Profiling the spatial relationship of land use & ridership on transit corridors using 3D GIS

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Introduction: Spatial analysis for transit supportive land-use

- Population thresholds for FTN?
- Employment to support Frequent Transit?
- Densities to grant frequent transit?
- Do these corridors qualify for FTN?
- When is this bus coming every 10 minutes?
Introduction: Required Indicators & thresholds for FTN Corridors

Land Use

| Qualitative Considerations (e.g. Design) | Quantitative Indicators (e.g. Density) |

Guidance to Municipalities Only

Transit Performance

| Qualitative Considerations | Quantitative Indicators (Absolute Demand) (Demand Distribution) |

For consideration in FTN qualification process
Introduction: Factors Influencing Transit Ridership

**Transit Supply**
- Transit Service
  - Speed & Frequency
  - Reliability
  - Coverage
  - Comfort

**Relative Cost of Other Modes**
- Policy Context
- TDM
- Market Forces

**Transit Demand**
- Socio-Demographic
  - Preferences
  - Attitudes
  - Demographics

**Built Environment**
- Land Use
- Urban Design
- Infrastructure
Research Framework: Purpose

- To understand the relationship between key land use variables and transit ridership for the FTN corridors
- To determine requirements against which to assess future corridors for extension
- To inform the development of transit-supportive land use guidelines related to the FTN
1. Identify key land use variables to analyze
2. Develop hypotheses to test and associated methodologies
3. Explore relationships between key land use variables and transit ridership
4. Generate FTN corridor profiles with diverse typology
5. Provide input into establishing land use thresholds/ranges associated with the FTN
Research Framework: Scope

- Focused on frequent bus corridors (not routes)
- FTN corridor and corridor-bound levels
- Within the current FTN network (no Rapid Transit)
- Not to define how transit ridership is generated
Research Framework: FTN Typology

• Typology used to structure the analysis

<table>
<thead>
<tr>
<th>Transit Service Type</th>
<th>10 min or better corridors</th>
<th>15 min or better corridors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequent Local Stop</td>
<td>Conventional</td>
<td>Conventional</td>
</tr>
<tr>
<td>Frequent Limited Stop</td>
<td>B-Line</td>
<td>B-Line</td>
</tr>
<tr>
<td>Frequent Limited Stop w/exclusive ROW</td>
<td>Rapid Transit</td>
<td>Rapid Transit</td>
</tr>
</tbody>
</table>
Within a 5-minute walking distance of an FTN bus stop:

1. Higher population levels correspond to higher transit ridership.

2. Higher occupation levels correspond to higher transit ridership.

3. There is an identifiable threshold in population and occupation levels that corresponds to FTN levels of service.
The following variables considered:

- Ridership at bus stop level (Hourly average boardings & alightings)
- Population (totals, averages and gross densities per hectare).
- Occupation levels - the combined sum of employment and enrolled students at post-secondary education institutions (totals, averages and gross densities per hectare).
Spatial Analysis: Data Sources

1. Davis Web outputs of Automated Passenger Counts - APC (Dec 2011 sheet)

2. Population counts per Dissemination Block (2011 Census) by Statistics Canada

3. Number and location of employees from Canada Business Points 2011 by MapInfo - Pitney Bowles

4. Enrolled students per major post-secondary academic institutions from U-pass data and from own survey
Spatial Analysis: Methodology

- Data Coding and Capture (Data Models)
Spatial Analysis: Limitations

- Issue with transfers
- Overlapping of buffers
- Complexity of urban systems
- Does not account for other factors affecting the land use/ridership relationship
Spatial Analysis: Results

Correlations per time period for:
- Corridors
- Corridor-side
- Bus Stops (contribution)

Correlations Mon-Fri for:
- Population Density
- Occupations
Correlations: Population Density & Boardings (M-F) 18:00 to 21:00

Legend
Pearson's Coefficient
\( r \geq 0.25 / \alpha \leq 0.05 \\
- Non-correlated
0.250 - 0.300
0.301 - 0.400
0.401 - 0.500
0.501 - 0.600
0.601 - 0.700
0.701 - 0.800
0.801 - 0.900
0.901 - 1.000

Population Density
Hab/ha
- 0
- 1 - 25
- 26 - 50
- 51 - 75
- 76 - 100
- 101 - 125
- 126 - 150
- 151 - 200
- 201 - 250
- 251 - 900

Road Network
Correlations: Population Density & Alightings (M-F) 18:00 to 21:00

Legend
Pearson’s Coefficient
≥ 0.25 / α ≤ 0.05
- Non-correlated
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Road Network
Spatial Analysis: Results

Correlations of Population and:

Boardings
• Higher in AM peak.
• Evidence some importance of the midday.
• Progressively decrease throughout the day after AM peak.

Alightings
• Higher in the PM peak.
• Evidence some importance of the early evening.
• Progressively increase throughout the day towards PM peak.

Consistent with reality: evidence of data & analysis robustness.
Correlations: Occupational Density & Alightings (M-F)

- **9:00 to 15:00**
- **15:00 to 18:00**
- **18:00 to 21:00**

**Legend**
- Pearson's Coefficient: $r \geq 0.25 / \alpha \leq 0.05$
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**Occupational Density**
- Persons/ha
Correlations: Occupational Density & Boardings (M-F) 6:00 to 9:00

Correlations: Occupational Density & Boardings (M-F) 9:00 to 15:00

Correlations: Occupational Density & Boardings (M-F) 15:00 to 21:00

Legend

Pearson’s Coefficient

$ r \geq 0.25 / \alpha \leq 0.05$

Non-correlated

0.250 - 0.300

0.301 - 0.400

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Occupational Density

Persons/ha

0

1 - 25

26 - 50

51 - 75

76 - 100

101 - 125

126 - 150

151 - 200

201 - 250

251 - 900

Road Network
Spatial Analysis: Results

Correlations of Occupation and:

Alightings

- Higher in AM peak.
- Evidence some importance of the early evening.
- Progressively decrease throughout the day towards PM peak.

Boardings

- Higher in PM peak.
- Evidence some importance of the early evening.
- Progressively increase throughout the day towards PM peak.

Consistent with reality: evidence of data & analysis robustness.
Spatial Analysis: Results

Scattergrams of Correlated FTN Corridors for Population Density

Identified Thresholds
10-minute FTN corridor: 70-75 habitants/ha
15-minute FTN corridor: 45-55 habitants/ha
Spatial Analysis: Results

Scattergrams of Correlated FTN Corridors for Occupations

Identified Thresholds

10-minute FTN corridor: 50-55 emp+students
≅ 20 persons/ha

15-minute FTN corridor: 15-35 emp+students
≅ 10 persons/ha
Profile of NS03 FTN Corridor

- Corridor name: Arbutus
- Limits: Broadway Ave. & Granville St.
- Direction: North-South/South-North
- Extension: 6.53 kilometers
- Type: Near-term FTN Candidate Corridor
- Bus Stops: 25 (Eastbound), 27 (Westbound)
- Employees+Students\textsuperscript{1,2}: 10,730 (2011)
- Average Occupation\textsuperscript{1,2}: 23 persons
- Population\textsuperscript{1}: 26,968 (2011)
- Average Population Density\textsuperscript{1}: 54 hab/ha
- Average Daily Ridership Load: 11,528 passengers

\textsuperscript{1} within a 400-meter distance from bus stops.
\textsuperscript{2} employees and students enrolled in major post-secondary institutions
Spatial Analysis: Results - Profiles

Profiles of NS03 FTN Corridor: Population @ Ridership Periods

FTN Corridor NS03 (Arbutus St.) Westbound
Population Density vs. Peak Passenger Count Data at Bus Stops

FTN Corridor NS03 Westbound
Population Density vs. Off-Peak Passenger Count Data at Bus Stops
NS03 FTN Corridor - Arbutus: Population @ Peak Periods

S03 FTN Corridor Land Use Analysis

Bus Stops
Corr Pop Dens & Board Midday
Corr Pop Dens & Alight Early Evening
Boardings Midday (9:00 to 15:00)
Alightings Early Evening (18:00 to 21:00)

Population Density
2006 hab/ha
0 to 20
21 to 40
41 to 60
61 to 80
81 to 100
101 to 120
121 to 140
141 to 160
161 to 180
181 to 200
201 to 220
221 to 260
261 to 300
301 to 500

FTN Corridor
Other FTN Corridors
Land Use
General Classification
Residential - Rural
Residential - Single Detached & Duplex
Residential - Townhouse
Residential - Low-rise Apartment
Residential - High-rise Apartment
Residential - Commercial/Mixed
Commercial
Industrial
Industrial - Extractive
Institutional
Transportation Corridor, Communication & Utility
Recreation and Protected Natural Areas
Agriculture
Harvesting and Research
Lakes and Water
Protected Watershed
Open and Undeveloped
Spatial Analysis: Results - Profiles

Profiles of NS03 FTN Corridor: Occupation @ Ridership Periods

FTN Corridor NS03 Westbound
Occupation vs. Peak Passenger Count Data at Bus Stops

FTN Corridor NS03 Westbound
Occupation vs. Off-Peak Passenger Count Data at Bus Stops
NS03 FTN Corridor - Arbutus: Occupation @ Peak Periods

FTN Land Use Analysis

- Bus Stops
- Corr Avg Occ & Alight AM Peak
- Corr Avg Occ & Board PM Peak
- Alightings Midday (9:00 to 15:00)
- Boardings Early Evening (18:00 to 21:00)

Occupational Data
2011 Average Employees + Students

- 0
- 1 - 10
- 11 - 20
- 21 - 30
- 31 - 48
- 49 - 59
- 60 - 82
- 83 - 102
- 103 - 144
- 145 - 180
- 181 - 300
- 301 - 500
- 501 - 1000

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FTN Land Use Analysis

Bus Stops
Corr Pop Dens & Alight PM Peak
Corr Pop Dens & Board AM Peak
Boardings AM Peak (6:00 to 9:00)
Alightings PM Peak (15:00 to 18:00)

Population Density
2011 hab/ha

FTN Corridor
Other FTN Corridors

Land Use
General Classification

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EW01 FTN Corridor – 4th/6th UBC: Population @ Peak Periods
Hypothesis 1 & 2: Higher population/occupation levels within walking distance of FTN corresponds to higher transit ridership:

- Mostly true for most of the corridors/corridor–bounds
- Relationships are dependent on the time period:
  - Population & boardings in morning peak & alightings in afternoon peak/early evening.
  - Occupation & alightings in morning peak & boardings in the afternoon peak/early evening.
  - Lesser though consistent relationship was found for the population density and boardings at midday & occupation and alightings at early evenings.
Hypothesis 3: FTN corridors have identifiable thresholds of population/occupation corresponding to LOS

- Identified land use thresholds to FTN service levels (corridor and corridor-bound levels), occupation not as clear as population.
- For population: 70 to 75 hab/ha for the 10-minute and 45 to 55 hab/ha for the 15-minute; for occupation: 20 persons/ha for the 10-minute and 10 persons/ha for the 15-minute.
- Some corridors exceed minimum population thresholds: other land use/transit performance variables required to warrant 15 minute/10 minute FTN levels of service.
- Consistent with similar studies: range from 20, 50 and 75 hab/ha.
Importance of mixed land use and densities in corridor design

- 10 or 15 minute FTN Corridors should have mixed land use at both ends and ideally in the middle (anchors).
- Population and occupation to be concentrated, with densities of at least 45 to 55 per/ha and ideally above 75 per/ha for 10 minute corridors.
- Higher occupation ideally located at intersections with other FTN or concentrated in urban centers.
Thank you
Questions?