the fatal crash
Case of Bangalore

**Pedestrian**
- Crossing the road: 57%
- Walking on the road: 27%
- Standing on the road: 8%
- Working on the road
- Playing on the road
- Sleeping on the road
- Unspecified

**Motorcyclist**
- Hit from back: 40%
- Hit from side: 15%
- Head on collision: 13%
- Skid & fell: 12%
- Hit a fixed object: 7%
- Nose to tail collision: 13%
- Others: 15%
- Overturn
- Hit a pedestrian

Source: Bengaluru Road Safety & Injury Prevention Programme: Injury snapshots and activity profile – 2009 - NIMHANS
How does BRT make things safer

Direct impact on the 3 vulnerable groups

- Separates buses from all other motor-vehicles
- Moves buses away from the path of pedestrians. BRT median improves safety while crossing
- Automatic doors & more frequent services prevent passengers from falling out of the bus

Other corridor impacts

- BRT involves a complete re-design of the road, which allows for correcting prior design flaws, improving road conditions and introducing traffic calming features
- Reduced no. of lanes for mixed traffic induces lower speeds
- Moving buses away from the kerbside allows tighter intersection design
- Reduces conflict points across minor intersections
- Better managed fleet and better trained drivers result in safer driving

City-level impact

- Affects modal shift away from private transport; reduced motorisation results in fewer accidents
The last point explained ...

City level impact of BRT through mode shift and reduced motorisation

Credit: Nicolae Duduta, EMBARQ
Some direct evidence from BRT corridors
Case of TransMilenio BRT in Bogota, Colombia

Potential road fatalities averted on account of the BRT

Credit: Dario Hidalgo, EMBARQ

A high quality public transport system can save lives
Further evidence from Macrobus in Guadalajara, Mexico ...

Credit: Nicolae Duduta, EMBARQ and EMBARQ Mexico
… and from Metrobus, Mexico City, Mexico

Accident comparison on open bus corridor vs BRT corridor

Credit: Nicolae Duduta, EMBARQ and EMBARQ Mexico
Safety impact analysis of different bus systems
Case of Mexico

Credit: Nicolae Duduta, EMBARQ and EMBARQ Mexico
We’ve established that BRT improves safety

But how to design the safest BRT system?
Between 2011-13, EMBARQ India, through a grant from Bloomberg Philanthropies, conducted road safety audits on Indian BRT corridors in

<table>
<thead>
<tr>
<th>City</th>
<th>Corridor length</th>
<th>Year of audit</th>
<th>Year op began</th>
<th>Alignment of BRT</th>
<th>Station location w.r.t. bus</th>
<th>Ticketing</th>
<th>Bus restriction</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Delhi</td>
<td>5.8 km</td>
<td>2011</td>
<td>2008</td>
<td>Median</td>
<td>Left side</td>
<td>On bus</td>
<td>All kinds of buses</td>
</tr>
<tr>
<td>Bhopal</td>
<td>23.4 km</td>
<td>2013</td>
<td>2013</td>
<td>Median &amp; kerbside</td>
<td>Left side</td>
<td>On bus</td>
<td>Only BRT bus</td>
</tr>
<tr>
<td>Indore</td>
<td>11.6 km</td>
<td>2011</td>
<td>2013</td>
<td>Median</td>
<td>Right side</td>
<td>At station</td>
<td>Only BRT bus</td>
</tr>
<tr>
<td>Ahmedabad</td>
<td>63.0 km*</td>
<td>2011</td>
<td>2009#</td>
<td>Median</td>
<td>Right side</td>
<td>At station</td>
<td>Only BRT bus</td>
</tr>
<tr>
<td>Surat</td>
<td>33.0 km^</td>
<td>2013</td>
<td>2014^</td>
<td>Median</td>
<td>Right side</td>
<td>At station</td>
<td>Only BRT bus</td>
</tr>
<tr>
<td>Rajkot</td>
<td>10.5 km</td>
<td>2013</td>
<td>2012</td>
<td>Median</td>
<td>Right side</td>
<td>At station</td>
<td>Only BRT bus</td>
</tr>
</tbody>
</table>

*As of April 2013

^ This is the first phase length which partly began operations in 2014

# First phase started in the year 2009
India’s BRT story has so far been a tryst of two models of BRT

- Median station
- Single platform
- Bus doors on the right
- Level boarding
- Closed stations
- Off-board ticketing

Ahmedabad
Indore
Surat
Rajkot

- Left-side station
- Split platforms
- Bus doors on the left
- Step-up boarding
- Open stations
- On-board ticketing

New Delhi
Bhopal
The Delhi & Bhopal BRT model
Open, low-level station platform on left side of bus docking area
The Ahmedabad, Indore, Surat & Rajkot BRT model
Closed, bus-floor-level station platform on right side of bus docking area
So which model is safer?
In our assessment, we found that the Ahmedabad model has some safety advantages over the other kinds of systems

**Safety advantages of Ahmedabad model**

- Bus drivers (seated on the right) find it easier to dock the bus closer to platform
- Level-boarding allows for safer access
- Closed stations induce commuters to enter and exit from designated points

- Having only BRT fleet on the bus lanes allows for greater control on driver behaviour – Centrally managed system
  - Also, less turning movements for the BRT lanes required at intersections

However, when planning for an overtaking lane with this model, certain precautions to be taken...more on the later
Kerbside or Median side

Which is a safer location for the BRT lanes?
In Bhopal, the BRT corridor changes from median lane to kerbside lane, and then back again.

The transitions from median lane to kerbside lane and vice versa creates safety issues.
Safety disadvantages of kerbside bus lane

• Buses move closer to the path of pedestrians and slow moving traffic

• Frequent breaks may have to be provided for property accesses

• Footpath spill-over, street-vendors, parking, etc. more likely to encroach kerbside lane than median lane

• Intersections will have to be wider to accommodate bus turning (left turns)

• Complications at intersection as mixed traffic would have to make a left turn across bus lane. More unsafe than mixed traffic making a right across a BRT lane, because typically, right turns are separated from straight movement through signal phasing.
If kerbside bus lane is unavoidable, then we recommend guardrails along the footpath side of the bus lane.

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Is the Indian (and perhaps the Asian context) different from globally successfully BRT cities?

Case for a different approach to BRT in Asia
Internationally successful BRT model: Bogota, Colombia
Internationally successful BRT model: Istanbul, Turkey
Abundant property development along the road edge

- Frequent property gates
- High right / U-turn demand
- High pedestrian volume and crossing demand
- Requirement for parking / waiting area
Cars are not the dominant motor-vehicle

Motorbikes dominate the mode share

Safety features for cars may not work for motorbikes
Much higher pedestrian volumes
Traffic discipline cannot be taken as a given
Bicycles are not the only NMT mode
Auto-rickshaws as the feeder system to BRT
Inconsistent road width and immovable obstacles
Designing for safe BRT in this context

What needs to be done differently?
The BRT corridor will have multiple uses

- BRT movement
- Thoroughfare for mixed-traffic
- Pedestrians & cyclists
- On-street parking / waiting area
- Street utilities
- Street Vendors
- Signals & street lights
- Trees
- Property accesses
- Street furniture
- Turning lanes
- Pedestrian gathering area
- Taxi stand

BRT lanes
Mixed traffic lanes
Footpath

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Planning for all uses
Allocation of road space
Good design leads to the optimisation of road space
BRT and pedestrian / NMT movement

- BRT imposes restrictions on established crossing patterns for pedestrians & NMT
- If alternatives are not provided, it can lead to safety issues

Much like a Traffic Impact Assessment study, a Pedestrian/NMT Impact Assessment study should be an essential component of BRT planning
Need for a refuge area and speed humps

Refuges need to be disabled friendly
If distance between successive intersections is very large, a mid-block pedestrian crossing should be provided.
Similar design with table-top crossing
Changing the position of bollards can help resolve the problem of motorcyclists using the pedestrian crossing, and still allow for wheelchair access.
BRT and local MV movement

- BRT imposes restrictions on right turns across the median into intersecting side roads and property gates
- Motorists are prone to drive in the wrong direction to avoid a lengthy detour or use pedestrian crossings to make turns

We recommend that a mid-block U-turn opportunity be provided if distance between 2 successive intersections is very large
U-turns can be provided in conjunction with pedestrian crossing
The U-turn movement can share the signal phase with the pedestrian crossing.
Extending these features to BRT station design
BRT station generates a high volume of pedestrians
A wide refuge is an essential component of station design

BRT station access
BRT and minor intersections

- All BRT intersections MUST be signalised if cross movement and right turns are permitted
- Wherever possible, we recommend that the BRT segregation continue through a minor intersection, such that straight / right movement is not possible
- But however, the nearest U-turn must not be too far.
Restricting right turns across minor intersections
Restricting right turns across minor intersections
Simplify intersection design where possible
The most prevalent crash type at intersections is of right turning mixed traffic colliding with straight moving bus.

One option: Replacing right turns with “around-the-block” loops
Restricted right turns: 2 alternatives

BUT for this to be a safe solution, 2 necessary ingredients:

- Block sizes are not very large
- Traffic discipline is high

NOTE:

- If right turns are not permitted from both arms of the intersection, then a U-turn will require two “around-the-block” loops
- U-turns on BRT corridors may typically have high demand on account of the BRT corridor eliminating median cuts. Hence this may not be acceptable
Option 2: Separating right turns via signal phasing

In this option, 5 phases in total
Option 3: Replacing right turns with after-intersection U-turns
Due to BRT stations, lane alignment at intersections is challenging to design. Care should always be taken to maintain lane alignment.
Another major safety issue: Lanes imbalance

Again, due to BRT stations, on one side of the intersection, lane misbalance can happen. There should never be less lanes after the intersection than there are before, vice versa is relatively okay.
Handling NMT right turns at intersections

- If NMT volumes are not very high, then it is better for NMT to cross like a pedestrian during the pedestrian signal phase. Thus, NMT makes right turn in 2 successive signal phases.
- However, if NMT volumes are high, a separate scramble phase, “red for all MV traffic” may be preferable.
Designing for safe crossings at intersections
Safety issues with express stations

This is a common crash type in some Latin American systems with an overtaking lane, due to the unusual case of overtaking from the left.

Designing for express BRT service

A long station length, with adequate taper is absolutely essential.

Integrating feeder bus with BRT terminal

EMBARQ resources on BRT and bus corridor safety

Road Safety Design Guidelines for Bus Rapid Transit in Indian Cities
with consideration for issues of local accessibility and traffic capacity

Draft version – October 2012

The final version of both these publications will be out later this year, 2014

www.embarqindia.org
Thank you!

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EMBARQ helps cities make sustainable transport a reality