Mass Transit Options
PT issues in developing cities

- Dirty, overcrowded buses- “poor man’s mode”
- Mix of modes
- >50% trips; <5% vehicle share
- Ad hoc planning
- No priority on roads

- Often high tax burden (much more than cars)
- No quality monitoring
Unattractive public transport systems

- Insufficient physical integration of various public transport modes and between public transport, walking, cycling and private car
- No integrated and transparent time schedules
- Signage, customer information on timetables, connecting services and fares not appropriate

→ discouraging the use of public transport
Unattractive public transport systems

• Insufficient cooperation between public transport operators
• Each change of mode normally requires the purchase of another ticket
• No uniform service level standards among modes and operators
Cities which increased the modal share of walking, cycling and PT saw a decrease in the consumption of energy for passenger transport per capita.

Source: UITP
Redefining Public Transport, Why?

How far can I travel on 1 ton of CO₂?

(values given in passenger-kilometers)

All values reflect a 100% occupation rate.

<table>
<thead>
<tr>
<th>Mode</th>
<th>passenger-kilometers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pedestrian</td>
<td>∞</td>
</tr>
<tr>
<td>Bicycle</td>
<td>∞</td>
</tr>
<tr>
<td>Bi-articulated BRT Bus (diesel)</td>
<td>146,100</td>
</tr>
<tr>
<td>Articulated Bus (diesel)</td>
<td>119,100</td>
</tr>
<tr>
<td>2-axle Urban Bus (diesel)</td>
<td>101,200</td>
</tr>
<tr>
<td>Metro Rail (single car)</td>
<td>80,600</td>
</tr>
<tr>
<td>Passenger Car (diesel)</td>
<td>31,100</td>
</tr>
<tr>
<td>Scooter (4-stroke, urban roads)</td>
<td>28,600</td>
</tr>
<tr>
<td>Passenger Car (petrol)</td>
<td>26,200</td>
</tr>
<tr>
<td>Scooter (2-stroke, urban roads)</td>
<td>17,200</td>
</tr>
</tbody>
</table>

All values in passenger-kilometers (Pkm), reflecting a 100% occupation rate.

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All data given in this diagram should be considered as guideline values, as real values may differ considerably, depending on e.g. actual load factors, smoothness of traffic flow and technical standards of vehicles and infrastructure.
What do citizens want?

- Convenience
- Easy Access
- Comfort
- Frequent Service
- Rapid journey
- Safety & Security
- Customer Service
- Affordability
- Have a network

Public Transport should be designed around the customer and not around a technology.
...because competition for PT is strong!
Conventional Public Transport Planning Approach

Step 1. Choose technology

- Technology chosen due to manufacturer lobbying efforts
- Design chosen to please existing operators
- Technology chosen to help property developer

Step 2. Fit city to the technology

- Reduce size of network due to financing limitations
- Charge higher fares in attempt to pay for expensive system
- Operate infrequent services to reduce operating losses
- Require large subsidies for lifetime of system’s operation

Step 3. Force customer to adapt to technology

- Extensive marketing campaign to convince customers that system is in their interest
- Operate infrequent services to reduce operating losses
The innovative and successful approach

Step 1. Design a system from customer’s perspective
- Rapid travel time
- Few transfers
- Frequent service
- Short walk to station from home / office
- Full network of destinations
- Low fare cost
- Safe vehicle operation
- Secure environment
- Comfortable and clean system
- Friendly and helpful staff

Step 2. Evaluate customer-driven options from municipality perspective
- Low infrastructure costs
- Traffic reduction benefits
- Environmental benefits
- Economic / employment benefits
- Social equity benefits
- City image

Step 3. Decision
Technology decision based on customer needs and municipality requirements
Checklist for efficient public transport planning
Accessibility - Options

- How to reach the PT station?
  - Walk, bike or drive
  - How good is the path?
Station Design

- Passenger friendly designs?
  - Clear signage, disabled friendly
  - Better interchanges
  - Public amenities
Vehicle and infrastructure design

- Comfortable
- Capacity
- Attractive

Which one to select?

Source: Carlos F. Pardo
Public Transport priority

- Is PT prioritized over other modes?
Modal Integration

- Can an individual take his/her bicycle? Is it easy to walk? Should he/she can drive to the station?
Professionalism

- Are the stations and the fleet clean?
- Do the drivers have good road etiquettes?
Network coverage

- Can I reach the CBD, shopping district, my home?
Frequency, Reliability

- How soon can I get a the next train, bus, tram?
The reality in most cities:

- Public transport is underdeveloped, not attractive enough for customers (often 2-4 tickets are required to get to work per direction)

- There often exist stand alone systems (Bangkok, Manila, Kuala Lumpur....) without proper physical, time table- and fare-integration

- Fares are collected at vehicles (causing slower services)

- Urban transport responsibilities are often fragmented between various ministries, provincial and municipal level

Looking forward:

Public transport integration is the challenge during coming years to considerably increase attractiveness of PT!
Fare Integration

How not to do...

- How many times one should buy a ticket?
- Where one should buy the ticket?
- Who are the operators?

an example

Approx 35 km

St. Petersburg → Pavlovsk

- Metro: 17 Rubles
- Train: 43 Rubles
- Minibus: 13 Rubles

= 73 Rubles
Fare Integration...(contd)

How to do...an example

Approx 40 km

Wiesbaden

Frankfurt

1 fare / 1 ticket

6.75 Euro

Integrated timetable
Now let’s look at available options in **Mass Transit**
Different Mass Rapid Transit Modes available

- Heavy urban rail
- Monorail
- Underground metro
- Light rail
- BRT
- Personal rapid transit
Selection Criteria for MRTs

- Availability of the mode to meet demand
- Cost
- Right-of-way availability
- Environmental impact
- Journey time
- Safety
- Comfort
- Flexibility
- Reliability
- Fare
- Technical sophistication
- Implementation complexities
- Image
Equivalency road width: In order to carry 20,000 automobile commuters PHPD, a highway must be at least 18 lanes wide.

(assumption 1.2 passengers per automobile)
Heavy rail transit
Heavy rail in Frankfurt (Germany)
• Metro

Santiago de Chile Metro (Underground)

Photo by Tamal
Heavy Rail - Metro

Trains of high performance, electrically powered rail cars operating in exclusive rights-of-way

- Metro is the most common international term for Heavy Rail Transit.
- Maximum service speeds range from 50 to 70 Kmph
- Conventional two rail "railroad" tracks, plus a slightly raised third rail
- Full grade separation ensures safety
- Cars are typically about 75 feet long by 10 feet wide, with about 75 seats
- Standing capacity of about 200. Trains lengths can vary from 2-10 cars
- Practical headways can be as short as two minutes
- Capacity of up to 60,000 PHPD passengers
• Commuter rail systems

German commuter rail

Source: Traffiq
Commuter Rail / Regional Rail

Commuter Rail is a mode of transportation that is based on operating passenger trains on the tracks of the general railroad system, which is shared with freight trains.

Some commuter rail systems carry up to 75,000 passengers per hour per direction (i.e. Mumbai), though quality of service is not the best.
• Light Rail Transit
• Budapest Tram

Photo by Carlosfelipe Pardo
Light Rail Transit

Commonly referred to as “streetcars” or “trolleys.”

Most systems are powered by overhead electric wires.

Run on either exclusive or shared rights-of-way with or without grade crossings, or occasionally in mixed traffic lanes on city streets.

Tracks can be laid in any of three generic right-of-way (ROW) categories.

Cars are typically articulated, about 28 m long by 2.65 m wide, with about 75 seats.

Trains vary from 2-4 cars, with a 4-car train capable of carrying about 300 seated passengers, and a total of up to 750 passengers.
• Bus Rapid Transit

Guayaquil’s BRT system

Photo by Carlosfelipe Pardo
BRT

BRT is a bus operation generally characterized by use of exclusive or reserved rights-of-way (bus ways) that permit higher speeds and avoidance of delays from general traffic flows.

Include reverse lane operation on limited access roadways, and/or prioritization of at-grade bus movements through signalized intersections.

A standard BRTS bus can carry 5,000 pphpd and with an overtaking lane, this number could go up to at least 20,000.

BRT in Bogota carries more than 40,000 pphpd!
168 BRT and busway systems in the world

Evolution of the # of cities and km per decade:

- Before 1990 (16 cities): 507 km
- 1991 - 2000 (19 cities): 1025 km
- 2001 - 2010 (103 cities): 3707 km
- Since 2011 (30 cities): 4119 km

Source: BRTdata.org, August 2013
182 Cities with Metro

10,435 km, 112 million passengers per day
BRT and busway systems in the world

Evolution of the number of cities per year

1972/2010*: Lima
1974/1991*: Curitiba
2000: Bogotá (TransMilenio), Colombia
2010: Guangzhou

* Busway / BRT year commenced

source: BRTdata.org, September 2013
No single alternative dominates the others

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Bus lanes</th>
<th>Light Rail - Tramway</th>
<th>Heavy Rail - Metro</th>
<th>Bus Rapid Transit - Metrobus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space Required</td>
<td>2-4 lanes Existing Roads</td>
<td>2-3 lanes Existing Roads</td>
<td>New Right of Way – Elevated or Underground</td>
<td>2-4 lanes Existing Roads</td>
</tr>
<tr>
<td>Flexibility</td>
<td>High</td>
<td>Limited</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Impacts on Traffic</td>
<td>Mixed</td>
<td>Mixed</td>
<td>Reducción de Congestión (?)</td>
<td>Mixed</td>
</tr>
<tr>
<td>Integration with Feeders</td>
<td>Easy</td>
<td>Difficult</td>
<td>Difficult</td>
<td>Easy</td>
</tr>
<tr>
<td>Level of Service (Fruquency, Occupancy)</td>
<td>Low</td>
<td>Good</td>
<td>Muy Good (corredor denso)</td>
<td>Good</td>
</tr>
<tr>
<td>Safety</td>
<td>Low</td>
<td>Buena</td>
<td>Muy Buena</td>
<td>Good</td>
</tr>
<tr>
<td>Emmissions</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
<td>High Medium</td>
</tr>
<tr>
<td>Reliability</td>
<td>Low</td>
<td>Medium (bunching)</td>
<td>Good</td>
<td>Medium</td>
</tr>
<tr>
<td>Transfers /Walking</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
</tr>
</tbody>
</table>

Sources: Adaptado por el autor de Halcrow Fox, 2000, L. Wright and K. Fjellstrom, 2003, y V. Vuchic, 1992
<table>
<thead>
<tr>
<th>Component</th>
<th>Metro</th>
<th>LRT</th>
<th>BRT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Running Ways</td>
<td>Rail Tracks</td>
<td>Rail Tracks</td>
<td>Roadway</td>
</tr>
<tr>
<td>Type of Right of Way</td>
<td>Underground/ Elevated/ At-grade</td>
<td>Usually At-grade – some applications Elevated or Underground (tunnel)</td>
<td>Usually At-grade – some applications Elevated or Underground (tunnel)</td>
</tr>
<tr>
<td>Segregation From the Rest of the Traffic</td>
<td>Total Segregation (no interference)</td>
<td>Usually Longitudinal Segregation (at grade intersections) – some applications with full segregation</td>
<td>Usually Longitudinal Segregation (at grade intersections) – some applications with full segregation</td>
</tr>
<tr>
<td>Type of Vehicles</td>
<td>Trains (multi-car)</td>
<td>Trains (two-three cars) or single cars</td>
<td>Buses</td>
</tr>
<tr>
<td>Type of Propulsion</td>
<td>Electric</td>
<td>Electric (few applications Diesel)</td>
<td>Usually Diesel/CNG – some applications Hybrid (Diesel/CNG-Electric) or Electric Trolleybuses</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Component</th>
<th>Metro</th>
<th>LRT</th>
<th>BRT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stations</td>
<td>Level boarding</td>
<td>Level boarding or stairs</td>
<td>Level boarding (few with stairs)</td>
</tr>
<tr>
<td>Payment Collection</td>
<td>Off-board</td>
<td>Usually off-board</td>
<td>Off-board</td>
</tr>
<tr>
<td>Information Technology</td>
<td>Signalling, control, user information, advanced ticketing (magnetic/electronic cards)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Service Plan</td>
<td>Simple; trains stopping at every station; few applications with express services or short loops</td>
<td>Simple; trains stopping at every station between terminals</td>
<td>From simple to very complex; combined services to multiple lines; express, local – some combined with direct services outside the corridor</td>
</tr>
<tr>
<td>User Information</td>
<td>Very clear signage, static maps and dynamic systems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Image</td>
<td>Modern and attractive</td>
<td></td>
<td>Advanced as compared with standard buses</td>
</tr>
</tbody>
</table>

Financial Benefit - What a city can have for 1Bn US$? Make a choice...

- 426 kilometres of BRT
- 14 kilometres of elevated rail
- 7 kilometres of subway
- 40 kilometres of LRT

* Source: Actual data from systems built or proposed in Bangkok, Thailand
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

- Do-nothing: Travel Time Savings - 682, Operational Cost Savings - 2.5, Costs - 7.3
- Bus Lanes: Travel Time Savings - 1,218, Operational Cost Savings - 2.0, Costs - 5.2
- Light Rail: Travel Time Savings - 1,226, Costs - 2.5
- Transit: Costs - 5.2, Benefit/Cost Ratio - 1.471
- Metro: Costs - 2.0, Benefit/Cost Ratio - 1.471
- HBRT: Costs - 2.0, Benefit/Cost Ratio - 1.471
Comparison of modes - Capacity and operating speed

- **Bus and BRT**
  - Low inter-station spacing, small vehicles, poor acceleration, Bus priority

- **LRT vs BRT**
  - Dynamic performance, vehicle capacity

- **Tram vs LRT**
  - Signalling, own ROW, vehicle capacity

- **LRT vs Metro**
  - Acceleration, signalling, longer vehicles, max speed

- **Suburban rail vs Metro**
  - Inter-station spacing, longer vehicles, max speed

<table>
<thead>
<tr>
<th>Mode</th>
<th>Speed (km/h)</th>
<th>Performance (Capacity, Reliability)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car (m’way)</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td>Suburban rail</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>LRT</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>Metro</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>Tram</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>BRT</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Bus on-street</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>
COMPARISON OF INVESTMENT COSTS FOR MRT

- COMMUTER RAIL
- HEAVY METRO
- LIGHT METRO
- LRT
- BRT SINGLE LINE
- BRT DOUBLE LINE

Bicivilízate
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
Corridor capacity for BRT systems

Source: Hidalgo
Life Cycle (20 years)
20 Km Corridor with 35,000 Passenger/hour/direction

US$ Million (Present Value 12%)

- Do-nothing: 1,885, 1849
- Bus Lanes: 1,145
- Light Rail Transit: 952, 1,120
- Metro: 800, 1,298
- HBRT: 826

Legend:
- Green: Infrastructure
- Cyan: Maintenance
- Purple: Vehicles
- Orange: Operations
- Blue: Total
Recommendations Mass Transit

• Do not choose the technology and then justify it

• For the conditions of any city the key is integration of different services, taking most advantage of the existing systems

• BRT can bring positive socio-economic impact in a short time frame and a relative low cost
Time for construction

Bus Rapid Transit
18 months – 3 years
i.e. within the term of a Mayor

Metros
> 5 years
Comparing the costs

<table>
<thead>
<tr>
<th>Mode</th>
<th>Cost Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>BRT</td>
<td>US$ 0.5 – 15 million / km</td>
</tr>
<tr>
<td>Tram</td>
<td>US$ 10 – 25 million / km</td>
</tr>
<tr>
<td>Light Rail Transit (LRT)</td>
<td>US$ 15 – 40 million / km</td>
</tr>
<tr>
<td>Urban commuter rail</td>
<td>US$ 25 – 60 million / km</td>
</tr>
<tr>
<td>Elevated rail</td>
<td>US$ 50 - 125 million / km</td>
</tr>
<tr>
<td>Metro</td>
<td>US$ 60 million – 320 million / km</td>
</tr>
</tbody>
</table>

Image source: Manfred Breithaupt
Some recent publications
Development underway on the 4th Edition of the BRT Planning Guide

Freely distributed world-wide in both electronic and bound versions in multiple languages:

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- French
- Indonesian
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- Non-motorised Transport
- Travel Demand Management
- Mass Transport Options
- Bus Regulation and Planning
- Financing Urban Transport
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