WORKSHOP SESSION URBAN CYCLING: THE INTEGRATION OF CYCLING AND PUBLIC TRANSPORT

PRINCIPLES AND EXAMPLES

MARK BRUSSEL, ITC, PGM DEPARTMENT
The integration of NMT with PT

- Theoretical principles of multimodal trips and integration at different scale levels
- Examples of multimodal integration from the NL, Brazil, Colombia
- Public bikes?
- The use of GIS in evaluation of accessibility in multimodal networks, WB project India

Discussion: how can the use of bicycles as an access mode be increased in Brazilian cities?
OBJECTIVES OF THIS WORKSHOP

After this workshop I would like you to be able to:

- Discuss concepts of PT- cycling integration at different scale levels (urban – network - facility level)
- Discuss requirements of effective PT - cycling integration
- Get an idea of a GIS based multi-modal model and accessibility analysis.
- Reflect on possibilities to improve PT- bike integration in Brazilian cities
Integration of bicycles into multi-modal transport chains, particularly with public transport (PT) modes, may contribute to a more efficient and environmentally sustainable transport system.

A well integrated PT-bike system increases PT ridership levels.
WHY DO WE BOTHER?

Public transport systems, particularly in larger cities in many countries are often dense enough to make the PT stations accessible by walking; So, do we need to look at integrating cycling and PT? Perhaps in relation to mass transit systems like urban rail and BRT!

- Low density networks
- High quality bus stop/station locations
- NMT infrastructure provisions alongside corridor??
DENSITY OF PT STATIONS
CENTRE OF RIO DE JANEIRO

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DENSITY OF PT STATIONS
SANTA CRUZ AREA, RIO DE JANEIRO

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FINDING THE OPTIMAL MIX OF MODES...

Cycling (& walking)
- Short distances
- Inner urban trips
- Limited luggage carrying

Public transport
- Longer trips
- Mass transportation
- Feeder trips required
- Cost effective in dense areas

Car
- Longer trips
- Thinly populated areas
- Less/not suitable for dense urban areas
- Needs lots of space for roads/parking is a problem
- Expensive
BUSES AND BIKES: FRIENDS OR FOES?

Cycling:
- No emission, personal means of transport
- Door to door, or multi-modal
- Cheap and available throughout the day
- Fast and efficient at short distances

Buses (in formal systems, how about informal?)
- Low emission, public means of transport
- Spatial coverage high, but dependent on stops
- Time table
- Slow and inefficient at short distances

Bikes and buses can be competing but can also be complementary by providing efficient and sustainable door-to-door service to the commuter

*Can bicycles take over the role of short distance bus trips in Brazilian cities?*

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**PUBLIC TRANSPORT INTEGRATION**

1. **Fare integration**: provision of integrated ticketing, one ticket including for parking/renting of bike

2. **Information integration**: information on almost all aspects of travelling in every mode

3. **Operational integration**: of different PT systems and operators

4. **Physical integration**: “seamless” trips with transfer facilities continuously improved and provided

5. **Network integration**: integrating different hierarchical levels and connecting modes

(adapted Ibrahim, 2003)
SPATIAL LEVELS PHYSICAL & NETWORK INTEGRATION

1. Facility level: the nodal interchanges and their facilities
2. Network level: the integrated transport system
3. Urban level: the land-use transport system

(picture: TRIPP)

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INTEGRATION AT THE FACILITY LEVEL

Facilities that can be provided for cyclists:
1. Bike parking at PT station or at very short distance
2. Appropriate bicycle infrastructure in catchment area and to access stations
3. Public bike schemes.
4. Bicycle rent schemes integrated with public transport systems.
5. Bike storage facility at the home and/or non-home end of the trip.

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Cycling potential in an integrated trip is a function of the public transport network lay-out and structure.

- Bike access trips are probably better accommodated in public transport systems with a relatively low PT stop density.
- Walking access is better accommodated in public transport systems with a high PT stop density.

An access network

A connecting network

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INTEGRATION AT THE URBAN LEVEL

At the highest level of integration the PT-bike system (supply) is compared to trip demand (potential) of locations.

(Krygsman et al., 2004)
1. time that can be attributed to the transfer of modes:
   - walking distance from parking to the bus or train.
   - average time needed to park and pay (if applicable) for the bicycle storage.

2. costs that can be attributed to the transfer of modes:
   - costs to park the bicycle (park and ride).

3. service, safety and comfort:
   - security and safety for both the bicycle as well as the users
   - availability of the parking facility around the clock
   - service from before to after the scheduled departure and arrival times of buses
   - stairs (i/a) to enter or exit the facility with a bicycle and from the bike parking to the platform (i/a)
   - quality of storage (racks, bicycle maintenance service)
   - bicycle renting possibility
   - attractiveness visual appearance and convenience of the bicycle parking facility as well as its direct surroundings

INTEGRATION AT THE FACILITY LEVEL
SEAMLESSNESS OF THE INTEGRATION

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FACILITY INTEGRATION – BIKE PARKING

FORMAL SYSTEM TRANSMILENIO BOGOTA, JARDIM HELENA TRAIN SAO PAOLO

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FACILITY INTEGRATION – BIKE PARKING

“INFORMAL” BIKE PARKING – SANTA CRUZ RAIL STATION, RIO DE JANEIRO
“Bicycle flat” at Amsterdam Central train station (capacity: 4000 bikes)

Largest bicycle parking in the world to be constructed at Utrecht Central Station, capacity 12000 bikes
INTEGRATION AT THE NETWORK LEVEL
REQUIREMENTS CYCLING INFRASTRUCTURE FOR CATCHMENT AREAS OF STATIONS

1. **Consistency**: the cycle infrastructure should be an uninterrupted consistent whole, connecting points of departure and destination.

2. **Directness**: cycle tracks are preferably the shortest possible routes between points of departure and the destinations (PT stations).

3. **Attractiveness**: lighting, shelter, traffic signs, intersection priorities etc. should be well designed and operational.

4. **Road safety**: smooth pavements, lighting and removal of dangerous junctions (accident hotspots) to ensure safe routes to the stops.

5. **Convenience**: preventing steep slopes, dangerous curves, open drainages, street hawkers and parked vehicles on the bike lanes.

Which issues are most difficult to resolve in Brazil?
São Paulo, Jardim Helena, Typical Catchment Area
Potential for Improving Cycling?
CYCLING FRIENDLY ROAD DESIGN
THERE IS A LOT YOU CAN DO!
A typical Public Bike System consists of: (litman, 2012)

- A fleet of bicycles
- A network of automated stations (also called *points*) where bikes are stored
- Bike redistribution and maintenance programs.
- Bikes may be rented at one station and returned to another.
- Stations with automated self-serve docking systems for 5-20 bikes
- Use is free or inexpensive for short periods (typically first 30 minutes).
- Allows residents and visitors to bicycle without needing to purchase, store and maintain a bike.
- PBS are most efficient when bikes are shared many users each day; some systems average as many as twelve daily users per bike.
## PROS AND CONS OF PBS

<table>
<thead>
<tr>
<th>Pros (Litman, 2012)</th>
<th>Cons ?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Congestion Reduction</td>
<td>Reverse logistics</td>
</tr>
<tr>
<td>Road &amp; Parking Savings</td>
<td>Empty and full stations</td>
</tr>
<tr>
<td>Consumer Savings</td>
<td>Theft</td>
</tr>
<tr>
<td>Transport Choice</td>
<td>Not custom built for person, 1 size fits all</td>
</tr>
<tr>
<td>Road Safety</td>
<td>High cost for operator (society)</td>
</tr>
<tr>
<td>Environmental Protection</td>
<td>Public space use</td>
</tr>
<tr>
<td>Efficient Land Use</td>
<td></td>
</tr>
<tr>
<td>Community Livability</td>
<td></td>
</tr>
</tbody>
</table>
PUBLIC BIKE SYSTEMS
DOES THIS MAKE SENSE IN THE BRAZILIAN CONTEXT?

- Some systems implemented, plans for more cities
- How to create successes?
- Would such system make sense in a city like Belem?

<table>
<thead>
<tr>
<th>City</th>
<th>Country</th>
<th>Region</th>
<th>System</th>
<th>Operator</th>
<th>Status</th>
<th>Numbers</th>
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</thead>
<tbody>
<tr>
<td>João Pessoa</td>
<td>Brazil</td>
<td>Americas</td>
<td>SAMBA</td>
<td>Mobilicidade</td>
<td>Active</td>
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<td>Toledo</td>
<td>Brazil</td>
<td>Americas</td>
<td>Toopedalando</td>
<td>Toopedalando</td>
<td>Active</td>
<td>2011</td>
</tr>
<tr>
<td>Rio de Janeiro</td>
<td>Brazil</td>
<td>Americas</td>
<td>Bike Rio</td>
<td>Mobilicidade</td>
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<td>2011</td>
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<td>São Paulo</td>
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<td>Bikesampa</td>
<td>Mobilicidade</td>
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<td>2012</td>
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<tr>
<td>Sorocaba</td>
<td>Brazil</td>
<td>Americas</td>
<td>Integrabike</td>
<td>Mobilicidade</td>
<td>Active</td>
<td>2012</td>
</tr>
</tbody>
</table>

THE INTEGRATED PT-BIKE SYSTEM

CONCLUDING ON REQUIREMENTS

Consists of:

1. Multi-modal transfer facilities (at interchanges or stops) that are fast, cheap, accessible, safe and convenient.

2. These facilities (integration points) need to be well located as per the optimal catchment of potential users (of the integrated bicycle-bus system) in the urban area.

3. A connecting public transport network, implying low density of stops and stations (system),

4. An integrated PT - bicycle network (system), i.e. access bike network linked to the connecting public transport network, and/or;

5. An access public transport network (public transport feedering system) with a bus stop density complementing the bicycle as an access mode.

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TARGET USERS OF THE INTEGRATED PT-BIKE SYSTEM

1. **Current PT users**, that would potentially benefit from an improved quality of their trip.

2. **Current cyclists**, that would potentially benefit from increased opportunities to reach more trip destinations at different distances/travel times, within their travel time budget.

3. **Potential users of PT** that are using other motorised modes such as motorcycles.

4. **Pedestrians**, that may shift to bicycles in case favourable conditions are created.

5. ... **Current car users**, aiming at providing an attractive trip chain that will induce them to switch to cycling and PT.

*Where is the potential in Brazilian cities?*

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HOW TO PROMOTE INTEGRATION?
AT THE FACILITY LEVEL

Capacity
- Capacity fits bicycle parking demand
- Integrated ticketing and fare systems
- Frequent traveler incentives (discount, priority parking)
- Priority parking (women)

Seamless access between parking and platform
- Good station design
- Accessible bicycle parking
- Shortcut from bicycle parking to platform

Service levels
- Guarded bicycle parking from before the first service till after the (delayed) last service
- Bicycle maintenance, puncture service
- General supplies shop

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HOW TO PROMOTE INTEGRATION?

At the network level
Bicycle network
- Complying with route quality criteria (consistency, directness, attractiveness, road safety)
- Bicycle network integrated with public transport network (particularly at the most important public transport stops)

PT network
- PT network integrated with bicycle network (particularly at the most important public transport stops)
HOW TO PROMOTE INTEGRATION?

At the urban level

- The integrated bus-bike network is planned as such to optimize the catchment of bus-bike users.
- Integrated land use – transport policy and planning
WB PROJECT AHMEDABAD, INDIA
ACCESSIBILITY DEFINED

The ability and ease of people to overcome the friction of distance in order to utilize opportunities (or services) at fixed points in space

- Point of Origin
- Transport network (Impedance)
- Point of destination (Utility/Benefit)
ACCESSIBILITY MEASURES

Indicator for the effectiveness of the transport system as a whole
ability to reach employment areas, service locations, center areas etc.

And

Indicator for the availability of facilities and services
Evaluating the geographical match between resources available and
resources needed

Accessibility measures therefore evaluate the combined LU-transport
system!
ACCESSIBILITY MEASURES

**Contour measures** (cumulative opportunity) – measures the cumulative number of opportunities (e.g. jobs) that can be reached in a given time or at certain threshold distance from a specified origin.

**Potential measures** (activity based) – discounts the number of opportunities that can be reached from a specified origin.
MODELLING BUS-BIKE INTEGRATION IN GIS

Not a transport model!
But.... a spatial planning tool for PT and LU integration
Ahmedabad is the largest city of Gujarat state and the seventh largest city in India \([\text{total area} = 190 \text{ km}^2]\).

The current population of Ahmedabad is 7.2 million.

In 1994 many mills faced liquidation leaving 67,000 workers jobless.

The percentage of housing categorized as slum increased from 17.2\% in 1961 to 25.6\% in 1991.

Ahmedabad is extending its current AMTS public transport system with a Bus Rapid Transit (BRTS) as well as Metro system (MRT).

**How will the urban poor (potentially) benefit of these public transport systems?**
1. How do the planned BRTS and MRT projects enhance levels of accessibility for the urban poor as compared to the existing AMTS public bus system?

2. What portion of the city benefits most from the new public transport options?

3. Where is the best place to locate new jobs from the perspective of accessibility to jobs for the urban poor?

4. Where to provide low income housing to ensure their access to jobs?

5. Where to provide new public transport infrastructure capacity to improve levels of accessibility, particularly for the urban poor?

6. How is cycling access and egress (e.g. through public bicycle schemes) improving levels of accessibility to jobs
CASE STUDY AHMEDABAD
CONCEPTUAL FRAMEWORK

Urban poor
- Income
- Education level

Physical condition of housing

Employment
- Location of jobs
- Job type

Transport
- Modes
- Networks
Not clear to me what the arrows imply
Brussel, 12/4/2012
INTEGRATED MULTI-MODAL PT NETWORK
CURRENT AND FUTURE PUBLIC TRANSPORT MODES

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MODELING THE PT TRIP SEQUENCE

Home -> Nearest suitable bus stop or transfer station and ticket purchase

NMT Access Trip (Walk or bike)

Waiting Time

Transfer

Boarding

Bus Line travel time

Is the final Destination reached?

Yes

No

Work

Egress Trip by Walking or Bike

Alighting
3D MULTI-MODAL TRANSPORT NETWORK
AHMEDABAD

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NETWORK IMPEDANCES
ALL MODES

<table>
<thead>
<tr>
<th>Mode</th>
<th>Speed km/h</th>
<th>Speed m/m</th>
<th>Access min.</th>
<th>Egress min.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walking</td>
<td>3.5</td>
<td>58.88</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Cycling</td>
<td>12</td>
<td>200</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>AMTS</td>
<td>15 - 20</td>
<td>250 - 333.33</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>BRTS</td>
<td>25</td>
<td>416.67</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>MRTS</td>
<td>35</td>
<td>583.33</td>
<td>3.75</td>
<td>2</td>
</tr>
</tbody>
</table>
LOCATIONS OF THE URBAN POOR AND THEIR JOBS
DENSITY OF POTENTIAL WORKERS
SLUMS AND CHAWLS COMBINED, WORKER DENSITY PER 0.25HA

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LOCATIONS OF EMPLOYMENT
ALL JOB SECTORS COMBINED, 100 X 100M. GRID

Job sectors:
- Industrial
- Retail
- Government
- Education
- Transport and logistics
- Office and commercial jobs
- All jobs combined (shown here)

Grouped as:
- Casual labour jobs
- Salaried jobs
- Self employment jobs

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LINKING POOR WORKERS AND JOBS
JOB ACCESSIBILITY BY POVERTY CLASS

Prioritized combinations (based on local knowledge – Ray (2010))

Urban poor
Least poor
Middle-poor
Very poor

Transport network

Employment
Salaried
Self employment
Casual labour

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Bit of a tricky slide that will probably lead to a lot of discussion/confusion. The one to one coupling of the different categories is of course a gross simplification. We might consider hiding this slide.

Brussel, 12/4/2012
SOCially & EconoMicalliWy WeakER SectiOn HOUSing (SEwSH)
On-GoIng PrOject Under JnNURM

- JnNURM, Basic Services to Urban Poor (BSUP) program
- The total number of buildings in this location is 976 and expected to relocate 78,080 poor.

- 21 locations are allocated for SEWSH.
- Used as a scenario

university of twente.
CONTOUR MEASURE – LOCATION 5
COUNTING JOB OPPORTUNITIES TO AND FROM SEWSH LOCATIONS

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This map is also confusing. It does not show job count, rather it only shows travel time contours form SEWSH locations. So maybe we should just call it like that.

Brussels, 12/4/2012
CONTOUR MEASURES
COUNTING JOB OPPORTUNITIES TO AND FROM SEWSH LOCATIONS

Looking at locations:
1, 13, 14, 15, 16

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CONTOUR MEASURES
COUNTING JOB OPPORTUNITIES TO AND FROM SEWSH LOCATIONS

Bars: walking (left), walking + AMTS (middle) and all modes (right)
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The potential of opportunities for interaction

\[
A_i = \sum_j W_j f(c_{ij}) = \sum_j W_j \exp(-\beta c_{ij})
\]

with \(W_j\) the number of jobs in location \(j\), \(c_{ij}\) the generalized cost of travelling between \(i\) and \(j\), and \(f(c_{ij})\) the distance decay function

- Distance decay function Ahmedabad (\(\beta=0.03838\)):
### Potential Measure

#### Legend

<table>
<thead>
<tr>
<th>Potential jobs for least-poor walking (per 4 Hect.)</th>
<th>AMTS+BRTS 1 [per 4 Hect.]</th>
<th>Formalised jobs [per 4 Hect.]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-10000</td>
<td>1-25000</td>
<td>0-250</td>
</tr>
<tr>
<td>10001-20000</td>
<td>25001-35000</td>
<td>251-300</td>
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<td>20001-30000</td>
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<td>3501-1000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5001-8000</td>
</tr>
</tbody>
</table>

#### Map Description

- **RRTS lines**
- **River**

The map illustrates the distribution of potential jobs for the least-poor walking and AMTS+BRTS, formalised jobs, and other relevant data. The legend provides a color key for interpreting the map.
Ratio of job-based potential accessibility for all potential workers comparing all public transport options with walking and AMTS only.
Overall the level of potential accessibility for the locations improves by 135% on average for the 21 locations.
KEY POLICY IMPLICATIONS

1. BRT systems can make a substantial contribution to accessibility of the urban poor provided that they form a network covering a large spatial extent. Individual corridors contribute only marginally.

2. Investing in cycling infrastructure to enable feeding to the BRT will enhance its potential and provides enormous gains in potential job accessibility for all poor sections of society.

3. In this way BRT systems are able to compete with regular bus systems that operate throughout the city. BRT becomes a viable alternative to link the poor’s home locations with their employment locations.

4. Integrating land use and transport planning offers clear benefits in reducing travel time and enhancing potential accessibility.
PROJECT TEAM
FOR AHMEDABAD (ONGOING) PROJECT

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Talat Munshi (CEPT University, Ahmedabad)
DISCUSSION

HOW CAN WE FURTHER DEVELOP AND IMPLEMENT INTEGRATED PT-NMT SYSTEMS IN BRAZILIAN CITIES?

Possible items for discussion:

• Which types of cities are suited to develop integrated PT-NMT systems
• What are the criteria required?
• Which type of integration are we after?
• What are the main obstacles?
• Which facilities are needed?
• How is the transport system as a whole changed?
• What is needed in terms of education, stakeholder involvement etc.?
THANK YOU FOR YOUR ATTENTION