BRT in Developing countries – case studies

Based on study developed by Darío Hidalgo, 2006: “A Critical Look at Major Bus Improvements in Latin America: Case Studies of Hitches, Hic-Ups and Areas for Improvement; Synthesis of Lessons Learned”
Contents

• Overview of systems

• Impacts of BRT systems in developing world

• BRT and climate change

• Advantages of BRT over bus, rail

• Challenges of BRT in developing countries
Brief history

Previous status quo (and sometimes current) in public transport:

- Chaos
- Competition in (not for) the market
- War of the cent
- Atomized sector, owners, drivers, cooperatives, etc
- Need of an alternative (BRT!)
Key characteristics of BRTs:

- Centralized control – operators by contract
- Pre-paid boarding (at station)
- Level access at stations
- Exclusive busways
- Large capacity, multi-door buses
- Not so much engineering as management structure
BRT systems seek changes in “business-as-usual” transit provision

<table>
<thead>
<tr>
<th>Business-as-usual</th>
<th>Transformed Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transit privately provided under permits or concessions granted by the authorities with weak control and supervision</td>
<td>Private provision under binding contracts (concessions) with strong supervision by the authority (new agencies)</td>
</tr>
<tr>
<td>▪ Low cost services with ample coverage,</td>
<td>▪ Similar fares to existing services</td>
</tr>
<tr>
<td>▪ Oversupply of buses,</td>
<td>▪ Balanced supply and demand</td>
</tr>
<tr>
<td>▪ Inadequate vehicle size,</td>
<td>▪ New bus fleet</td>
</tr>
<tr>
<td>▪ High average age of the fleet,</td>
<td>▪ Low accidents and emissions</td>
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<tr>
<td>▪ Long routes with inefficient operation,</td>
<td>▪ High commercial speeds</td>
</tr>
<tr>
<td>▪ Lack of vehicle and infrastructure maintenance,</td>
<td></td>
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<tr>
<td>▪ High levels of accidents and emissions, and</td>
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<tr>
<td>▪ Very low speeds</td>
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<tr>
<td>Competition in the market (war of the penny)</td>
<td>Competition for the market or direct negotiation with incumbents</td>
</tr>
</tbody>
</table>
BRT Corridors have high performance

<table>
<thead>
<tr>
<th>Performance Measure</th>
<th>Quito Metrobús-Q</th>
<th>Bogotá TransMilenio</th>
<th>León SIT-Optibús</th>
<th>México City Metrobús Insurgentes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand (Pax/day)</td>
<td>Trolebus 246,000</td>
<td>1,220,000</td>
<td>220,000*</td>
<td>260,000</td>
</tr>
<tr>
<td></td>
<td>Ecovía 81,000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>North 120,000*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak Load Section (Pax/hour/direction)</td>
<td>Trolebus 9,000</td>
<td>45,000</td>
<td>3,000</td>
<td>8,000</td>
</tr>
<tr>
<td></td>
<td>Ecovía 5,000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>North N.A.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commercial Speed (km/hour)</td>
<td>Trolebus 14.5</td>
<td>26.0</td>
<td>18.0-20.0</td>
<td>19.0</td>
</tr>
<tr>
<td></td>
<td>Ecovía 18.0</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>North 23.0</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Passenger per Kilometer Index (PKI)</td>
<td>Trolebus 10.6</td>
<td>5.3</td>
<td>10.0</td>
<td>10.0</td>
</tr>
<tr>
<td></td>
<td>Ecovía 11.1</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>North 7.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Passenger per Bus/Day</td>
<td>Trolebus 2,181</td>
<td>1,450</td>
<td>N.A.</td>
<td>3,095</td>
</tr>
<tr>
<td></td>
<td>Ecovía 1,928</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>North N.A.</td>
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</table>
Capital Costs are Relatively Low
“snowball” in LAC

<table>
<thead>
<tr>
<th>Decade</th>
<th>Cantidad de sistemas por década (solo LAC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970-1979</td>
<td>2</td>
</tr>
<tr>
<td>1980-1989</td>
<td>1</td>
</tr>
<tr>
<td>1990-1999</td>
<td>1</td>
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<tr>
<td>2000-2007</td>
<td>9</td>
</tr>
</tbody>
</table>
Examples (short)

Curitiba (1972)

- “First” BRT system
- 64.6 kms of trunk lines
- 560,000 pax/day
- 20,000 pax/h/direction
- (bi) articulated vehicles
- 1.1-6 mio USD/km
Examples (short)


- 3 systems
- 37 kms of trunk lines
- 440k pax /day
- Public /private operator
- No physical or fare integration (!)
- 0.5-5mio USD/km

- Three BRT corridors
- 37 Km median busways
- 68 stations, 9 terminals
- Integrated feeder services (each corridor)
- 189 articulated buses (113 trolley buses); 185 feeder buses
- Coin based fare collection
- 440,000 pax/day
- USD 0.25 per trip (discount for special groups)
- Public operator/owner (Trole, Ecovía); Private Operator (Central Norte)
- No fare integration among corridors.

Population: 1’600,000 inhabitants

<table>
<thead>
<tr>
<th>Capital Cost Infrastructure (USD Million)</th>
<th>Trolebus</th>
<th>Ecovia</th>
<th>North</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trolebus</td>
<td>20</td>
<td>12</td>
<td>26</td>
</tr>
<tr>
<td>Ecovia</td>
<td></td>
<td></td>
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<tr>
<td>North</td>
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</table>

<table>
<thead>
<tr>
<th>Capital Cost Buses and Other Equipment (USD Million)</th>
<th>Trolebus</th>
<th>Ecovia</th>
<th>North</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trolebus</td>
<td>80</td>
<td>7</td>
<td>17</td>
</tr>
<tr>
<td>Ecovia</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>North</td>
<td></td>
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<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Total Capital Costs (USD Million)</th>
<th>Trolebus</th>
<th>Ecovia</th>
<th>North</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trolebus</td>
<td>100</td>
<td>19</td>
<td>43</td>
</tr>
<tr>
<td>Ecovia</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>North</td>
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</tbody>
</table>
Things done well

- The concept of organized feeder-trunk operations has evolved as the paradigm of public transport in Quito
- The infrastructure costs have been very low
- Inclusion of electric trolleybuses for the first corridor
- High performance

Things that perhaps should have been done differently

- Corridors do not have physical and fare integration yet.
- Fares are politically defined and do not cover operation and bus capital costs.
- A transition to private operation could be beneficial, but no adequate mechanisms have been used.
- Some infrastructure problems: pavement rutting and station floor deterioration;
- Implementation of advanced fare collection technologies has been delayed.

**Critical positive enablers**
- International cooperation, e.g. UNDP and the Government of Spain
- Decentralization of transport authority from the National government to the municipality of Quito.
- Continuous mayoral support, even with changes in political parties.
- Initial leadership of project director César Arias; continued leadership of Architect Hidalgo Nuñez
- Initial success of the Trolebús corridor

**Critical barriers**
- Opposition from existing transit operators
- Negotiations with historic operators have brought unbalanced results for the city.
- Not enough capacity has been built in public authorities
- Very low fare (USD 0.25) does not cover capital investment in Trolebús and Ecovía, and may cause financial problems to private operators in Central Norte
Examples (short)


- “Full BRT”
- 84 km operation
- 1,6 million pax / day
- Up to 45k pax/h/direction
- NMT integration
- Phase 3 construction
- 5.3-13.3 mio USD/ km
Bogotá, TransMilenio (Phase I 2000, Phase II 2003)

- High capacity BRT system
- 84 Km median busways;
- 104 stations; 10 integration points,
- Integrated feeder services
- Advanced centralized control
- 841 articulated buses; 344 feeder buses
- Electronic fare collection system
- 1,220,000 pax/day
- USD 0.51 per trip (flat rate includes integration)
- Five private groups partially formed by some traditional operators - 7 trunk, 6 feeder zone concession contracts

Population: 6’400,000 inhabitants

<table>
<thead>
<tr>
<th>Capital Cost Infrastructure (USD Million)</th>
<th>Phase 1</th>
<th>Phase 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase 1</td>
<td>240</td>
<td></td>
</tr>
<tr>
<td>Phase 2</td>
<td>273**</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Capital Cost Buses and Other Equipment (USD Million)</th>
<th>Phase 1</th>
<th>Phase 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase 1</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Phase 2</td>
<td>72</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total Capital Costs (USD Million)</th>
<th>Phase 1</th>
<th>Phase 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase 1</td>
<td>340</td>
<td></td>
</tr>
<tr>
<td>Phase 2</td>
<td>345</td>
<td></td>
</tr>
</tbody>
</table>

** Transit Only
Bogotá, TransMilenio (Phase I 2000, Phase II 2003)

**Things done well**

- Planning and implementation in a very short time.
- Adequate distribution of responsibilities, incentives and risks for public-private participation.
- Regulation and control through binding contracts awarded after a competitive process.
- No operational subsidies required.
- High performance.

**Things that perhaps should have been done differently**

- Some pavement structures and station floors had early deterioration.
- Implementation was rushed; several details had to be adjusted with the system under operation.
- Infrastructure for Phase II could have been designed and constructed at lower cost.
- Implementation for Phase II could have been preceded by large scale user education campaign.
- Better reorganization of remaining routes and actual reduction of capacity in traditional system.
Bogotá, TransMilenio (Phase I 2000, Phase II 2003)

**Critical positive enablers**

- Leadership of Mayor Enrique Peñalosa, continued in succeeding administrations
- Conformation of a planning and implementation team outside the existing institutions
- Dedication of time and effort to carefully design system components (technical, financial, legal, regulatory)
- Existence of basic planning data from previous studies

**Critical barriers**

- Opposition from existing operators, especially bus owners. Priority was given to existing bus companies (and bus owners in Phase II)
- Busways had a very bad perception. It was necessary to improve the urban space and develop a distinctive image
- Low prevailing transit fares, required the highest efficiency and even redefine components to match cost and revenues
- Interference from non project participants within the government – solved through leadership of the Mayor
Road safety - TransMilenio Bogotá

- Collisions
- Injuries
- Deaths

<table>
<thead>
<tr>
<th>Year</th>
<th>Collisions</th>
<th>Injuries</th>
<th>Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>33</td>
<td>174</td>
<td>66</td>
</tr>
<tr>
<td>2003</td>
<td>80</td>
<td>254</td>
<td>11</td>
</tr>
<tr>
<td>2004</td>
<td>104</td>
<td>451</td>
<td>2</td>
</tr>
<tr>
<td>2005</td>
<td>155</td>
<td>382</td>
<td>2</td>
</tr>
</tbody>
</table>

Values before TransMilenio (TM) introduction.
• Increase in rent value
  (darker green is increased value, darker blue is decreased value)
Bogotá- more impacts

**Environment** 40% reduction of some pollutants

**Efficiency** 32% travel time savings

**Customer satisfaction** 88%

**Physically disabled users:** 9,000 trips per day
CDM methodologies

• Bogotá’s TransMilenio: abating 0.25 Mt CO2e per year (certified emissions) – only certified project

• Other Four CDM transport-related projects in Colombia: expected to abate a total of 0.55 Mt CO2e per year.

• Cali’s MIO, Pereira’s Megabus, aerial cable car in Medellín
Examples (short)

7 Colombian cities

- Pereira (2006)- 3 years operation (15 km, 100mil pax / day)
- Cali
- Bucaramanga
- Barranquilla
- Other cities: planning
  - Cartagena, Medellín, Soacha
- Pereira 1.7 mio USD/km
Examples (short)

**Sao Paulo (2003)**
- System “interligado”
- 129.5 km
- 140k pax/day
Examples (short)

México (2005)
- 50 km trunk lines
- 473 mil pax / day
- 7 operators (public, private)
- Subsidised fare
- Complements metro
- 1.5 mio USD/km
México City, Metrobús Insurgentes (2005)

- One BRT Line (until 2005)
- 20 Km median busway
- 34 stations
- 2 terminals
- Centralized control using IT
- 84 articulated buses
- Electronic fare collection system
- 260,000 pax/day
- USD 0.35 per trip
- Two operators, one private, one public
- Physical integration with regional buses and Metro.

Population: 7’000,000 inhabitants
39% of the Metropolitan Area

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost (USD Million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital Cost Infrastructure</td>
<td>30</td>
</tr>
<tr>
<td>Capital Cost Buses and Other Equipment</td>
<td>24</td>
</tr>
<tr>
<td>Total Capital Costs</td>
<td>54</td>
</tr>
</tbody>
</table>
**Things done well**

- Planning and implementation took a very short time.
- Infrastructure costs were relatively low.
- Showed the potential of high capacity/better quality bus operations.
- Involves private operators formed out of existing concessionaries.
- High performance/ good users’ ratings

**Things that perhaps should have been done differently**

- Implementation was rushed. Most problems were solved during the first weeks of operation.
- Financial planning was too tight (little room for contingencies) and assumptions were on the non-conservative side – operational deficit
- Early destruction of several segregation devices, bad alignment of some stations, conflicting turning bays for general traffic, and interference in Glorieta Insurgentes. Pavements were not reconstructed
- Fare collection implementation could have longer time-
México City, Metrobús Insurgentes (2005)

**Critical positive enablers**

- Leadership of Secretary Claudia Sheinbaum – creation of a planning and implementation team outside the existing institutions
- Pressure from environmental groups - NGOs, international development institutions,
- Selection of a highly visible corridor with low technical and political requirements for initial implementation.

**Critical barriers**

- Opposition from existing concessionaries. Good conditions were negotiated with them.
- Low technical capacity and hands on experience of the implementation team and consultants. Technical cooperation partially covered the gaps.
- Low target fare (USD 0.35) generated financial difficulties for the corridor to be self sustainable.
- Interference from non project participants within the government, required the intervention and leadership of the Head of Government.
Examples (short)

**Guayaquil (2006)**

- 15.5 km trunk lines
- 100mil pax/day
- Foundation is manager
- Publicity revenue covers admin costs
- 1.4 mio USD/km
Examples (short)

**Santiago de Chile (2007)**

- Complete public transport reorganization (!)
- Problems with implementation…
- High cost of fixing problems...
Examples (short)

**Guatemala (2007)**

- 11 kms trunk lines
- Part of Guatemala
- 2020 plan
- 143,000 pax/day
Examples (short)

**Lima (2010)**

- Slow implementation
- (before) low political commitment
- 32km trunk lines
- Started 2010 (trials from April, full operation from August)

Gerhard Menckhoff
Summary and impacts
### Relevant data - transformation

<table>
<thead>
<tr>
<th>Single corridor</th>
<th>Various corridors, feeder routes</th>
<th>Citywide transformation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Non Integrated</strong></td>
<td></td>
<td></td>
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<tr>
<td>Metrobús – Mexico</td>
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<tr>
<td>BRT – Beijing</td>
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<tr>
<td><strong>Integrated</strong></td>
<td></td>
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<tr>
<td>Megabús - Pereira</td>
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<td></td>
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<tr>
<td>Metrovía - Guayaquil</td>
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</tr>
</tbody>
</table>

- TransMilenio - Bogotá
- Metrovía - Guayaquil
- Interligado – Sao Paulo
- Transantiago
- RIT - Curitiba
- Megabus - Pereira
- BRT – Beijing
- Yakarta (1, 2, 3)
- Quito (Trole, Ecovía, North)

*Directly taken from Hidalgo et al, 2007*
Relevant data - fares

Información directamente tomada de Hidalgo et al., 2007

User Fare (USD/pax)

- 0,20 0,40 0,60 0,80 1,00 1,20

RIT, Curitiba
Trolebus, Quito
Ecovia, Quito
North, Quito
TransMilenio, Bogota
Interligado, Sao Paulo
Metrobus, Mexico
Transjakarta
Beijing BRT
Megabus, Pereira
Metrovia, Guayaquil
Transantiago

User Fare (USD/pax)
The most relevant planning issues observed were:

- Planning activities depended on the ideas and expectations of key decision makers.
  - When a clear vision of the Mayor was observed (e.g. Bogotá), planning for implementation received priority and development cycles were short.

- Funding for planning was scarce,
  - Cities needed to rely on donations, grants from other levels of government, and loans. The process took several months as well as approval of project activities. Valuable time was expended at the beginning of the processes.
  - Lack of experienced local staff was also an issue and caused delays.

- Once decisions were achieved, planning became secondary to implementation.
  - Implementation was rushed. Fast evaluation and design was possible when adequate and experienced consultants were retained and the cities formed capable planning teams.

- Lack of familiarity with BRT concepts made planning difficult.
  - Most effort was dedicated to transport planning issues and technical details with less effort on key institutional, legal and financial issues.

- Definition of fare levels by the political authority was complex.

- Teams coordinating the efforts were outside the existing structures.
  - The cities reviewed created “task forces” that were later transformed in new institutions to overcome the burden of business-as-usual in existing agencies.
Top-down decision processes resulted in faster implementation and less inter-agency conflicts.

- The creation of an adequate regulatory framework seems to be more important than solving technical details.
  - All cities reviewed required changes either in the regulations and definition of authority or the creation of new institutions to plan, develop and control the projects.
  - Providing adequate levels of funding for infrastructure was challenging, despite the fact that most projects were relatively low cost.
  - New mechanisms to provide funding and intergovernmental grants were required to spark project implementation.
Private participation has been preferred to public take-over – but there has been a need to overhaul private operators

- Negotiation with existing operators
  - Involves all existing stakeholders in the project
  - Opposed stakeholders, even if they are a few, can result in project failure
    - May be unbalanced, in favor of the existing operators, especially if time runs out
    - Interest of special groups is privileged over larger public interest
- Limited Bidding – priority to existing operators
  - Includes a number of stakeholders in the project – those not interested are left out
  - Interested stakeholders help the project to advance, specially if they see their interest taken into account
  - Existing operators may have low technical capacity and managerial abilities – may cause additional costs, but learning curve seems to be very steep
- Open Bidding – no priority to existing operators
  - Experienced operators (generally from abroad) are considered – lower costs
  - Places public interest over special interests, but can cause early rejection and total project failure
Implementation was rushed, but most problems were solved within the initial weeks

- Infrastructure and fare collection systems were delayed due to inherent implementation problems (short lead times; contractual problems; delays in approvals by different authorities, etc.).
- Little time between bus delivery and start of operations, and drivers’ training was incomplete.
- User education was also scarce (especially for expansion Phase II, causing severe problems)
- Public protests by affected groups caused problems. The use of the authority was required and implementation was not affected at the end. Support from different levels of government, helped solving citywide standoffs. Fear of protests has caused cities to seek to prevent unrest by involving all existing operators.
Main operational concerns are high occupation, pavement maintenance, and pickpockets.

- Systems are designed for very high occupation to keep operational costs as low as possible – structural solutions may involve route reorganizations and large capital investments (additional buses, higher user costs).
- Large waiting times for feeder buses operating on mixed traffic in local streets – may also require large capital and operational expenses.
- Pavement and other infrastructure maintenance – depend on the initial design and construction methods, as well as availability of recurrent funding.
- Solution to safety concerns (pickpockets), is only partially on hands of the transport authorities (implementation of CCTV and expansion of safety manpower), but also goes to economic environment (rate of unemployment) and legislation (penalties applied to offenders).
- Service gap between organized and traditional services.
The main structural problems are financial and regulatory

- Expansion of the system is limited due to pressures by existing operators and lack of funds – no earmarked funds for maintenance (existing funds dedicated to system expansion)
- Current services are not integrated with other type of services: dual (feeder-trunk) and complementary – improvement of coordination of traffic lights and some bottlenecks such as at-grade access to terminals
Conclusion

- Systems reviewed have greatly improved travel conditions.
- The main achievement has been travel time savings as well as enhanced reliability.
- As efficiency has improved, systems have also reduced energy consumption and emissions.
- Urban enhancements are also evident in the cases of Bogotá and Quito Trolebús where the appalling conditions of the corridors before system implementation have completely changed.
- Nevertheless, in every case there are elements that deserve attention and indicate lessons for the development of similar projects in other developing cities.
Recommendations

• Planning
  - Plan with implementation bias, solving “how” rather than “what”.
  - Combine financial, legal and environmental aspects with engineering.
  - Dedicate enough resources (time, money) to good preparation.
  - Use experiences available in other cities as a reference, but adapt system components and characteristics to local conditions.
  - Try to create special purpose teams for system planning and implementation, not affected by day-to-day responsibilities.

• Decision Process
  - Get approval of high level decision makers early on the process (top-down approaches are faster and help solving inter agency conflicts).
  - Give priority to regulatory issues, adapting regulatory framework if required.
  - Try to create a special purpose agency to plan, oversee and control system development, and provide adequate coordination mechanisms.
  - Be creative in funding project development, using new taxes, loans and non traditional sources – privatizations, special purpose bonds. Funding often conditions project scope.
  - Involve existing operators to mitigate conflicts, but keep open bidding processes to reduce user costs.

• Implementation Approach
  - Only attempt citywide reorganization of transit services if you have strong authorities and large public support.
  - Try to use gradual implementation and adapt the project with initial experiences.
  - Make an effort to use existing right-of-way to reduce land acquisition and non-voluntary displacement.
  - Seek pavement improvements to avoid rapid deterioration.
Recommendations

• Implementation
  • Generate a credible time table and manage it to prevent rushed implementation. Commissioning dates usually do not have slack due to end of terms of elected officials.
  • Have contingent plans ready if system components are not complete.
  • Dedicate funding to plan and implement user education programs.
  • If there are protests, emphasize general benefit over special interests and apply authority.

• Operation
  • Use the intrinsic flexibility of buses to balance supply and demand.
  • Be aware that pavement maintenance is a permanent issue.
  • Use strong dividers to segregate traffic.
  • Prefer median lanes and level access platforms to increase speed and reliability.
  • Allow time to adapt and implement advanced fare collection systems.
  • Use advanced transit management systems if operations are complex, and apply it as tool to control reliability, not just as a means of acquiring operational data.

• Structural issues
  • Try to provide mechanisms for technical (automatic) definition of fares without political interference.
  • Make a strong effort to stick to the contracts—permanent renegotiation is often unbalanced in favor of the operators.
Main challenges of BRT

• Credibility of the BRT “brand”
• Rail lobbies
• Adjustment of fare distribution among actors
• More PPP developments (e.g. terminal stations, land development)
• NMT integration