A level-based approach to public transport network planning

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Reference:

Hermann Orth, Andrew Nash and Ulrich Weidmann

*A Level-based Approach to Public Transport Network Planning*

Presented at: US Transportation Research Board 2015 Annual Meeting (15-1171)
The Idea

Robert Cervero


Cervero describes Zurich’s approach of (1) making surface public transport faster and (2) building closely spaced regional rail stations in the centre city as a solution that eliminates the need for a rapid rail system.
So, what’s a level?
Level = f (mode, market characteristics)
## Characteristics

**Transport Mode**
- Speed
- Capacity
- Capital cost
- Operating cost
- Flexibility
- Reliability

**Travel Market**
- Distance (time)
- Cost
- Demographics
- Comfort
- Reliability
Characteristics

Transport Mode

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- Capacity
- Capital cost
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- Flexibility
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- Demographics
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*Speed influences all other characteristics.*
Speed = Trip length served “effectively”

... for passengers and operators.
Speed = f (right-of-way)

Exclusive = fast
Shared = slow
### Traditional Approach
### 3-level System

<table>
<thead>
<tr>
<th>Level</th>
<th>Cost</th>
<th>Speed</th>
<th>Stop Spacing</th>
<th>Network Density</th>
<th>Frequency</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface (Bus &amp; Tram)</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>O</td>
<td>-</td>
</tr>
<tr>
<td>Rapid Transit</td>
<td>-</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Regional Rail</td>
<td>O</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
</tbody>
</table>

*But, vehicle, infrastructure and services can be adjusted to serve “non traditional” markets.*
Infrastructure + Market Areas
3-level System

Surface Transit
Rapid Transit
Regional Rail
Two-Level Public Transport Network

- Regional rail station
- Regional rail line
- Area accessible within time budget by walking from rapid transit station
- Rapid transit line
- Area accessible within time budget by conventional surface public transport
- Area accessible within time budget by upgraded surface public transport

Limited additional benefit of a three-level network

Faster surface public transit.

Infrastructure + Market Areas

2-level System

More regional rail stations in center.

Limited added benefit of 3-level network
S-Bahn Zürich.
Die beste Verbindung zwischen Stadt und Land.
Other approaches
Tram-Trains: Trams on regional rail tracks (Karlsruhe approach)
Bus Rapid Transit: Provide level 2 service with level 1 infrastructure (Curitiba approach)
Move level 1 underground
Build level 2 and eliminate level 1 (German 1970s approach)
Functional Coverage Diagram: 3- vs. 2-level PT System

- **level 3**: Regional rail
- **level 2**: Rapid transit
- **level 1**: Surface public transport
- **"level 0"**: Non-motorized

Trip length served attractively
### Speed Comparison: 3- vs 2-level PT System

<table>
<thead>
<tr>
<th>Mode/Level</th>
<th>Speed [km/h]</th>
<th>Separate ROW</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vienna</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bus</td>
<td>1</td>
<td>17</td>
</tr>
<tr>
<td>Tram</td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>Rapid Transit</td>
<td>2</td>
<td>32</td>
</tr>
<tr>
<td>Regional Rail</td>
<td>3</td>
<td>45</td>
</tr>
<tr>
<td><strong>Boston</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bus</td>
<td>1</td>
<td>18</td>
</tr>
<tr>
<td>Light Rail</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>Rapid Transit</td>
<td>2</td>
<td>25</td>
</tr>
<tr>
<td>Regional Rail</td>
<td>3</td>
<td>50</td>
</tr>
<tr>
<td><strong>Zurich</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bus</td>
<td>H</td>
<td>18</td>
</tr>
<tr>
<td>Tram</td>
<td>H</td>
<td>15-20</td>
</tr>
<tr>
<td>Regional Rail</td>
<td>H</td>
<td>50</td>
</tr>
<tr>
<td><strong>San Francisco</strong></td>
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<td></td>
</tr>
<tr>
<td>Bus</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>Tram (Muni Metro)</td>
<td>H</td>
<td>15-27</td>
</tr>
<tr>
<td>Rapid Transit (BART)</td>
<td>H</td>
<td>56</td>
</tr>
<tr>
<td>Regional (Caltrain)</td>
<td>3</td>
<td>65</td>
</tr>
</tbody>
</table>
### Measures of Success: Zurich

**Passenger**
- Good coverage
- Relatively high speeds
- High frequency

**Operator**
- High farebox recovery
- Growing market share
Passenger demand vs population in Zurich
But now ... too many passengers!

Zurich’s system is operating above its effective capacity.

• High regional rail use for very short center city trips;
• Extreme crowding on regional rail within city;
• High crowding on city buses and trams.
Functional Coverage Diagram:
Impact of capacity problems on Zurich system

- Walking
- Cycling
- Bus
- Tram
- S-Bahn

- Loss in service speed due to increased traffic and crowding as capacity cannot keep up
- Regional rail rolling stock not suited for short trips when crowded
- Loss in service speed due to crowding and longer passenger exchange times
Over Capacity = Reduced Speed = Reduced Effectiveness

Without a dedicated medium-distance medium-speed service (rapid transit), capacity constraints on surface and regional rail levels become acute.
Traditional approaches for solving capacity problems
Larger vehicles with more doors (so large it doesn’t fit on the slide!)
Speed-up boarding
Off-board ticketing and Proof-of-payment
Level-based approaches for solving capacity problems
Solving capacity problems in Zurich’s 2-level system

**Surface**
- Longer stop spacing
- More priority
- “Metrotram” (LRT)

**Regional Rail**
- Differentiated service
  - Inner
  - Outer
Metrotram – larger vehicles & tunnels
Shift short trips from public transit to Level “0” – Biking and Walking
Prioritize the limited space available for transport in cities.
Slow Transit

Designed specifically to serve short trips.

Example: Line 100 – Circle Line Woensel
Municipality of Eindhoven
Bus route designed by and for seniors.

Source: http://www.muzus.nl/
Conclusions

• Public transport vehicle, infrastructure and services can be adjusted to serve “non traditional” markets.

• 2-level systems can be a flexible and very cost effective way to provide public transport service (no rapid transit system).

• 2-level systems could be especially attractive for medium-to-low density metropolitan areas (e.g., USA).

• Capacity is the Achilles Heel of 2-level systems, but there are many design strategies to overcome this limitation.

• Since 2-level systems use streets for bus and tram operations, they require clear priority setting for the use of street space.

• High quality pedestrian and bicycle systems reduce the demand for capacity on public transport and are increasingly being considered as alternatives to PT expansion projects.
Andrew Nash helps clients design and manage innovative public transport, railway, urban planning and active transport projects. Current work includes greencitystreets.com (using information technology for better public participation), open source railway dispatching applications, public transport planning and active transport projects. See andynash.com for details and contact information.