Components of a Bus Rapid Transit system (BRT)
What is a Bus Rapid Transit system?

“It is a high quality public transport system, oriented to the user that offers fast, comfortable and low cost urban mobility”

Lloyd Wright ITDP

Components of a BRT*

- Dedicated lanes
- Prepaid stations
- Buses with multiple doors, high capacity and low emissions
- Differentiated services express and local
- Intersection priority (includes not at grade)
- Coordination with operators of buses of lower capacity
- Fare integration
- Use of advanced technologies and centralized control

Dedicated lanes

- Bus tunnel: Seattle, Boston, Brisbane
- Exclusive bus lane (completely segregated or “bus only”): Charlotte, Hartford, Miami, Ottawa, Pittsburgh, Adelaide, Brisbane, Sydney, Ruancom (France)
- Highway lanes: Houston, Los Angeles, Nueva York
- Central lanes on exclusive arteries: Cleveland, Eugene, Belo Horizonte, Bogotá, Curitiba, Porto Alegre, Quito, Sao Paulo
- Bus lanes: Ottawa, Pittsburg, Vancouver, Rouen (France), Barcelona, Madrid
- Mixed traffic: Honolulu, Los Angeles, Vancouver, Leeds (exclusive overtaking lane at intersections)
Bus tunnel Seattle Washington (dual buses, operate with electricity in tunnel)
Open from september 1990, has 1.2 miles and cost US$444 MM
Exclusively lane for buses, Brisbane, Australia (model)

Miami-Dade Busway, opened in 1997
8.5 miles exclusive, two lanes per direction, overpass at stations

Pittsburg West Busway
Opened on Sept. 2000
5 miles, 6 stations
O-Bahn, Adelaide, Australia
Opened in 1986
12 Km, guided, $98 MM Aus (including buses), up to 18,000 pax/hour
Leeds Superbus, UK
Exclusive buslane in center of highway
Guided bus, operates in normal streets out of exclusive lane
HOV lane
Houston, TX

Exclusive bus lane
Access to Lincoln tunnel, New Jersey

Bus lane - Highway to Coruña – Madrid, Spain
Exclusive lane in median - Eugene, Oregon

Madrid, Paseo de la Castellana

Barcelona, Expansion
Semi-exclusive
Alameda Santiago de Chile (before Transantiago)
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Prepaid stations

- Spacings
  - 600 m to 2,300 m in bus only and highway
  - 350 m (Cleveland, Porto Alegre) to 1,300 m in arteries (Vancouver, Los Angeles)

- Location
  - Right side sidewalk (majority)
  - Isles right side (Quito, Curitiba)
  - Median (Sao Paulo, Bogotá)

- Overpass for express services (not common)
  - Same for both sides (4 lanes)
  - Shifted (3 lanes)

- Platform
  - Low (majority)
  - High (Curitiba, Goiania, Quito, Bogotá)
Busway Stations, Brisbane, Australia

Station Metro Rapid, Los Ángeles

Anhanguera axis, Goiania, Brasil
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Buses

- **Type**
  - Conventional
  - Articulated
  - Bi-articulados
  - Two floor
  - Special (Civis)

- **Propulsion**
  - Diesel (majority, with emissions reduction)
  - CNG
  - Electric
  - Hybrid and dual (Diesel-electric)

- **Platform**
  - Low (increasing tendency)
  - High and without connecting platform at station floor
Conventional IVECO Low platform (it kneels)
CNG propulsion, Operated by EMT Madrid

Conventional Renault Citaro, France
Diesel Euro II

Prototype Advanced Vehicle for public transport ATV – Hydrogen cell, USA
Bi-Articulated Van Hool
low platform
Civis Irisbus, Dual (Diesel-Electric), low platform, optical guidance

Clermont Ferrand, France

Rouen, France
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Differentiated services

- Local service (stops at all stations, majority)
  - Different local services share the same infrastructure (Quito)
  - Local services are integrated to special stations (Curitiba)
  - Local and express services share infrastructure and services (Bogotá)
  - Buses operate in zones and are integrated to run through trunk lines (majority)
  - Trunk-feeder services (Curitiba, Quito, Bogotá)
Integrated transport network in Curitiba, Brasil
Integrated transport system in Sao Paulo

(Empresa Metropolitana de Transporte Urbano)
Integrated transport system in Quito
Trolley and feeder service lines
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Intersection priority

• Programmed stop lights with priority (Quito)
• Actuated stop lights (Miami, Los Angeles, Eugene)
• Fast passage through entrances to tunnels, toll plazas, highway access ramps (North America systems)
• Critical spots intersections at different levels (Bogotá)
• Tunnel passing through central sectors (Seattle, Boston, Brisbane)
Components of a BRT

- Dedicated lanes ✓
- Prepaid stations ✓
- Buses with multiple doors, high capacity and low emissions ✓
- Differentiated services express and local ✓
- Intersection priority (includes not at grade) ✓
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Coordination with operators of lower capacity and fare integration

- Nearby stations without physical integration (additional service paid with discount)
- Virtual integration in stations
- Physical integration in stations
- Integrated feeder services
Components of a BRT

- Dedicated lanes ✓
- Prepaid stations ✓
- Buses with multiple doors, high capacity and low emissions ✓
- Differentiated services express and local ✓
- Intersection priority (includes not at grade) ✓
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- Use of advanced technologies and centralized control

Use of advanced technologies

• Acting stop lights
• Operation control
  • Advanced localizing of vehicles
  • Processing operation information
  • Operational planning
  • Online and real time control
• User information
  • In stations and buses in real time
  • From home for route and schedule planning
• Vehicle safety and operation
  • Telemetrics and state of parts, fuels, lubricants
  • Guiding and assisted braking
  • Maintenance control
Components of a BRT

- User information
- Good access to pedestrians and cyclists
- Adequate contracting and compensation of operators
- Increase densities around stations
- Parking lots for automobile integration
- Pedestrian access for disabled people
- Excellence in user service (cleanliness, information)
- Marketing strategies

User information

- Static in stations and buses (maps, flyers, signaling)
- Dynamic in stations and buses (visual, audio)
- Personalized (guides)
- At distance (information cabins, Internet, call center)

User information systems in London, UK
Components of a BRT

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Pedestrian and bicycle access

- Wide and leveled sidewalks, with street furniture and trees
- Designed bikeways, separated from the rest of the vehicle flow and signalised pedestrian
- Bridges and pedestrian tunnels and for bicycles
- Safe parking of bicycles

Bus tunnel station, Seattle, EEUU
Bicycle Lockers in Perth, Australia
Central pedestrianised streets in Santiago de Chile
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Linking operators

- Public operation (local authorities)
- External contracting of services (driving, cleaning, maintenance, policing, supervision)
- Private operation
  - Concession contracts
  - Operation contracts
- Operational balance fare
- Contractual payment that allows utility and transfers risks
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Coordination of land use and attention to effects of economic development

- Compatible land use (dense around stations and corridors)
- Vehicles parking to reduce access to central areas
- Adelaide, Brisbane, Ottawa, Pittsburgh, and Curitiba demonstrate that BRT can generate effects in land use and benefit economic development similar to those of rail urban transport.

Example of transit oriented development, Kings County (Area de Seattle, EEUU)
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Access and attention to disabled people, minors, elderly, pregnant women

- Ramps or elevators in stations, pedestrian overpasses, terminals
- At grade access from station to bus
  - Buses of low platform that “kneel”
  - Mechanical platform that ties bus and station (Curitiba, Quito)
  - Adequate distances to ensure fitting between bus and station (Goiânia, Bogotá)
- Buses with elevators
- Seats and areas designated for disabled people in buses (elements to grab wheelchair)
- Visual systems for hearing impaired
- Auditive systems and changes of texture for visually impaired (Braille maps)
- Trained staff and ready to attend special users
Bus ramp in AC Transit, California, EEUU

Trolebús access-Quito

Curitiba, Brasil
Components of a BRT

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User service

- Reception mechanisms, attention, follow-up and claim consolidation, suggestions, information
  - Direct mailing, Internet, call center
  - Database and frequent or critical topic reports
- Recollection of information on service quality with surveys to users and/or focus groups
- Quality indicator systems and service behavior
- Oriented to management of problem solving of service quality reported by users in direct communication and surveys
- High standards of cleanliness of stations and buses
- Preventive maintenance and immediate correction
- Service training to operators, fare collectors and administrators
Components of a BRT

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- Increase densities around stations
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Marketing

• Massive means of communication
  • Expectation campaigns, image, consolidation, general education

• Direct marketing
  • Community groups
  • Potential users and corridors in zones of influence
  • users
  • During construction, launching of operation, during operation

• Corporate image and strong service
  • Name, logo, color and design of buses, material and design of stations, operator uniforms
  • Associate with advantages: speed, reliability, comfort, environment
Comparing BRT with others

Frequency-capacity

Compared BRT Line capacity - commercial speed

Compared BRT productive capacity - investment

**Effects on stopping time**

<table>
<thead>
<tr>
<th>Tipo de Servicio</th>
<th>Tiempo de Parada (Segundos por Pasajero)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal (1 puerta angosta, escaleras, pago abordo)</td>
<td>4.20 2.50 0.60 0.30</td>
</tr>
<tr>
<td>Prepago</td>
<td>2.50 2.50</td>
</tr>
<tr>
<td>Acceso a Nivel</td>
<td>2.00</td>
</tr>
<tr>
<td>Puertas Multiples (3 puertas anchas)</td>
<td>0.60</td>
</tr>
<tr>
<td>Bus Articulado (4 puertas anchas)</td>
<td>0.30</td>
</tr>
</tbody>
</table>

**Diagrama:**
- **Abordar**
- **Descender**

**Porcentajes de cada tipo de servicio:**
- Acceso a Nivel: 12.8%
- Puertas Multiples (3 puertas anchas): 35.9%
- Bus Articulado (4 puertas anchas): 7.7%
- Prepago: 43.6%
Commercial speed and fleet size

- Normal: 10.8
- Prepago: 11.0
- Acceso a Nivel: 11.1
- Multiples Puertas: 11.5
- Espaciamento 600m: 12.9
- Carril Exclusivo: 13.9
- Servicio Expreso: 24.0
- Bus Articulado: 28.3

Speed Km/h: 0, 200, 400, 600, 800, 1000, 1200, 1400, 1600, 1800

Buses

Velociad Operacional: Flota Requerida
# Impact on travel time

<table>
<thead>
<tr>
<th>Mode</th>
<th>Minutos</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>53.5</td>
</tr>
<tr>
<td>Prepago</td>
<td>55.2</td>
</tr>
<tr>
<td>Acceso a Nivel</td>
<td>48.5</td>
</tr>
<tr>
<td>Multiples Puertas</td>
<td>50.8</td>
</tr>
<tr>
<td>Espaciamiento 600m</td>
<td>50.1</td>
</tr>
<tr>
<td>Carril Exclusivo</td>
<td>33.0</td>
</tr>
<tr>
<td>Servicio Expreso</td>
<td>29.2</td>
</tr>
<tr>
<td>Bus Articulado</td>
<td>29.8</td>
</tr>
<tr>
<td>Perceived Time</td>
<td>45.8</td>
</tr>
</tbody>
</table>

The chart above illustrates the impact on travel time with various modes of transport, showing how different factors like normal travel, prepago, access level, multiple doors, spacing, express service, and articulated bus can affect travel times. The perceived time is also indicated on the chart.
Contribución a Ahorro de Tiempo de los Usuarios

<table>
<thead>
<tr>
<th>Componente</th>
<th>Ahorro de Tiempo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prepago</td>
<td>-1.64</td>
</tr>
<tr>
<td>Acceso a Nivel</td>
<td>0.93</td>
</tr>
<tr>
<td>Multiples Puertas</td>
<td>1.89</td>
</tr>
<tr>
<td>Espaciamento 600m</td>
<td>3.15</td>
</tr>
<tr>
<td>Carril Exclusivo</td>
<td>17.13</td>
</tr>
<tr>
<td>Servicio Exprés</td>
<td>3.32</td>
</tr>
<tr>
<td>Bus Articulado</td>
<td>-0.19</td>
</tr>
<tr>
<td>Total</td>
<td>24.59</td>
</tr>
</tbody>
</table>
When comparing alternatives, there is no technological option that outperforms the others in every aspect.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Priority lanes / only bus</th>
<th>Light rail/ street car</th>
<th>Heavy rail/ Metro</th>
<th>Bus Rapid Transit BRT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Required space</strong></td>
<td></td>
<td></td>
<td>New road underground or elevated</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2-4 lanes existing roads</td>
<td>2-3 lanes existing roads</td>
<td>2-4 lanes existing roads</td>
<td></td>
</tr>
<tr>
<td><strong>Flexibility</strong></td>
<td>High</td>
<td>Limited</td>
<td>Low</td>
<td>Alta</td>
</tr>
<tr>
<td><strong>Impacts on traffic</strong></td>
<td>Variable</td>
<td>Variable</td>
<td>Congestion reduction (?)</td>
<td>Variable</td>
</tr>
<tr>
<td><strong>Integration with feeders</strong></td>
<td>Easy</td>
<td>Difficult</td>
<td>Difficult</td>
<td>Easy</td>
</tr>
<tr>
<td><strong>Level of service</strong></td>
<td>Regular</td>
<td>Good</td>
<td>Very Good (dense corridor)</td>
<td>Good</td>
</tr>
<tr>
<td>(frequency and occupancy)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Safety</strong></td>
<td>Regular</td>
<td>Good</td>
<td>Very Good</td>
<td>Good</td>
</tr>
<tr>
<td><strong>Emissions</strong></td>
<td>High</td>
<td>Low</td>
<td>Low</td>
<td>High Medium</td>
</tr>
<tr>
<td><strong>Reliability</strong></td>
<td>Low</td>
<td>Low (bunching)</td>
<td>Good</td>
<td>Media</td>
</tr>
<tr>
<td><strong>walk/transfers</strong></td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
</tr>
</tbody>
</table>

Sources: Adapted from el D. Hidalgo de Halcrow Fox, 2000, L. Wright and K. Fjellstrom, 2003, y V. Vuchic, 1992
Bus Rapid Transit can have similar capacity to metro systems at a fraction of the initial investment cost. 20,000 to 40,000 pphpd, 20-30 Km/h, for 5-20 MM/Km.
Bus Rapid Transit can result in smaller life cycle costs than rail alternatives.

![Graph showing life cycle costs for different transit systems.](image-url)
BRT is likely to be more cost-efficient than a Light Rail or Metro, both per kilometer and per passenger.

20 Km Corridor, 35,000 pax/hora per direction, 350,000 pax/day

Capital Cost per Kilometer
Total Cost per Kilometer
Cost per Passenger

US$ Millions (Present Value 12%, 20 years)
BRT is likely to result in greater social benefits than a metro, at a fraction of the life cycle costs—Net Present Value 20% higher, Benefit/Cost ratio 160% greater.

Present Value 20 years, Discount Rate 12%
20 Km Corridor, 35,000 pax/hour, 350,000 pax/day, average trip length 8 Km, US$0.70/hour

<table>
<thead>
<tr>
<th>Option</th>
<th>Net Benefits</th>
<th>Benefit/Cost Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do-nothing</td>
<td>-1,500</td>
<td></td>
</tr>
<tr>
<td>Bus Lanes</td>
<td>-1,000</td>
<td></td>
</tr>
<tr>
<td>Light Rail Transit</td>
<td>1,218</td>
<td>2.5</td>
</tr>
<tr>
<td>Metro</td>
<td>1,226</td>
<td>2.0</td>
</tr>
<tr>
<td>HBRT</td>
<td>1,471</td>
<td>5.2</td>
</tr>
</tbody>
</table>

Slides developed originally by Dario Hidalgo
This results are not applicable to all single cases. A sensitivity analysis shows that chances are more favorable to BRT under many variations in the analysis inputs – costs, benefits.

<table>
<thead>
<tr>
<th>Probability that the Net Present Value is Higher</th>
<th>Bus lane- Bus only</th>
<th>Light rail</th>
<th>Heavy rail</th>
<th>Bus Rapid Transit BRT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bus lane- Bus only</td>
<td>-</td>
<td>31.5%</td>
<td>47.2%</td>
<td>8.5%</td>
</tr>
<tr>
<td>Light rail</td>
<td>68.5%</td>
<td>-</td>
<td>60.5%</td>
<td>24.1%</td>
</tr>
<tr>
<td>Heavy rail</td>
<td>52.8%</td>
<td>39.5%</td>
<td>-</td>
<td>20.1%</td>
</tr>
<tr>
<td>Bus Rapid Transit BRT</td>
<td>91.5%</td>
<td>75.9%</td>
<td>79.9%</td>
<td>-</td>
</tr>
</tbody>
</table>

Note: - means not applicable. Read row header compared to column header. 20 Km 35,000 pax/hour.
<table>
<thead>
<tr>
<th></th>
<th>Bus lanes/ bus only</th>
<th>Light rail</th>
<th>Heavy rail</th>
<th>Bus Rapid Transit BRT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicles and operations covered with fare (may not require operational subsidies)</td>
<td>Yes</td>
<td>No</td>
<td>No*</td>
<td>Yes</td>
</tr>
<tr>
<td>Short implementation time</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Use of the local capacity (existing transport companies/industry)</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Contribution to road based transit improvement</td>
<td>No</td>
<td>Low impact</td>
<td>Low impact</td>
<td>Yes</td>
</tr>
<tr>
<td>Promotes cultural changes (behavior)</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Urban development impacts</td>
<td>Negative Impact</td>
<td>Low positive impact</td>
<td>High positive Impact</td>
<td>Medium-low Positive Impact</td>
</tr>
</tbody>
</table>

Note: Mostly applicable to developing countries conditions