Bus Rapid Transit System

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Part I  What do people want?

Part II  What is Bus Rapid Transit System?

Part II I  Thimphu BRTS Proposal

Part IV Discussion
The diagram illustrates the preferences of users regarding public transportation. The preferences are ranked as follows:

1. Safety & Security (998)
2. Better Seating (1143)
3. Frequency (375)
4. Reliability (805)
5. Travel Time (363)
6. Cost (1416)
7. ?
8. Bus Shelter (1517)
Willingness to Pay

- 2.1% Extra
- 20% Extra
- 50% Extra

% of Respondents

- 27% at 2 Times
- 87.8% at 50% Extra
- 92.1% at 20% Extra
- 96.4% at 10% Extra

Graph showing willingness to pay for extra costs.
REASONS FOR NOT USING PUBLIC TRANSPORT

Not Using Public Transport (Bus)

- Frequency: 25%
- Comfort: 11%
- Travel time: 13%
- Safety/Security: 9%
- Reliability: 9%
- Information: 3%
- Fare: 10%
- Other: 20%

I have school children with me

I have to make multiple stops on journey

Cycle user (Less distance)

Personal Disability
Willingness to Pay (Non-User)

<table>
<thead>
<tr>
<th>% of Respondents</th>
<th>2 Times</th>
<th>50% Extra</th>
<th>20% Extra</th>
<th>10% Extra</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>77.3</td>
<td>89.5</td>
<td>99</td>
<td>99</td>
</tr>
</tbody>
</table>

The graph shows the percentage of respondents willing to pay at different levels of extra cost.
Part II  What is Bus Rapid Transit System?
Bus Rapid Transit is high-quality, customer-orientated transit that delivers fast, comfortable and low-cost urban mobility.

Characteristics:
- Segregated bus ways
- Rapid boarding and alighting
- Efficient fare collection
- Comfortable shelters and stations
- Clean bus & modern technologies
- Sophisticated marketing identity
- Excellence in customer service

WHAT IS BUS RAPID TRANSIT (BRT) SYSTEM?

BRT - A METRO EXPERIENCE ON ROAD THROUGH TECHNOLOGY INNOVATIONS AT 1/20TH THE COST

High Quality Transport at Affordable Costs

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Components of successful BRTS

Leadership - Political will and support
Ownership - System operation & maintenance
Partnerships - Institutions, Media, People

Pragmatic Approach:

- BRT - A Program and not a Project
- Comprehensive Planning
- Design efficiency
- Contextual Sustainable Design
- Safety, Reliability, Comfort and Speed
- Branding Strategies
BRT DESIGN COMPONENTS

**Network**
- Networks - Not corridors
- Connect Activities, Low & Middle Income Areas

**Running ways**
- Segregated bus ways

**Bus Stations**
- Accessible, Comfortable stations - Level boarding, External Ticketing

**Vehicles**
- Clean buses & modern technologies
- Trained Driver

**ITS & Fare Payment**
- Public Information System (Next bus/Next stop)
- External Ticketing, Smart Cards, AVL
- Automatic Ticketing
- Affordable Fare
- Area Traffic Management for Bus Priority & Minimise wastage of GREEN TIME

**Operating Plan**
- Frequent, Reliable service
- Trunk-Feeder - Closed System
- Operations under Single Management Control

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ELEMENTS OF FULL BRT SYSTEM

Click on Video clip
Network Selection

- NETWORK and Not Corridors
- Connectivity of important origin and destinations
- Catalyst for area development
  - Formation of strong network for flexible route operations
  - low income, low accessibility zones (old walled city)
- Availability of right of way to build infrastructure
  - Add capacity and take away apprt of capacity for BRTS
- Overall impact of transit on city
- Connect ‘busy places’ but avoid ‘busy roads’

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Comparing Car vs. Bus Space:
MORE BUSES MEAN LESS TRAFFIC

- **Personal vehicles**
  - People moved: 165
  - Area occupied: 120 sqm.

- **Public Transport**
  - People moved: 165
  - Area occupied: 75 sqm.

- **Non Motorized Transport**
  - People moved: 165
  - Area occupied: 50 sqm.

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Janmarg – Focus on Moving People…

MORE BUSES MEAN LESS TRAFFIC

Janmarg
People moved - 170
Area occupied - 80 sq. m.

Mixed traffic
People moved -168
Area occupied - 550 sq. m.

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Focus on moving people...
Focus on moving people...
Focus on moving people...
Focus on moving people...
Focus on moving people...
Segregated Bus lanes & Median Bus stations
Provide clear right of way for buses (Bus Priority)

QUITO, Ecuador

BUS RAPID TRANSIT SYSTEM
moves from 5,000 passengers/hr to 45,000 passengers/hr

JANMARG, Ahmedabad, India
BUS STATIONS
High quality, Safe, Comfortable, ‘barrier free’ access

Smart Bus Stations
Transmilenio, Bogota

JANMARG Bus Stations, Ahmedabad

- A ‘shift’ from regular bus stops to high quality, safe and comfortable bus stations
- Controlled Access Points to the Bus Stop
- Efficient Monitoring
- Easy transfers

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RAPID BOARDING AND ALIGHTING

safe, fast, accessible for all...

Transmilenio, Bogota

- At level boarding reduces boarding time and increases safety
- Reduces delays
- Accessible for all...physically challenged, senior citizens, women, children

Janmarg, Ahmedabad

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Automatic Fare collection System (off-board)

Use of Smart cards, Coins and paper tickets in Janmarg, Ahmedabad

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CHOICE OF BUS FLOOR HEIGHT

High and flat floor buses

Low floor bus

Semi - Low floor bus

Janmarg bus - Flat floor

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ITS – Public Information System

LED displays at Bus stations
Schedules of arrivals / departures

LED and audio announcements in buses

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ITS – CONTROL CENTRE
Vehicle tracking, Real time service monitoring

Operations monitoring at JANMARG - Control centre

- Follow scheduled departures/arrivals
- Vehicle status, speeds
CHARACTERISTICS OF FULL BRT SYSTEM

- Closed system – trunk and feeder services
- Central bus lanes
- Median bus stops
- Off-board fare collection
- At-level boarding alighting
- Distance based fare – smart cards
- Integrated ticketing system – Trunk, feeder
- Automatic vehicle tracking system

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Type of System Operations:
Open and Closed

- **Open system**
  - Regular buses in BRT lanes
  - Partial BRT segregation
  - Reduced Reliability and quality
  - Delays due to boarding/alighting, Ticketing
  - Bus turnings at junctions become critical

- **Closed system**
  - Specially designed BRT buses ply in BRT lanes
  - Full BRT Segregation
  - High reliability and quality of service
  - Delays averted
  - Bus turnings at junctions rationalised
BRT-Station Locations:
Kerb side or Median side

Kerb side Bus stops

- Need to Build 4 small bus stops at each location
  - Delhi BRT (8-12 bus stops per location)
  - Pune (4 -6 bus stops per location)
  - Passenger transfers critical

Median Bus stops

- 1 large bus stop per location
  - Ahmedabad BRT – 1 bus station per location
  - Easy and safe passenger transfers
# Summary of Cost – BRT systems in India

<table>
<thead>
<tr>
<th>BRT</th>
<th>Network Length (in Kms.)</th>
<th>Pavement + Chief components</th>
<th>Cost/ km. (in Cr.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ahmedabad BRT Phase 1</td>
<td>58</td>
<td>Flexible</td>
<td>9.5</td>
</tr>
<tr>
<td>Ahmedabad BRT Phase 1I</td>
<td>30.5</td>
<td>Flexible + 4.5 kms. Elevated BRT</td>
<td>15</td>
</tr>
<tr>
<td>Surat BRT Phase I</td>
<td>30</td>
<td>Rigid</td>
<td>16</td>
</tr>
<tr>
<td>Hubli-Dharwad BRT</td>
<td>22</td>
<td>8 lane rigid</td>
<td>15</td>
</tr>
</tbody>
</table>

Ahmedabad BRT spends Rs. 55 per bus km. On operations incl. Bus costs Recovers same through fare box
**TYPES OF COMPETITION**

**Indirect Competition:** Competitive procurement of Supplies & Support Services, Competition between business units, Competition from other modes etc.

**Direct Competition:** *Service competition* (most effective forms of competition are likely to be between different enterprises)

- Public Monopoly
- Less Regulation
- Gross Cost Contract
- Net Cost Contract
- Franchises
- Concessions
- Competitive procurement of Supplies & Support Services
- Competition between business units
- Competition from other modes etc.

- Competition for the Market
  - Service Contract
    - (Most commonly used in Urban Bus Transport)
  - Less Public Funding

- Competition in the Market
  - Quantity Licenses
  - Quality Licenses
  - Open Market

- Para-Transit
TYPES OF SERVICE CONTRACT

Service Contracts

Gross Cost
- Route Based
- Area Based

Minimum Cost
- Operator states the whole cost of operating the contract
  - Ex. Helsinki (Finland)
  - Ex. Goteborg (Sweden)
  - AMTS
  - JANMARG
  - SITILINK
  - BOGOTA
  - Delhi (Proposed – DIMTS)

Cost per Passenger
- Operators are repaid based on the cost per passenger
  - Ex. London (before 1993)
  - Ex. Santiago (Chile)

Net Cost
- Route Based
- Area Based

Min. Subsidy/Max. Premium
- Operators states minimum subsidy required or maximum premium offered to the authority
  - Ex. London (after 1993)
  - Surat, Rajkot, Indore, Vadodara, Jodhpur, Delhi-Blue Line, Delhi Mtero Feeder, Bhopal
SERVICE CONTRACT – GROSS COST

Bidding on the basis of the total costs of provision of the specified service, with all revenues accruing to the authority. Volume and nature of the services is determined by the TA.

Usually incentives for the Operator if revenue targets are exceeded, thus motivating him to increase patronage & hence reduce the revenue risk of the TA.

**More appropriate in case of large & evolving transit markets.** Needs strong contract management capacity.

- Avoid on-street competition for passengers
- Advantage of facilitating **integration** between modes
- **Provide free or discounted interchange between all routes in all areas**
- Avoid discrimination against concession fare passengers
- **Lower cost** to authority & greater compatibility with complex subsidy mechanism
- Avoid the need to apportion off bus revenues between operators

**Where to be used**

**Disadvantage**

- No direct incentive to ensure revenue collection
- Extra monitoring cost

**Monitoring requirement**

- Stopping the leak of public revenue from private buses are likely to prove impossible. Only if prepaid fare cards are in use, Gross cost contracts are likely to have obvious advantages
**SERVICE CONTRACT – NET COST**

*Bidding on the basis of subsidy required or premium offered by the bidder.* This puts revenue as well as supply cost risk with the supplier. The role of the authority is limited to setting down the fares, service parameters & monitoring the performance.

**More appropriate in cities who wish to introduce organised transit system cities**

- Due to concerns over revenue risks, small Operators are reluctant to bid
- Obviates the need for complex fare collection and security arrangements
- Needs the least amount of public sector administration & management
- Provide an incentive to Operators to increase ridership & thus revenue
- Provide Operators some flexibility to amend routes and schedules
- The authority wishes to fix the absolute amount of subsidy OR premium
- A small percentage of revenue is collected off-bus & sharing is not a problem

**Where to be used**

- Make integration more difficult to achieve
- Require safeguard to ensure that any loss making service is not being neglected
- Encourages on-street competition where more than one company operates
- Fewer Operators usually bid for Net Cost as opposed to Gross Cost tenders

**Disadvantage**

- Requires a greater monitoring requirement as the revenue risk is born by the Operator due to which they are more likely to indulge in unfair practices
Part III Thimphu BRTS

Part I What do people want?
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Part IV Discussion
Trunk Route

24 bus stops with an average spacing of 0.5 km in the core area and 1 km in the outside core city

<table>
<thead>
<tr>
<th>Phasing</th>
<th>From</th>
<th>To</th>
<th>Route length(km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013-16</td>
<td>Babesa</td>
<td>Jungshina</td>
<td>12.5</td>
</tr>
<tr>
<td>2016-32</td>
<td>Babesa</td>
<td>Denchencholing</td>
<td>16.7</td>
</tr>
</tbody>
</table>
Secondary Routes
Bus Infrastructure
Northern and Southern Terminals

<table>
<thead>
<tr>
<th>Area</th>
<th>2 Acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial And Retail Space</td>
<td>29,000 Sq Ft</td>
</tr>
</tbody>
</table>
Depot Design

Design Area: 5,000 sq ft
Central Bus Terminal Options

• No Terminal
  - No facilities
  - Passenger Transfers at the BRT

• Minimum Improvement (1 acre)
  - Integration of BRT/Secondary
  - No commercial/retail/parking
  - Medium Social Impact

• Full Terminal (2 acres)
  - Integration of BRT/secondary
  - Commercial/retail/parking spaces
  - High Social Impact

<table>
<thead>
<tr>
<th>Minimum Improvement</th>
<th>Total Area (Sq Ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bus bay</td>
<td>4,300</td>
</tr>
<tr>
<td>Terminal Amenities</td>
<td>24,000</td>
</tr>
<tr>
<td>Bus Operations</td>
<td>5,000</td>
</tr>
<tr>
<td>Car parking</td>
<td>10,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>43,300</strong></td>
</tr>
</tbody>
</table>
Pedestrianization Of Norzin Lam

- Limit Car Access from just north of petrol station to main intersection on Norzin Lam with Phendey Lam
  - Improving transit flow
  - Increasing transit ridership
  - Creating a walkable city center
- Pedestrian and transit vehicles only from 8:00am – 8:00pm; open to delivery vehicle and other traffic at night
- Single lane for transit vehicles (heading North), remaining area for Pedestrians
- Requires connecting Gongdzim Lam to Norzin Lam* for Northbound traffic flow

Pedestrianization as envisaged in TSP (2002-2027)
*Preliminary Concept Drawing will require detailed engineering and feasibility study after decisions is made about transit option.
Part IV Discussion

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BRT DESIGN COMPONENTS

Fast
Customer orientated
High-quality
Comfortable
Low-cost

Network
• Networks – Not corridors
• Connect Activities, Low & Middle Income Areas

Running ways
• Segregated bus ways

Bus Stations
• Accessible, Comfortable stations – Level boarding, External Ticketing

Vehicles
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Operating Plan
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Exclusive Feeder - Design interventions

LIGHT BRTS - CONCEPT
I. Cable-Propelled Transit

Cable-Propelled Transit (CPT) is a transit technology that moves people in motor-less, engine-less vehicles that are propelled by a steel cable.

- Employed as transportation systems in alpine areas particularly in the ski resorts and other less accessible areas.

- Three major types of terrain specialized cable propelled transit:
  - Aerial Tram, Gondola and Funicular

Aerial Tramways
- Oldest system. Typically, two large (20-180 person) cabins shuttle back and forth between two stations.
- Can carry more number of passengers at a time.
- Lower line capacity; an inability to turn corners; and little potential for intermediary stations.
- High-cost.

Gondolas
- Multiple small carriers (4-15 persons) circulate along a line.
- Types: Monocable, bicable, funitel.
- High line capacity, ability to turn corners.
- Multiple stations possible.
- Cost dependant on the type of Gondola.

Funicular (Inclined Planes)
- A cable attached to a pair of tram-like vehicles on rails moves them up and down a steep slope.
- Mostly works as two cars/trains on counterbalancing.
- Ideal alignment is a straight line.
- Carrying capacity is heavily dependent on route length.
- Funiculars are extremely well-suited for use in mountain regions with very steep gradient.
TRANSIT OPTIONS FOR HILL

II. OTHER TECHNOLOGIES

COGWHEEL
- Cogwheel rail engages central toothed rail (good grip hence lesser chance of accidents)
- Provide higher-capacity rail access to mountain locations too difficult to serve with normal rail
- low maximum speed of cog railway (25 km/hr)

PERSONAL RAPID TRANSIT
- Small, automated vehicles with seating for 2 – 8 people.
- Vehicles available on demand at stations throughout the system
- Direct from origin to destination. Vehicles do not have to stop at intermediary stations.
- Provides last mile connectivity
- Minimal right-of-way required

BICYCLE LIFT
- The bicycle lift consists of an underground cableway which consists of a footplate which simply pushes the passenger up the hill

OTHERS
- Inclined lift
- Elevators
Medellin is the second largest city in Colombia. Located in the valley surrounded by hills (barrios) of Santo Domingo barrio, where the only form of public transit was a private bus company that infrequently served the area. The residents of Santo Domingo spent 2-2.5 hours commuting to work in the city centre.

It is largely considered to be the world's first Cable Propelled Transit system (MDG).

- 18 km/hr, 3000pas/day 3 lines: Linea K (1.8 km, 4 stations) cost $26 million USD in 2006; Linea J (2.7 Km, 4 stations) cost $50 million USD in 2008; Linea L cost $25 (4.8 Km, 2 stations) million USD in 2010.

- Crime in Santo Domingo disappeared; jobs have increased 60%
- huge social change in the Colombia’s historically wide gap between rich and poor.
The city of Covilha is a small town in the hillside of the highest mountain in continental Portugal
- Area: 46.29 sq.km
- Population: 34,772
- Divided into three parts: the uptown, the downtown and the new town.
- Covilha faces three natural barriers:
  - Two creeks (Goldra and Carpinteira) and
  - A difference in altitude of 230 meters between the uptown and the new town
- Other barriers:
  - The streets are narrow around 3 meter wide lane and most permit only one-way traffic
  - The main artery through the town is a busy national road, which is used to access the national park and ski track on the mountain passes above the town

- Started on 15.04.2009
- Cost: 500 Euros
- Avg. pax / car: 11
- Max. Gradient: 45°
- Length: 250 m
- Connects the old city, municipal market & university of Beira
Morgantown is a city in Monongalia County (30,000 residents)

- Buses were used in the beginning but soon by 1970s the hilly roads experienced severe traffic congestion. This was when the Morgan People’s Mover (MPM) relieved the traffic chaos.

  - A length of 13.9 km (2-sec headways), 5 stations, 8 seated, 40km/hr, 319 million (USD).

BENEFITS

- Serves 38% of the Morgantown residents.

- A major force in influencing travel habits within its service areas; reduced private vehicles use

- The PRT also had a positive impact on travel between campuses with a 10% change in mode split.
# Transit Options for Hill Cities

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Funicular</th>
<th>Cable Cars</th>
<th>Personal Rapid Transit</th>
<th>Cog Wheel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right-of-way</td>
<td>Exclusive at grade</td>
<td>N.A Elevated aerial</td>
<td>Exclusive At grade/Elevated</td>
<td>Exclusive At grade</td>
</tr>
<tr>
<td>Station Spacing</td>
<td>2 or more but symmetric in relation to terminals</td>
<td>At any point depends on the demand at locations</td>
<td>@ 500m</td>
<td>@ 1km</td>
</tr>
<tr>
<td>Propulsion</td>
<td>Stationary electric motor propels cable affixed to 2 vehicles</td>
<td>Stationary electric motor propels traction cable for lines</td>
<td>lead acid battery powered</td>
<td>Electric motors on vehicles</td>
</tr>
<tr>
<td>Seated capacity</td>
<td>40 - 200</td>
<td>4 - 15</td>
<td>upto 200</td>
<td>4-6</td>
</tr>
<tr>
<td>Avg. Speed</td>
<td>40 - 50</td>
<td>10 - 45</td>
<td>45</td>
<td>40</td>
</tr>
<tr>
<td>line capacity/hr/dir</td>
<td>500-3000</td>
<td>3000-6000</td>
<td>upto 2000</td>
<td>3000</td>
</tr>
<tr>
<td>Gradient (%)</td>
<td>70</td>
<td>N.A</td>
<td>N.A</td>
<td>20</td>
</tr>
<tr>
<td>Flexibility of route</td>
<td>Low</td>
<td>High</td>
<td>Medium</td>
<td>high</td>
</tr>
<tr>
<td>Wind Speed (m/s)</td>
<td>N.A</td>
<td>50 -100</td>
<td>100</td>
<td>N.A</td>
</tr>
<tr>
<td>Approx. Capital Cost per Km (Crores)</td>
<td>0.80</td>
<td>20 - 130</td>
<td>45 - 220</td>
<td>20- 40</td>
</tr>
</tbody>
</table>
Thank You....

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