Bus and Rail Corridor Service Options

Outline
- Corridor Objectives and Strategies
- Express
- Local
- Limited Stop Overlay on Local Service
- Deadhead
- Metro Rail in Santiago, Chile


Strategies

- Express Service
  - Downtown orientation
  - Zonal Express
  - Limited Stops on Express Segment
- Local Service
  - Short Turns/Lines
  - Restricted Zonal
  - Semi-Restricted Zonal
  - Limited Stop Zonal
- Light Direction Strategies
  - Complete Deadheading
  - Partial Deadheading

Corridor Design Objectives

- Design Objectives
  - To reduce cost for providing existing level of service, or
  - To improve the level of service without increasing resources on existing, longer high-frequency corridors
- Operational Objectives
  - Increase the operating speed
  - Reduce the vehicle miles of service
  - Reduce unnecessary slack time at terminals
  - Maintain high, uniform vehicle loadings on all segments
- Issues
  - Service Quality Impacts
    - Changes in wait time, walk distance, and need to transfer
  - Ridership Changes
    - What ridership changes will result from level of service impacts?

Local and Express Service: Local

<table>
<thead>
<tr>
<th>SCHEDULE  Route 1</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>CBD</th>
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</table>
Local and Express Service: Express

SUBURBS

A B

C D E

CBD

Zonal Express Service

SUBURBS

A

B

Non-stop express

C D

CBD

Local and Express Service: Express

SUBURBS

A

B

C

D

E

CBD

Issues In Designing Express Services

- Downtown Routing
  - Minimize time on local streets
- Adding Stops to Express Portions
  - Minimize impact on capacity and running time
- Reverse Commuting
  - Maximize potential for reverse commuting traffic
- Fares
  - What fare premium is appropriate?
- Local Service Interaction
  - Is parallel local service viable?
  - Is express time advantage and frequency sufficient to attract (almost) all downtown riders?

Zonal Express Service Zonal Express Service in the Sheridan Road corridor (simplified)

Local Service

80 buses
### Zonal Express Service in the Sheridan Road corridor (simplified)

- **Conventional Express Service**: 72 buses
- **Zonal Express Service**: 47 buses

#### Schedule - Inbound

<table>
<thead>
<tr>
<th>Time</th>
<th>A</th>
<th>B</th>
<th>C</th>
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### Short-Turning Local Service

#### Schedule - Inbound

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<td>7:47</td>
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</tbody>
</table>

### Restricted Zonal Local Service

#### Schedule - Route 1

<table>
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<tr>
<th>Time</th>
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<th>B</th>
<th>C</th>
<th>D</th>
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<tr>
<td>7:00</td>
<td>7:08</td>
<td>(7:15)*</td>
<td>(7:24)</td>
<td>(7:30)</td>
<td>7:42</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7:15</td>
<td>7:23</td>
<td>(7:30)</td>
<td>(7:39)</td>
<td>(7:45)</td>
<td>7:57</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7:30</td>
<td>7:38</td>
<td>(7:45)</td>
<td>(7:54)</td>
<td>(8:00)</td>
<td>8:12</td>
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<td></td>
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</table>

#### Schedule - Route 2

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<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>CBD</th>
</tr>
</thead>
<tbody>
<tr>
<td>7:10</td>
<td>7:20</td>
<td>(7:27)*</td>
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<td>7:39</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7:22</td>
<td>7:32</td>
<td>(7:39)</td>
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<td></td>
<td>7:51</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7:34</td>
<td>7:44</td>
<td>(7:51)</td>
<td></td>
<td></td>
<td>8:03</td>
<td></td>
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### Restricted Zonal Local Service

#### Schedule - Route 3

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<th>C</th>
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<td></td>
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<td>7:35</td>
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<td>7:49</td>
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<tr>
<td>7:45</td>
<td></td>
<td>8:59</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Inbound buses do not stop except to let passengers alight; boarding prohibited.
Outbound buses do not stop except to let passengers board; alighting prohibited.
Wilshire Boulevard Corridor

Santa Monica
Beverly Hills
Los Angeles CBD

Local Service
Limited Stop Service

Route 308

Routes 20, 21, 22

Semi-Restricted Zonal Local Service (Inbound only)

- Buses stop only to allow passengers to alight; once stopped, waiting passengers may board.

SCHEDULE - Inbound

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
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<tr>
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<td>7:08</td>
<td>(7:15)*</td>
<td>(7:24)</td>
<td>(7:30)*</td>
<td>7:42 Route 1</td>
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<tr>
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<td>7:20</td>
<td>(7:27)*</td>
<td>7:39 Route 2</td>
<td></td>
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</tr>
<tr>
<td>7:25</td>
<td>7:39 Route 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>7:15</td>
<td>7:23</td>
<td>(7:30)*</td>
<td>(7:39)*</td>
<td>(7:45)*</td>
<td>7:57 Route 1</td>
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<td>7:32</td>
<td>(7:39)*</td>
<td>7:51 Route 2</td>
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</tr>
<tr>
<td>7:35</td>
<td>7:49 Route 3</td>
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<tr>
<td>7:45</td>
<td>8:59 Route 3</td>
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<td>7:30</td>
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<td>(7:54)</td>
<td>(8:00)*</td>
<td>8:12 Route 1</td>
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<td>7:44</td>
<td>(7:51)*</td>
<td>8:03 Route 2</td>
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<td></td>
</tr>
<tr>
<td>7:55</td>
<td>8:09 Route 3</td>
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Limited Stop Zonal Local Service (Inbound only)

- Designated Stops

SCHEDULE - Inbound

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<th>C</th>
<th>D</th>
<th>E</th>
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<th>G</th>
<th>H</th>
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<td>7:12</td>
<td>---</td>
<td>7:19</td>
<td>---</td>
<td>7:26</td>
<td>---</td>
<td>7:33</td>
<td>---</td>
<td>7:40 Route 1</td>
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<td>7:17</td>
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<td>7:31</td>
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<td>7:38</td>
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<td>7:45 Route 2</td>
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<tr>
<td>7:30</td>
<td>7:35</td>
<td>7:40</td>
<td>7:45</td>
<td>7:50 Route 3</td>
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<td></td>
<td></td>
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<tr>
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<td>7:27</td>
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<td>7:34</td>
<td>---</td>
<td>7:41</td>
<td>---</td>
<td>7:48</td>
<td>---</td>
<td>7:55 Route 1</td>
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<td>7:28</td>
<td>7:32</td>
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<td>7:46</td>
<td>---</td>
<td>7:53</td>
<td>---</td>
<td>8:00 Route 2</td>
<td></td>
</tr>
<tr>
<td>7:45</td>
<td>7:50</td>
<td>7:55</td>
<td>8:00</td>
<td>8:05 Route 3</td>
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Limited Stop Overlay on Local Service: Research Objectives

- Establish guidelines for the addition of limited-stop service
- Create a procedure and model for evaluation and design
- Apply the model to CTA case studies


Key Elements of Limited-Stop Service Design

- Stop Reduction
- Running Time Savings
  - Dwell times
  - Traffic and traffic signal delay
- Frequency split
- Resources: neutral or increased?

Model Overview

- Model Assumptions
  - Demand is fixed (or adjusted using frequency elasticity model)
  - Local Stop Spacing is fixed
  - Total Dwell Time for the route does not change based on the stop spacing, frequency configuration, or boardings
    - Scorfia’s update relaxes these assumptions and assigns demand probabilistically.
- Makes use of AVL and APC data to determine running times and the O-D demand matrix
- Evaluates a specific user defined stop spacing and headway configuration
- Calculates travel time components for each O-D pair

CTA Limited-Stop Routes

- 3/X3, 4/X4, 49/X49, 55/X55, 80/X80, 9/X9, 54A/54B/X54
- Average Route Length: ~8 miles; range: 7.5 to 16 miles
- Stop Reduction: 60-70% of existing stops
- Run Time reductions range from 13-26%
- Frequency split: 50-60% local service initially; based on MIT research, changed to 60-67% express, maintaining at least 15-minute headway on local service

Assignment

- Stop Choice (can be modeled based on user surveys or smart card home address information)
- Route Choice (at combined stops only)
- Local captive, choice, and limited-stop only riders
- Based on minimum weighted travel time
  - Access Time=3, Wait Time=2, In Vehicle Time=1
  (Loosely based on the Chicago Area Transportation Study)

Calculates evaluation measures

- Net passenger minutes of total travel time, number of limited-stop only riders
Findings

- Success of limited-stop service depends on
  - Running time savings
  - Frequency split between local and limited-stop service
  - Demand pattern: trip end concentration and trip length
  - Large number of limited-stop-only or choice riders
- Eliminating stops affects access time: the number of limited-stop only riders decreases as stop spacing increases
- Eliminating stops on CTA routes has had moderate impacts (13-26%) on running times
- Potential Strategy for Limited-Stop Service
  - Increase stop spacing while maintaining low frequency service on the local

Key Factors in Determining the Potential Benefit of Route Redesign of a Corridor

<table>
<thead>
<tr>
<th>Overall Trunk Frequency</th>
<th>Short-Turn</th>
<th>Restricted Zonal</th>
<th>Semi-Restricted Zonal</th>
<th>Limited-Stop Zonal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below 1.7 (f_{\text{min}})^*</td>
<td>valuable in AM</td>
<td>none</td>
<td>none</td>
<td>unnecessary in AM</td>
</tr>
<tr>
<td>1.7 (f_{\text{min}}) - 2.0 (f_{\text{min}})</td>
<td>vital in PM</td>
<td>none</td>
<td>none</td>
<td>valuable in PM</td>
</tr>
<tr>
<td>2 (f_{\text{min}}) - 4 (f_{\text{min}})</td>
<td>none</td>
<td>strong</td>
<td>moderate</td>
<td>strong</td>
</tr>
<tr>
<td>Above 4 (f_{\text{min}})</td>
<td>none</td>
<td>considerable</td>
<td>moderate</td>
<td>considerable</td>
</tr>
</tbody>
</table>

Corridor Length

- Below 2 miles: NOT A CANDIDATE FOR REDESIGN
- 2-4 miles: MILD POTENTIAL
- 4-6 miles: CONSIDERABLE POTENTIAL
- 6-8 miles: HIGH POTENTIAL
- Above 8 miles: POTENTIAL

*\(f_{\text{min}}\) = minimum acceptable frequency for a peak period radial route

Deadheading Strategies

Strategies

- Deadhead all vehicles on route:
  - Possible with one (or more) routes of short turn or zonal route system
- Deadhead some vehicles on route
  - Deadhead every other bus (or 2 out of every 3) with remainder in service

Issues

- Can a vehicle be saved by deadheading?
- Will there be adverse public reaction?
  - easier if by different route

General Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Short-Turn</th>
<th>Restricted Zonal</th>
<th>Semi-Restricted Zonal</th>
<th>Limited-Stop Zonal</th>
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</thead>
<tbody>
<tr>
<td>Need for schedule coordination and strict adherence</td>
<td>valuable in AM</td>
<td>none</td>
<td>none</td>
<td>unnecessary in AM</td>
</tr>
<tr>
<td>Reliance on overtaking</td>
<td>none</td>
<td>strong</td>
<td>moderate</td>
<td>strong</td>
</tr>
<tr>
<td>wait time</td>
<td>higher in outer part lower in inner</td>
<td>higher</td>
<td>higher in outer part lower in inner</td>
<td>higher in outer part lower in inner (key stops)</td>
</tr>
<tr>
<td>in-vehicle time reduction</td>
<td>none</td>
<td>considerable</td>
<td>moderate</td>
<td>considerable</td>
</tr>
<tr>
<td>typical walk distance impact to peak direction travelers</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>up by 0.2 mi. for some passengers</td>
</tr>
<tr>
<td>difficulty in public comprehension</td>
<td>little</td>
<td>greatest</td>
<td>considerable</td>
<td>moderate</td>
</tr>
<tr>
<td>ideal corridor length</td>
<td>short</td>
<td>long</td>
<td>medium-long</td>
<td>long</td>
</tr>
<tr>
<td>fraction of local (non-CBD) travel</td>
<td>moderate to high</td>
<td>small</td>
<td>moderate</td>
<td>moderate to high</td>
</tr>
<tr>
<td>outer segment volume</td>
<td>low</td>
<td>low</td>
<td>low</td>
<td>any</td>
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Strategies Best Suited to Different Ratios of Peak Volume to Uptown Boardings

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<th>25</th>
<th>50</th>
<th>75</th>
<th>100%</th>
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<td>Restricted zonal</td>
<td></td>
<td></td>
<td>60</td>
<td>80</td>
</tr>
<tr>
<td>Semi-Restricted zonal</td>
<td>40</td>
<td>60</td>
<td>85</td>
<td>100%</td>
</tr>
<tr>
<td>Limited-Stop zonal</td>
<td>30</td>
<td>40</td>
<td>80</td>
<td>90%</td>
</tr>
<tr>
<td>Overlapping zonal</td>
<td>25</td>
<td>50</td>
<td>80%</td>
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</tr>
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</table>

Legend:
- range in which strategy can be effectively operated
- range in which strategy is likely to be most promising

1 For inbound direction. When the peak direction is outbound, use the ratio of peak volume to uptown alightings (PV/UA). The same figures apply.
2 Can be operated inbound only.

Can this happen in Metro too?

Diagnostic
- Passenger Congestion (boarding and alighting)
- Vehicle Congestion (entering stops)
- Bunching affecting waiting times
- Unreliability affecting passengers
- Unreliability affecting operators
- Crowdedness

Opportunity for improving the level of service significantly in a cost-effective way.

Metro of Santiago, March 2007

What can we do cost-efficiently?
Capacity needs to be increased.

Skip-Stop Operation

Objectives
- Decrease running times
- Increase frequency at key stations
- Minimize required transfers
  - Analyze the OD matrix

Constraints
- Tracks prevent overtaking
- ATO/ATP enables skipping stops safely and quickly
Skip-Stop Operation: Results

- Increased frequency by 2 trains per hour
- Decreased operations cost by skipping stations
  - decreased electric energy consumption due to less frequent acceleration
  - decreased braking (less mechanical wear)

<table>
<thead>
<tr>
<th></th>
<th>kW hr / year</th>
<th>USD / year</th>
<th>Percent</th>
</tr>
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<td>Line 2</td>
<td>3,352,654</td>
<td>351,568</td>
<td>6</td>
</tr>
<tr>
<td>Line 4</td>
<td>1,640,000</td>
<td>171,936</td>
<td>4</td>
</tr>
<tr>
<td>Line 5</td>
<td>2,420,000</td>
<td>253,699</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>7,412,654</td>
<td>777,203</td>
<td>5</td>
</tr>
</tbody>
</table>

- Decreased running time
  - 44 to 36 minutes in Line 4
  - 26 to 24 minutes in Line 5

- Improved ride comfort
- Improved perception of service quality
  - 59% believe their trips are faster
  - 71% have a favorable view of the scheme

Adapted from slides by Prof. J.C. Muñoz (PUC)
1.258J / 11.541J Public Transportation Systems
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