INTERNATIONAL EXPERIENCES WITH BUS RAPID TRANSIT

Gerhard Menckhoff
Lipinski Symposium, Northwestern University
November 8, 2010
Elements of BRT

Objective: provide reliable, fast and attractive service

- Segregated busways in center of road
- Level boarding of bus, through many doors
- Off-board fare collection
- Creation of attractive image
  - Large, often articulated buses
  - Bus control through GPS technology
  - Simple service plan (trunk-feeder or direct services)
  - Express bus services on trunk busway
  - Real-time passenger information systems
  - Smart-card fare collection technology
  - Bus priority at traffic signals
  - Special training of bus operators
Elements of BRT

Segregated busway in center

- **Why reserved busways?** So buses do not get held up by traffic congestion.
- **Why physically segregated?** So other vehicles do not encroach on the reserved busway.
- **Why in center of road?** So loading vehicles, driveway access, right-turning vehicles do not block busway operation. In one-way streets and some exceptional cases, curb busways may be OK.

➡️ Good traffic engineering is required to fit busways into general traffic pattern, address need for left-turns,
Elements of BRT

Level boarding of bus through many doors

- **Problem:** In conventional bus operations, much time is needed for passengers to step up into one door and pay the fare.

- **Solutions:**
  - Passengers should be enter through many doors at the same time, like in a Metro.
  - Bus floor and station platform should be at same level
  - Fares should be paid (or ticket cards validated) well before the bus arrives – see next slide.
Elements of BRT

Off-board fare collection

To minimize stopping delays:
- passengers enter quickly, without any fare transaction
- passengers enter through all doors, like in a Metro

Conventional operation in Goiânia (Brazil)

Turnstiles in Bogotá BRT station

Multi-door access to BRT bus in Bogotá
Elements of BRT

Creation of an attractive image

The Issue:

• BRT is not just another bus service
• But: communicating this to the public is not easy
• The negative stigma of “the bus” makes it hard to sell the BRT idea

Key aspects to consider:

• System name
• System logo
• Campaign strategy
• Public education

Good examples:

• Avoid the word ”bus” when choosing the name;
  • TransMilenio (Bogotá)
  • Metro Orange Line (Los Angeles)
  • TransMetro (Barranquilla)
  • El Mio (Cali) – *Masivo Integrado del Occidente*

  *Catchy logos  *Salsa jingles  *Inform the Press

Bus shelter in Johannesburg
Elements of BRT

Large, often articulated buses

- Important when there is high demand
- Contributes to image of BRT

Typical bus sizes on Latin American BRTs
- Standard (12 m – 100 passengers)
- Articulated (18 m – 160 passengers)
- Double-Articulated (26 m – 250 pass.)
Elements of BRT

Bus control through GPS technology

Vital for reliable operation
- Keep buses equally spaced
- Prevent bunching
- Quick Incident response
Elements of BRT

Simple service plan

GREEN → Advantages
RED → Disadvantages

Trunk-feeder services
- Requires restructuring of existing bus routes
- Superior bus control on busway
- Less waiting time on trunk busway
- Fewer buses required
- More passenger transfers required
- Need to build transfer stations
- Preferred for high-volume BRTs

Direct services
- Easier to adapt existing routes to new BRT
- More bunching of buses
- More buses required
- Busway often not fully segregated
- More passenger accumulation at stops
- Thus: longer stations along busway
- Less $$$ needed for transfer terminals
- Fewer passenger transfers
- Preferred for low-volume BRTs
Elements of BRT

Express bus services on trunk busway

Requires:
- Passing lanes (normally at stations)
- Good operational control (maybe GPS)

Benefits:
- Increases average commercial speed: fewer buses required
- Less travel time – attracts passengers
- Raises systems capacity as buses can skip high-demand stops

Busway widens to let express buses pass (Bogotá)
### “Full” BRTs operating in Developing Countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Since</th>
<th>Km of Busway</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latin America</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Curitiba (Brazil)</td>
<td>1974</td>
<td>65</td>
</tr>
<tr>
<td>Goiânia (Brazil)</td>
<td>1976</td>
<td>35</td>
</tr>
<tr>
<td>Quito (Ecuador)</td>
<td>1995</td>
<td>37</td>
</tr>
<tr>
<td>Bogotá (Colombia)</td>
<td>2000</td>
<td>85</td>
</tr>
<tr>
<td>León (Mexico)</td>
<td>2003</td>
<td>25</td>
</tr>
<tr>
<td>Mexico City</td>
<td>2005</td>
<td>48</td>
</tr>
<tr>
<td>Guayaquil (Ecuador)</td>
<td>2006</td>
<td>38</td>
</tr>
<tr>
<td>Pereira (Colombia)</td>
<td>2006</td>
<td>18</td>
</tr>
<tr>
<td>Guatemala City</td>
<td>2007</td>
<td>11</td>
</tr>
<tr>
<td>Guadalajara (Mexico)</td>
<td>2009</td>
<td>18</td>
</tr>
<tr>
<td>Bucaramanga (Colombia)</td>
<td>2010</td>
<td>9</td>
</tr>
<tr>
<td>Barranquilla (Colombia)</td>
<td>2010</td>
<td>13</td>
</tr>
<tr>
<td>Lima (Peru)</td>
<td>2010</td>
<td>27</td>
</tr>
<tr>
<td>Ecatepec (Mexico)</td>
<td>2010</td>
<td>12</td>
</tr>
<tr>
<td>Elsewhere</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Istanbul (Turkey)</td>
<td>2007</td>
<td>44</td>
</tr>
<tr>
<td>Johannesburg (South Africa)</td>
<td>2009</td>
<td>25</td>
</tr>
<tr>
<td>Ahmedabad (India)</td>
<td>2009</td>
<td>31</td>
</tr>
<tr>
<td>Guangzhou (China)</td>
<td>2010</td>
<td>23</td>
</tr>
</tbody>
</table>
BRT Systems in Latin America

Integrated public transport systems in Sao Paulo and Santiago (with some BRT elements)

“full” BRTs operating as of Oct. 2010

Integrated public transport systems in Sao Paulo and Santiago (with some BRT elements)
### Some Characteristics of Latin-American BRTs

<table>
<thead>
<tr>
<th></th>
<th>km of corridors</th>
<th># of artic. buses</th>
<th>passengers per weekday ('000)</th>
<th>max. pass. flow ('000 pphpd)</th>
<th>Fare in equivalent US $</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curitiba (busways)</td>
<td>65</td>
<td>189</td>
<td>532</td>
<td>14</td>
<td>1.25</td>
</tr>
<tr>
<td>Quito</td>
<td>37</td>
<td>189</td>
<td>560</td>
<td>11</td>
<td>0.25</td>
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<tr>
<td>Bogotá</td>
<td>85</td>
<td>1192</td>
<td>1650</td>
<td>45</td>
<td>0.87</td>
</tr>
<tr>
<td>León</td>
<td>25</td>
<td>55</td>
<td>220</td>
<td>3</td>
<td>0.48</td>
</tr>
<tr>
<td>Mexico City</td>
<td>48</td>
<td>226</td>
<td>500</td>
<td>8</td>
<td>0.39</td>
</tr>
<tr>
<td>Guayaquil</td>
<td>38</td>
<td>115</td>
<td>280</td>
<td>7</td>
<td>0.25</td>
</tr>
<tr>
<td>Pereira</td>
<td>18</td>
<td>45</td>
<td>104</td>
<td>6</td>
<td>0.76</td>
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<td>Guatemala City</td>
<td>11</td>
<td>62</td>
<td>155</td>
<td></td>
<td>0.13</td>
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<td>Guadalajara</td>
<td>18</td>
<td>41</td>
<td>127</td>
<td>4</td>
<td>0.47</td>
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<tr>
<td>Lima</td>
<td>27</td>
<td>308</td>
<td>200 *</td>
<td></td>
<td>0.54</td>
</tr>
</tbody>
</table>

* Partial operation

**Notes:**
- **highest** indicates the highest value for each category.
- **lowest** indicates the lowest value for each category.
BHLS in Europe (Buses with a High Level of Service)

• In the 1990s, BHLS emerged in Europe in order to “increase bus service quality and ridership”
• The Context: Most medium-sized and large European cities were already served by trains (S-Bahn, RER, etc), metros and trams. The BHLS were to fill the gap between regular buses and rail-based systems.
• BHLS has been adapting some BRT elements to the conditions of European cities with their often historical pattern of relatively narrow streets and mixed land use.
• The main objectives of BHLS are to provide
  – Reliable and regular bus services
  – Accessibility and passenger comfort
  – Improve the quality of the urban environment

This part of the presentation is based on talks by Giorgio Ambrosini and Julien Allaire at the ITDP Annual Meeting on October 1, 2010
## Characteristics of selected BHLS systems

<table>
<thead>
<tr>
<th>System</th>
<th>Name of System</th>
<th>Reserved Lanes (km)</th>
<th>Passengers per day</th>
<th>Pk Headway (minutes)</th>
<th>Dedicated Fleet?</th>
<th>Ridership increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amsterdam</td>
<td>Zuid-Tangent</td>
<td>33</td>
<td>40,000</td>
<td>6</td>
<td>Yes</td>
<td>+47%</td>
</tr>
<tr>
<td>Dublin</td>
<td>QBC</td>
<td>8.4</td>
<td>34,000</td>
<td>&lt; 1.5</td>
<td>Yes</td>
<td>+125%</td>
</tr>
<tr>
<td>Gothenburg</td>
<td>TrunkBus</td>
<td>7.5</td>
<td>24,000</td>
<td>3.3</td>
<td>Yes</td>
<td>+73%</td>
</tr>
<tr>
<td>Hamburg</td>
<td>MetroBus</td>
<td>4.0</td>
<td>60,000</td>
<td>3.5</td>
<td>Yes</td>
<td>+20%</td>
</tr>
<tr>
<td>Helsinki</td>
<td>Jokeri Line</td>
<td>6</td>
<td>25,000</td>
<td>5</td>
<td>Yes</td>
<td>+100%</td>
</tr>
<tr>
<td>Madrid</td>
<td>Bus-VAO</td>
<td>16.1</td>
<td>33,000</td>
<td>&lt; 1</td>
<td>No</td>
<td>+70%-100%</td>
</tr>
<tr>
<td>Nantes</td>
<td>BusWay</td>
<td>6</td>
<td>24,600</td>
<td>3.3</td>
<td>Yes</td>
<td>+55%</td>
</tr>
<tr>
<td>Paris</td>
<td>TVM</td>
<td>19</td>
<td>65,800</td>
<td>3.5</td>
<td>Yes</td>
<td>+134%</td>
</tr>
<tr>
<td>Prato</td>
<td>LAM</td>
<td>15</td>
<td>n/a</td>
<td>7</td>
<td>Yes</td>
<td>+57%</td>
</tr>
<tr>
<td>Stockholm</td>
<td>Blue Line</td>
<td>12</td>
<td>36,575</td>
<td>5</td>
<td>Yes</td>
<td>+27%</td>
</tr>
</tbody>
</table>
BHLS program in France

- 10 BHLS systems operating now
- 23 BHLS systems to operate by 2013
- 40 BHLS systems planned to operate by 2015

**Map:**
- BHLS in operation
- BHLS to operate by 2013
- At least 17 more BHLS by 2015
1st BHLS example:  
Transval de Marne

- Opened 1993
- Located in suburban Paris
- Length: 22 km (13.5 in 1993 and extension in 2007).
- Cost (2nd phase: 7 km): $9.1 million (rolling stock excluded)
- Commercial speed: 23 km/h
- Demand: 65,000 passengers/day

- PICTURE ON RIGHT:  
  Single-lane busway for peak direction, buses in off-peak direction use mixed traffic lanes
2nd BHLS example:

**TEOR in Rouen**

- Rouen is a city 400,000 of inhabitants about 110 km northwest of Paris
- BHLS was implemented after the city had first built a tramway line
- Opened in 2001 and extended in 2007
- Investment: $20 million per km
- 11.5 km of dedicated bus lanes
- Demand: 45,000 passengers per day
Nantes is a city of 600,000 inhabitants near the west coast of France.
It was the first French city to build a modern tramway in 1985.
The Busway® opened in 2006.
It is considered like the 4th tramway line.
Investment: $10 million per km, tram lines cost 3 times as much.
7 km length (87% dedicated bus lanes).
Headway: 4-6 min in peak.
Demand: 28,000 passengers per day.
BRT in Istanbul

• First line (30 km) opened in 2007
• Extension (11 km) across Bosphorus bridge and into Asian part of metropolitan area in 2009
• → “Intercontinental BRT”
• Mostly in center of expressway, with counterflow operation
• 800,000 passengers per day
BRT Service Plan Options: Integrated (e.g. Ottawa, Brisbane)

- **Base:** all-day, all-stops trunk line
- **Peak-only or all-day integrated services**
- **Peak-only or all-day expresses**

![Brisbane, Australia]
BRTs in Ottawa and Brisbane

Ottawa Transitway
- Opened in 1983 – first major busway system outside Brazil
- 34 km of busway, with bus lines fanning out into residential zones
- 240,000 passengers per day
- Peak load: 10,000 passengers per hour per direction

South-East Busway, Brisbane

Brisbane Translink Busways
- South-East Busway opened in 2001
- 16.5 km of high-grade busway, of which 1.6 km in tunnel, and 2 km elevated
- Half of main river bridge allocated to busway
- Underground terminal in city center
- 10 stations
- 475 buses, mostly on-board ticketing
- Bus routes fanning out into residential zones
- Northern and Eastern busways in 2008 and 2009
  → Additional 8 km of busway and 9 stations
Orange Line in Los Angeles

- 22-km BRT line in San Fernando Valley opened in 2005
- 6-km extension to open in 2012
- On right-of-way of abandoned railroad
- 1.7 km average station spacing
- Off-board fare collection ($1.50)
- 22,000 passengers/day
- Articulated buses ($700,000 apiece)
- Peak frequency: 12 buses per hour
- Construction cost: $24 million per km
Other BRTs in the USA

Pittsburgh: 1977, 7 km, 9 stops, 14 routes, 9,000 passengers per day.

Las Vegas: 2004, 12 km, low-floor articulated buses with level boarding. Off-board fare collection. 2010: ACE lines – 32,000 passengers per day. Another 15 km BRT under construction.

Eugene: 2007, 6 km, 60% on exclusive busway, extension to open in 2011. Off-board fare collection,

Cleveland Health Line:
- opened in October 2008,
- 15 km long, 36 stations,
- 20 articulated low-entrance buses ($880,000 apiece) to allow for at-level boarding, with doors on both sides, lateral guide wheels,
- off-board fare collection,
- 14,000 passengers per day,
BRT in Guangzhou

- Opened operation in February 2010
- 800,000 passengers per day
- 350 standard buses per direction in peak hr
- Articulated buses being introduced
- Peak load: 26,900 passengers/hour/direction
- Open service plan, with many lines feeding in and out of trunk busway
- Off-board payment before entering station
- Long stations, up to 250 m
- Connecting tunnels with metro stations
Myths about BRT

- BRT has a low capacity, when compared to rail alternatives
- BRT is slow when compared to rail alternatives
- BRT has high operating and life-cycle costs
- BRT cannot generate high-density "Transit-Oriented Development" (TOD)
Myths about BRT

BRT has a low capacity

Observed peak-hour (peak direction) passenger flows on rail systems, in pphpd:

- Hong Kong Metro 80,000
- Sao Paulo Metro (East Line) 60,000
- London Victoria Line 25,000
- Boston Green Line 9,500
- Denver LRT 3,000
- Los Angeles Blue Line 2,500

Observed pphpd for BRTs

- Bogotá TransMilenio 45,000
- Guangzhou BRT 27,000
- Istanbul BRT 19,000
- Curitiba BRT 14,000
- Pereira BRT 6,000

Comment: Metros (MRT or Rail Rapid Transit) have indeed a higher capacity than BRT, but few cities need it – their corridor demand is below the capacity of BRT
**Myths about BRT**

**BRT is slow when compared to rail**

- Yes, grade-separated metros are faster than at-grade BRTs passing through traffic signals.
- Some of that advantage is offset by long walking times from street level to rail platform.
- For at-grade systems, the commercial speeds of LRT and BRT are similar.

**BUT:** BRT permits express services which are faster than fixed-guideway systems.

**ALSO:** For a given demand, the frequency of BRT buses is 2 to 3 times greater than for LRT trains, and even greater than for metros. Thus, passenger waiting times are less.

**Observed commercial speeds (km/h)**

- Philadelphia: 31
- Chicago CTA Trains: 30
- New York City Subway: 29
- Denver (LRT): 23
- Boston Green Line (LRT): 22
- San Francisco Muni (LRT): 18
- Bogotá TransMilenio (BRT): 28
- Ahmedabad Janmarg (BRT): 24
- Guayaquil Metrovía (BRT): 22
- Pereira Macrobús (BRT): 20
- Quito Metrobús-Q (BRT): 18
- León Optibús (BRT): 18
Myths about BRT

BRT has high operating and life-cycle costs

• The chart on the left shows the results of a study, which estimated 20-year costs for a 20-km high-demand corridor for (a) do-nothing, (b) bus lanes, (c) LRT, (d) metro, and (e) BRT.

• The BRT costs of infrastructure and vehicles are only half of those for LRT, and a quarter of those for metros.

• HOWEVER: The BRT costs of operations and maintenance are 26% greater than for LRT, and 250% greater than for metro.

• Overall, the total 20-year cost of BRT is 26% less than LRT, and 36% less than metro.

Source: Dario Hidalgo, UITP conference, Feb. 2007
Capital costs per km

Costs in $ (2010) per km of line, including infrastructure and equipment

- Caracas Metro Line 4 118
- Washington Green Line 86
- Santiago Line 5 Extension 80
- San Juan, Puerto Rico 70
- Portland West Line (LRT) 41
- Los Angeles Gold Line (LRT) 40
- San Diego LRT 30
- Tunis Metro (LRT) 27
- Los Angeles Orange Line (BRT) 15
- Bogotá TransMilenio (BRT) 13
- Pereira Megabús (BRT) 6
- Ahmedabad Janmarg (BRT) 3
- Guayaquil Metrovía (BRT) 2
- León Optibús (BRT) 2

Santiago Metro
Tunis LRT
Bogotá BRT
Myths about BRT

BRT cannot generate high-density «Transit-Oriented Development» (TOD)

Curitiba is the prime example of BRT spurring high-density development
What is not BRT

- Uncontrolled operation of old buses (1)
- No physical busway segregation (3)
- No same-level entry and alighting (1,2,3)
- On-board fare collection (1,2,3)

Los Angeles Metro Rapid

Sao Paulo Passa Rápido

Lima – Av. Brasil
“BRT is a high-quality bus-based transit system that delivers fast, comfortable, and cost-effective urban mobility through the provision of segregated right-of-way infrastructure, rapid and frequent operations, and excellence in marketing and customer service.”

Elements of BRT

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- Segregated busways in center of road
- Level boarding of bus, through many doors
- Off-board fare collection
- Creation of attractive image
- Simple service plan (trunk-feeder or direct services)
- Large, often articulated buses
- Bus control through GPS technology
- Express bus services on trunk busway
- Real-time passenger information
- Smart-card fare collection technology
- Bus priority at traffic signals
- Special training of bus operators
Some final thoughts

- Most high-capacity and high-performance BRTs are in Latin America (15)
- Some recent replication in Asia and Africa (4-5)
- Some systems were low-standard attempts and gave the BRT concept a bad name – jeopardizing the introduction of ”true” BRTs in other cities
- A few ”true” BRTs have been implemented in the USA, serving relatively low passenger volumes – but with scope for future growth.
- Some BHLS lines in Europe have been effective – also serving relatively low passenger volumes
thanks for listening!