The Transit Metropolis

A GLOBAL INQUIRY

2009 Lecture
PROYECTO DE TRANSPORTE URBANO DE BUENOS AIRES (PTUBA)

Robert Cervero

Propelled by: (1) Rising Incomes; (2) IT; (3) Push Factors (Congestion)

Shanghai, São Paulo, Mexico City, Jakarta.
**Transport Sector Energy Use per capita plummets with Density**

Elasticity = -.822

*Source: UITP (50 Global Cities)*

**Density Matters**

**ATTP = Annual Transit Trips Per Capita**

- **Spreading/Polycentric: Berlin** (4.2 million people)
  - ATTP = 310

- **Compact/Linear: Mumbai** (9.8 million people)
  - ATTP = 530

- **Compact/Concentric: Moscow** (8.5 million people)
  - ATTP = 490

- **Compact/Polycentric: Hong Kong** (5.4 million people)
  - ATTP = 720
Linear Densities: Organization & Planning Also Matter!

Smart Growth = Being Resourceful

Or...135 Cars with 3 Trams
Supply-side Responses & Technological Fixes Don't Work

U.S. “induced demand” experiences: 80% of new road capacity gets consumed within 3-5 years

Contrasting Models of Transit & Development

• TOD (Transit Oriented Development): built forms conducive to transit riding & alternative modes

• DOT (Development Oriented Transit): adapting transit & mobility options to the lay of the land (usually low-density, car-based development patterns)
The Transit Metropolis: A Global Inquiry

- **Premise:** Transit Metropolises enjoy a “glove-on-hand” fit between their settlement patterns and transit services/technologies

- **Key:** Visions of the Metropolis shapes Transport, not vice-versa
**Annual Transit Trips/ Capita 1998-2001**

<table>
<thead>
<tr>
<th>City</th>
<th>Annual Transit Trips/Capita 1998-2001</th>
</tr>
</thead>
<tbody>
<tr>
<td>Karlsruhe</td>
<td>280</td>
</tr>
<tr>
<td>Bogota</td>
<td>360</td>
</tr>
<tr>
<td>Curitiba</td>
<td>390</td>
</tr>
<tr>
<td>Munich</td>
<td>420</td>
</tr>
<tr>
<td>Singapore</td>
<td>492</td>
</tr>
<tr>
<td>Stockholm</td>
<td>540</td>
</tr>
<tr>
<td>Zurich</td>
<td>660</td>
</tr>
<tr>
<td>Hong Kong</td>
<td>725</td>
</tr>
</tbody>
</table>

**Annual Public Transit Trips per Capita**

**Case:** Stockholm, Sweden

**Transit-Oriented Corridors in a Land of Volvos and Saabs**
Stockholm: Targeted Regional Growth

“Necklace of Pearls” Model

Evolution of a Transit Metropolis: Regional Growth Guided by Rail

- Jobs-Housing balance along corridors
- 55%/45% directional splits

Source: City of Stockholm, Development of Stockholm, 1989
Vällingby: *Urban Design Features*

- Car-free center
- Accent on Livability
- Human-Scale
- Compact & Diverse
- Child-care Centers

Public Spaces
Art & Amenities
Station as Centerpiece & Gateway

*Intermodalism & Access > 1 KM*

Connecting to the Town Center
Los Angeles

Stockholm

<table>
<thead>
<tr>
<th>Category</th>
<th>Los Angeles</th>
<th>Stockholm</th>
</tr>
</thead>
<tbody>
<tr>
<td>VKT (000s)/capita/year</td>
<td>20.4</td>
<td>8.5</td>
</tr>
<tr>
<td>% Person Trips: Walk/Bike</td>
<td>4</td>
<td>27</td>
</tr>
<tr>
<td>Ped. Fatalities/100K Pop.</td>
<td>18</td>
<td>3</td>
</tr>
<tr>
<td>Workdays Lost to Pollution/Pers.</td>
<td>0.5</td>
<td>5</td>
</tr>
</tbody>
</table>
Stockholm’s City Plan for 2020 Science City (Greenfield) & Urban Regeneration (Brownfield)

- Kista Science City
- Lindhagen City

Today

- Hammarby Sea City

2010 plan

- Inner-Ring Interconnected by Fast Trams

Before Development

- Hammarby Sjöstad
- Lindhagen

After Development

- Green TOD as Brownfield Transformation
- Road Pricing
Hammarby Sjöstad: an Eco-Community

- Residents produce 50 percent of the power they need — by turning recycled wastewater and domestic waste into heating, cooling and electricity.
- Waste treatment: all garbage is separated and much of it goes to produce energy.

GREEN URBANISM: Self-Sufficient/Zero Waste

- Biogas production from waste
- Power generation from trash
- Installed photovoltaic arrays
- Solar hot water tubes
- Centralized vacuum tube recycling collection
- Storm water remediation

- Green roofs
- Brownfield cleanup
- Community betterment campaigns
- Public environmental education
Green TOD
A Marriage of TOD & Green Urbanism

TOD Mobile Sources
• Design
  World-class transit (trunk & distribution)
  Station as hub
• Reduced VKT (30%-50% ridership bonus)
• Non-motorized access (bikepaths, pedestrian ways)
• Bikesharing/Carsharing
• Minimal Parking
  (reduced land consumption, building massing & impervious surfaces)

Green Urbanism Stationary Sources
• Energy self-sufficient (renewably powered - solar, wind turbines)
• Zero-waste (recycle; re-use; methane digesters; rainwater collection for irrigation & gray-water use)
• Community gardens (compost, canopies, food security)
• Buildings: Green Roofs, Orientation (optimal temperatures), Materials (recycled; low impact)

Case: Tokyo, Japan
Profiteering through Bundling Transit and New Town Development
METRO TOKYO: Entrepreneurial Transit

Greater Tokyo (23 Ward Area)
- ~30 million population; 20% of Japan’s pop. on 0.6% of land
Growth pattern of Tokyo

Japanese Suburban Retail Center

% increase in land values

Distance (km) from Station

New Residential Towns
New Railway Line

Terminal

Residential

CBD
Rates of Return by Railway Corporations in Metro Tokyo, 1980-1996

- Real Estate: 53.4%
- Rail Services: 15.9%
- Retail: 5.4%
- Bus Services: -3.5%

Return on Investment, %, 16 Years
Case: Hong Kong

The Entrepreneurial Transit Metropolis

“R+P” (Rail + Property) Projects in Hong Kong

MTRC’s property developments along rail line
MTR: Revenue Sources

Tung Chung Station
Kai Tak Station

*2001-2005 Average
SYNERGY
R+P + Ped-Friendly Designs = Ridership Bonus

- VKT per resident 23% below City Average
- Land Value premium for ped-friendly TOD designs
If the Modal Share of Travel in China eventually mimics the US, by 2030 there will be twice as many Cars in China as there are in the whole world today.

**Green TOD: Sustainable Living**

Design self-sufficient, "zero waste" neighborhoods.
Case: Singapore

Getting the Prices Right

TOD “empowered” by TDM
(Transportation Demand Management)

Singapore:
The Constellation Plan
Getting the Prices Right
Singapore’s Three-Tier Model

- **Fixed-Fees:** vehicle taxes & surcharges.
  - import duties; registration fee + add-on; quota system; island entry/exit fee; fuel topping tax (leave > ¾ tank; return < ½ tank)

- **Use-Related Fees:** fuel taxes; parking surcharges

- **Externality Fees:** congestion tolls; annual road tax (by engine cc);

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**Singapore: Electronic Road Pricing (ERP)**

725 Hectare ERP Zone:

1st year:
- Traffic down 24%
- Avg. Peak Hour Speed: 32 → 42 kph
Singapore: Respectable Alternative to Car

Singapore: Extended TOD – the “Last Mile”
Problem: Bukit Panjang; Sengkang New Towns
All housing within 400m of LRT; feeds into MRT
Case: Munich, Germany

Integrated Transit: Institutional, Tariffs, and Designs

Integration on Multiple Fronts

Blanketing the City With Public Transport
• **Unified fares; coordinated schedule** for 5500 km² area; 2.5 million population; matches commutershed

• **Executive Board:** sets regional service & fare policy; approves budget for capital investments; pools income and re-allocates resources (based on VKm) to ensure minimum service levels are met; rewards efficiency

• **Management Board:** does route & service planning
Case: Zurich, Switzerland
Rewarding Sustainable Mobility

Zurich: Transit First
Signal prioritization
- Trams/ buses have priority >90% of 280 controlled intersections
- Signal transmitters in vehicles; >3000 induction loops; systemwide cost = ½ km of Metrorail tunnel

1985-1995: Waiting times for trams & buses fell by an average of 38%
Fare Innovations

- Regenbogenkarte
- Kombiticket
- Deep discounted youth fares
- Self-Service: 800 automated ticket machines

TOD, Car-free living, Car-sharing
Development Oriented Transit (DOT)/
Adaptive Transit : Australia

- **Exclusivity:** physical segregation
- **Seamless Transfers**
- **Advanced Bus Technology:** clean fuels, light-weight materials, low floors, advanced communications, docking systems
- **Supportive Armature:** signal priorities, bus turnouts, curb realignments, AVL, automated routing & dispatching
- **Expeditious Fare Collection & Boarding:** off-vehicle payment, smart cards
Case: Curitiba, Ottawa, Bogota

Bus Transit Metropolises

Ottawa, Canada

From Concept to Plan
**Ottawa Transitway**

- Mainline
- Feeder

Same-vehicle Connectivity: eliminate the transfer

**Land Use Management**
- 40% of jobs to be within 400 m of Transitway
- Preference to commercial trip generators
- Large regional shopping (>375,000 ft²) must be within 400m of Transitway

**Supportive Initiatives**
- Real-Time Passenger Information System
- Integrated Fares/ Deep Discounts for frequent riders (Ecopass)
- Commercial-rate downtown parking
- Walkable urban core
- BRT Enhancements
### Ridership Productivity: Passengers per Guideway Mile, 1st Year of Operations

<table>
<thead>
<tr>
<th>City</th>
<th>Ridership</th>
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<tbody>
<tr>
<td>Ottawa</td>
<td>16,000</td>
</tr>
<tr>
<td>Pittsburgh</td>
<td>15,000</td>
</tr>
<tr>
<td>Edmonton</td>
<td>13,900</td>
</tr>
<tr>
<td>Boston</td>
<td>13,754</td>
</tr>
<tr>
<td>Calgary</td>
<td>2,143</td>
</tr>
<tr>
<td>Portland</td>
<td>7,293</td>
</tr>
<tr>
<td>San Diego</td>
<td>1,275</td>
</tr>
<tr>
<td>Pittsburgh</td>
<td>1,244</td>
</tr>
<tr>
<td>Sacramento</td>
<td>874</td>
</tr>
<tr>
<td>San Jose</td>
<td>534</td>
</tr>
<tr>
<td>Buffalo</td>
<td>469</td>
</tr>
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</table>

### Curitiba: Cities for People

- **LINEAL GROWTH**
- **Trinary: High Rise Mixed Use Corridors**
Terminal de Integração

<table>
<thead>
<tr>
<th>Tipo de Linha</th>
<th>Capacidade</th>
<th>Nº de Linhas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circular Contorno</td>
<td>30</td>
<td>09</td>
</tr>
<tr>
<td>Caminhonel / Micro Especial</td>
<td>40579</td>
<td>19</td>
</tr>
<tr>
<td>Convencional / Trolez</td>
<td>80</td>
<td>30</td>
</tr>
<tr>
<td>Trinco Articulado</td>
<td>160</td>
<td>24</td>
</tr>
<tr>
<td>Alimentador / Micro Especial</td>
<td>40579</td>
<td>638</td>
</tr>
<tr>
<td>Articulado</td>
<td>160</td>
<td>74</td>
</tr>
<tr>
<td>Interbusos Padrão</td>
<td>110</td>
<td>33</td>
</tr>
<tr>
<td>Interbusos Articulado</td>
<td>140</td>
<td>99</td>
</tr>
<tr>
<td>Linha Direta</td>
<td>110</td>
<td>378</td>
</tr>
<tr>
<td>Expreso Articulado</td>
<td>270</td>
<td>162</td>
</tr>
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</table>
Average distance per person to the CBD related to size of the built-up area.

Average Distance per Person to CBD, City Built-up Area and Dispersion Index

San Francisco Bay
Chicago
Cincinnati
Discount index = 1

Dispersion index = 0.75

Average Brasilia resident lives 3 times farther from center than average Curitibano

<table>
<thead>
<tr>
<th></th>
<th>Curitiba</th>
<th>Brasilia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Persons/km²</td>
<td>3,470</td>
<td>420</td>
</tr>
<tr>
<td>Transit trips/capita/year</td>
<td>355</td>
<td>97</td>
</tr>
<tr>
<td>VKT/capita/year</td>
<td>7,900</td>
<td>16,700</td>
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</table>
Following Curitiba’s Footsteps

Performance Measures
- 45,000 pax/lane/direction/hr
- 1st year: > 700,000 pax/day
- 32% in travel times
- 98% pax acceptance level

Bogotá

São Paulo

1995

2001

Bogotá’s Transmilenio
3 lanes for mixed traffic
Bogota’s Green Connectors:
Transportation Demand Management

- Auto-Restrains/Safe Pedestrian Corridors

CAR-FREE SUNDAYS

Horario Pico y Placa
7:00 a 9:00 a.m.
5:30 a 7:30 p.m.

1 2 3 4 Monday
5 6 7 8 Tuesday
9 0 1 2 Wednesday
3 4 5 6 Thursday
7 8 9 0 Friday

Before

After

Informal Housing in Bogotá

- ½ households live below poverty level
- 22% of the population live in informal housing; 18% of land area.
- Average daily commute time for residents of Bogotá’s informal housing > 2 ½ hours

EXPERIENCIA RECENTE DE PLANEACIÓN EN BOGOTÁ

ASIENTAMIENTOS DE ORIGEN ILEGAL
BOGOTA - 2001

INFORMAL SETTLEMENTS
Metrovivienda

“Killing 2 Birds with 1 Stone”: Affordable & Improved Transport & Housing

To date, little TOD tied to Transmílineo – a Uni-sector Mobility Project
- **Bogota’s Green Connectors (70% BRT access by NMT)**
- **Cicloruta (1990 onward):** 291 kms (today); plan for > 600 kms by 2020

**Ciclovias: Sunday exclusive bike-lanes (since 1976)**
Recycling Urban Space

• Parks: San Victorino (Urban Renewal)

Before

After

SAN VICTORINO SQUARE

JIMENEZ AVENUE

RENAZIMIENTO P. SIDEWALK
Mockus Administration: Civilities on the Road

Sober Reminders
**Social experiments**

- ‘Pico y Placa’ (daily car restriction)
- Day without private cars (once a year)
- All night pedestrian lanes (once a year)
- ‘Carrot hour’ / (daily alcohol control)
- Only women night
- Voluntary disarmament

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**“Software Policy”: Transportation Demand Management**

- **Auto-Restraints/Safe Pedestrian Corridors**

  **CAR-FREE SUNDAYS**

  Horario Pico y Placa
  7:00 a 9:00 a.m.
  5:30 a 7:30 p.m.

  1 2 3 4  Monday
  5 6 7 8  Tuesday
  9 0 1 2  Wednesday
  3 4 5 6  Thursday
  7 8 9 0  Friday

  Before
  After
Happiness & Social Equality

*“... our goal is not to generate as much income as possible, but to generate as much happiness as possible ...”*

*“... on the sidewalks or the bike lanes you can find the president of the company and the cleaning lady encounter as equals; there is not hierarchy there ...”*

E. Peñalosa

Multi-modal Corridors promote Alternative Transport

Bikepaths/ Pedways in Greenfields promote Non-Auto-Dependent Development Patterns
Bikeways in Advance of Development: *Imprinting Travel Behavior?*
**International Context/Competitiveness**

- Based on:
  - Cost of life
  - Criminality rate
  - Internet availability
  - Cost of mailing FedEx
  - Time of creation of businesses/enterprises

<table>
<thead>
<tr>
<th>CIUDADES</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
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<tbody>
<tr>
<td>MIAMI</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>SÃO PAULO</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>BUENOS AIRES</td>
<td>3</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>SANTIAGO</td>
<td>4</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>MONTREAL</td>
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<td>7</td>
<td>8</td>
</tr>
<tr>
<td>CIUDAD DE MÉXICO</td>
<td>6</td>
<td>8</td>
<td>9</td>
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<tr>
<td>CURITIBA</td>
<td>7</td>
<td>9</td>
<td>10</td>
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<tr>
<td>BELO HORIZONTE</td>
<td>8</td>
<td>10</td>
<td>11</td>
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<tr>
<td>RIO DE JANEIRO</td>
<td>9</td>
<td>11</td>
<td>12</td>
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<tr>
<td>BRASILIA</td>
<td>10</td>
<td>12</td>
<td>13</td>
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<tr>
<td>MÉXICO CITY</td>
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<td>TEGUCIGALPA</td>
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<td>SAN JOSE</td>
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<td>PUEBLA</td>
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<td>CIUDAD JUÁREZ</td>
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<tr>
<td>SALVADOR</td>
<td>19</td>
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</tr>
<tr>
<td>ROSARIO</td>
<td>20</td>
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**Political campaign: 2003**

- Bogotá sigue adelante
- Juan Lozano
- Alcalde

2007 Mayor:
- Samuel Rojas – major public works
- Project – Metro
Case: Seoul, Korea

BRT, Freeway Removal, and Urban Regeneration

Seoul, Korea: Poor quality of bus in 60-70’s

200 passengers on a bus (60–70 limit)
Response: Created Bus Priority Lane

**Bus Lanes (2005):**
- Exclusive median bus lanes: 7 lines/ 84 km
- Curbside bus lanes: 293.6 km

**Achievement : Median Bus Lane**
- **Increase of speed for both bus and passenger-car**
  10 km/h to over 20 km/h
- **Higher passenger loads**
  6 times more passengers than other lanes
- **Less travel time variation**
  5 times less than other bus lanes

- Transfer terminal
- Attractive street furniture
Seoul, Korea: Reclaiming Urban Space

Redesign of Seoul Plaza
“Calmed” Traffic with a Pedestrian Oval

Before: 2003
After: 2005

Cheong Gye Cheon
Freeway Removal/Stream Restoration

Seoul: Freeway Removal-Stream Restoration
Cheong Gye Cheon

June 2003 Before Restoration
June 2004 Under Restoration
September 2005 After Restoration
Greening of Central Seoul

Thermal Intensity in CBD

Temperature down by Average lowering 2% ~ 5%

Marginal Effects of Freeway vs Greenway on Commercial Land Price
Impact on Employment in “Creative Class” Sectors
Distance to Ramps or Pedestrian Entrances

- Marginal Effects on Location Quotients

![Graph showing the impact on employment in “Creative Class” sectors with distance to ramps or pedestrian entrances.]

Case: Karlsruhe, Germany
Adaptive Transit Through Dual-Mode Technologies
Tram-Trains

* 10 % Probability Level
Karlsruhe, Germany
Tram-Train/Track-Sharing

Same Vehicle Integration
Line-Haul & Distribution

VERSATILE EQUIPMENT

In-City Operations: 750 DC

Suburban/Exurban Operations: 15K AC

Vehicles: Acceptable “passive safety”
but Great “active safety”
**System Design**

- **Track-Sharing:** Same-Vehicle integration of line-haul & feeder functions

![Diagram showing Residential Collection, Line-Haul, and Destination Distribution]

- Quality key in image-conscious Germany (30% "rail bonus")

- **Design Principles:**
  - Dual-System Vehicles
  - Junctions
  - Improved Access/New Stops

**Access Spurs**

**Direct Connections**

![Diagram showing access spurs and direct connections]
Karlsruhe: The Pay-off

- Transit ridership doubled from mid-1980s to mid-1990s; market share increased while falling most elsewhere in Germany

Lessons I

- Visioning
- Visionaries
  - Jaime Lerner Curitiba
  - Enrique Penalosa Bogotá
- Efficient Institutions and Governance
- Pro-active Planning & Urban Management
- Balanced Growth & Flows
Lessons II

- **Competition/Entrepreneurialism**
- **Prioritization to Transit**
- "**Small is Beautiful**"
- **Urban Design: Cities for People**
- **Adaptive & Transitional**

Think Regionally,
Act Locally!

- Transit-Oriented Developments (TODs) are not islands
- TODs must be planned & designed as part of a larger regional system...to build a critical mass that effectively competes with private cars.