URBAN COMMERCIAL TRAFFIC PATTERNS:
BUILDING THE STORY OF URBAN FREIGHT

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URBAN CV TRAFFIC IS DIFFERENT AND MORE COMPLEX THAN HIGHWAY TRAFFIC
RESEARCH OBJECTIVE

1. Identify and describe typical weekday urban commercial traffic flow patterns

2. Explore how geography, roadway infrastructure and land use influence weekday commercial traffic flow patterns
SEATTLE’S VEHICLE COUNT STUDIES

Greater Downtown Area (GDA) cordon study

Ballard/Interbay Vehicle Count Study
INSIGHTS INTO URBAN CV TRAFFIC FLOW

• *Service vehicles are a significant share of CV traffic (30%)*

• *The smaller CV fleet is the biggest share of CV traffic (60%)*

• *Fleet size variations are influenced by CV activity type*

• *Most CVs were observed during regular business hours, 6 AM – 6 PM, and had only one bump throughout the day.*

• *Peak hours took place between 8:45 AM and 1:00 PM. CVs appear to utilize the ‘spare’ capacity freed up by the decline in private vehicles between AM and PM commuter peaks.*

• *Significant variation in traffic flow were observed between locations*
GENERAL VS COMMERCIAL TRAFFIC DAILY PATTERNS

Vehicle rolling hour by the time of day based on Seattle’s GDA Cordon Count
CV ACTIVITY CATEGORY IMPACTS DAILY TRAFFIC

Average daily traffic based on Seattle’s GDA vehicle count by:

**CV body type**

- Multi-trailer & Trailer
- Single Unit
- Smaller CV Fleet

**Activity type**

- Construction
- Goods Transport
- General CM
- Waste Mgt.
- Service
FINDING TYPICAL URBAN “CV” TRAFFIC PATTERNS

Daily traffic flow profile (i.e., average weekday flow at individual road segment)
(a) CV share of total traffic for northern gateways.

(b) CV share of total traffic for eastern gateways.

(c) CV share of total traffic for western gateways.

(d) CV share of total traffic for southern gateways.
This research uses data collected to evaluate three popular instinctive understandings about traffic flows on road segments describe by (Banaei-Kashani, Shahabi, and Pan 2011):

1) each road segment has a typical traffic flow profile,
2) segments can be categorized and grouped into a set of distinct clusters based on the similarity of their traffic volume variations,
3) within each category or clusters, road segments not only have similar traffic volume but also are similar in other characteristics (geographical, infrastructure-related, connectivity).
CLUSTER ANALYSIS

Clustering Process

Cluster Algorithm
- K-means
- HAC
- DBSCAN

Spectral Clustering
- Similarity Graph
- Spectral Embedding
- K-means

Clustering Parameters
- Definition of distance
- Selection of K
- Size of K
- Euclidean
- Correlation-based
- DTW
FLOW-BASED CLUSTERS

Shape-based

Feature-based

CV Traffic flow descriptors

Traffic Compositions

Time Series Distribution
PRELIMINARY RESULTS: HCA FOR THE BALLARD/INTERBAY AREA
PRELIMINARY RESULTS: K-MEANS

Dataset
64 locations
Total CV is aggregated by small, single-unit and trailer body types.
Directionality is not considered

Distance measure: DTW
PRELIMINARY INSIGHTS ABOUT CV TRAFFIC VARIATIONS (1/2)

• Directionality patterns:
  • Morning peak is observed for CV traffic going in the city center from the industrial land
  • Afternoon peak is observed for CV traffic going out of the city center toward the industrial district

• Ferry and port gateways show higher traffic variability

• Heavy truck traffic (i.e., (trailer and multi-trailer) is more active overnight than other vehicle types.
PRELIMINARY INSIGHTS ABOUT CV TRAFFIC VARIATIONS (2/2)

• The smaller fleet has a peaked volume curve – reflecting a concentration of activity in time and space compared to larger vehicles

• More heavy truck traffic & less CV service vehicles are associated with industrial lands

• Although, some similarity of traffic patterns are observed within street designations; clustering would support the identification of the real functionality of the road segment as part of the freight network.
SUMMARY

- Unique dataset provides an opportunity to uncover urban commercial vehicle data stories

- Preliminary work suggests there are distinct sub-populations of commercial vehicle activity, unique from personal travel

- Inform more impactful planning and operations and correct existing misconceptions about freight activity
QUESTIONS?

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SUMMARY

- Framework to support the evaluation of the heterogeneity of the urban CV traffic flow.

- Foundational knowledge about the CV urban travel demand patterns, and potential factors contributing to these flows' temporal and spatial variations.

- Identification of temporal and spatial similarities/dissimilarities between commercial vehicle flows that can be summarized in an actionable way with “typical” within-day traffic patterns for urban freight modeling and planning.

- Method to describe and classify urban road segments based on their CV demand throughout the day.
EVALUATING COMMERCIAL DAILY TRAFFIC PATTERNS

Study sample size for all the locations in a 48hr period:

<table>
<thead>
<tr>
<th>Activity Type</th>
<th>GDA (veh)</th>
<th>Ballard/Interbay (veh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private</td>
<td>1,141,711</td>
<td>907,393</td>
</tr>
<tr>
<td>CVs</td>
<td>87,718</td>
<td>58,823</td>
</tr>
<tr>
<td>Public Transit</td>
<td>13,611</td>
<td>11,733</td>
</tr>
<tr>
<td>Other Transit</td>
<td>10,188</td>
<td>4,737</td>
</tr>
<tr>
<td>Emergency</td>
<td>1,381</td>
<td>483</td>
</tr>
<tr>
<td>RVs</td>
<td>194</td>
<td>116</td>
</tr>
<tr>
<td>Unknown</td>
<td>1,684</td>
<td>-</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>1,256,487</td>
<td>983,285</td>
</tr>
</tbody>
</table>

Features

- **Study Area**: Ballard, GDA
- **Roadway Segment**: Arterials, highway, highway ramp, local street
- **Direction**: E, W, S, N, NW, SW, NE, NW
- **Cordon Dir**: Inbound, Outbound
- **Body Type**: Work van, CV Pick-Up, Single-unit truck, Trailer, Multi-trailer
- **Vehicle Activity**: Goods transport, Waste management, Construction, Service, General
- **Number of axles**: 2 axles, 2 axles +, 3 axles, 4 axles +, 3 or 4 axles, 5 axles, 6 axles +, 5 axles or less, 6 axles, 7 axles +
Summary Statistics for *Ballard locations* CV daily flow profiles

<table>
<thead>
<tr>
<th>CV daily traffic flows descriptors</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>Median</th>
<th>St. Deviation</th>
<th>Coefficient of variations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak Hour</td>
<td>7</td>
<td>13</td>
<td>-</td>
<td>10</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Peak Hr Volume</td>
<td>16</td>
<td>275</td>
<td>114</td>
<td>93</td>
<td>68</td>
<td>0.6</td>
</tr>
<tr>
<td>Mean Hr Volume</td>
<td>6</td>
<td>117</td>
<td>42</td>
<td>34</td>
<td>28</td>
<td>0.7</td>
</tr>
<tr>
<td>Median Hr Volume</td>
<td>4</td>
<td>86</td>
<td>25</td>
<td>17</td>
<td>20</td>
<td>0.8</td>
</tr>
<tr>
<td>St. deviation</td>
<td>6</td>
<td>107</td>
<td>40</td>
<td>33</td>
<td>26</td>
<td>0.6</td>
</tr>
<tr>
<td>CV ADT</td>
<td>150</td>
<td>2818</td>
<td>1014</td>
<td>815</td>
<td>673</td>
<td>0.7</td>
</tr>
<tr>
<td>Business Hr. Vol Share (%)</td>
<td>0.86</td>
<td>0.95</td>
<td>0.91</td>
<td>0.92</td>
<td>0.02</td>
<td>0.02</td>
</tr>
</tbody>
</table>

**Time Series Distribution**

<table>
<thead>
<tr>
<th>Autocorrelation (lag = 2)</th>
<th>0.64</th>
<th>0.74</th>
<th>0.72</th>
<th>0.73</th>
<th>0.02</th>
<th>0.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skew</td>
<td>0.23</td>
<td>0.94</td>
<td>0.60</td>
<td>0.62</td>
<td>0.18</td>
<td>0.3</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>-1.86</td>
<td>-0.56</td>
<td>-1.25</td>
<td>-1.25</td>
<td>0.37</td>
<td>-0.3</td>
</tr>
</tbody>
</table>

**Traffic Composition at the location**

| CV Share                   | 5%   | 11%  | 6%   | 6%   | 1%   | 0.2 |
| Service CV Share           | 33%  | 46%  | 41%  | 41%  | 4%   | 0.1 |
| Small CV Fleet Share       | 54%  | 65%  | 60%  | 60%  | 3%   | 0.1 |
| Transit Share              | 0%   | 6%   | 2%   | 1%   | 2%   | 1.0 |

Tentative additional features
- Flatness of the peak
- Increase rate
- Decrease rate
NEXT STEPS - SPATIAL EXPLORATORY ANALYSIS

Geometric Design

Infrastructure Designation

Topological Features
The resulting cluster scheme will be display and evaluated spatially to perform a spatial interpretation of commercial vehicle traffic patterns using a geospatial processing program (ArcGIS). A set of non-temporal features for each road segments will be considered in this task (Banaei-Kashani et al., 2011, Weijermars, 2007, SDOT, 2016):

- Roadway Width
- Number of Lanes
- Spatial capacity
- Segment direction
- Presence of cycling infrastructure
- Presence of transit lanes

**Independent features of the roadway segments**

- Controlled access
- Vehicle size restrictions

**Regulations**

- Roadway Connectivity
- Locality
- Adjacent land use
- Freight Network Connectivity

**Topological features**

- Freight network designation
- Roadway designation
- Seattle Street Classification

**Infrastructure Designation**
RESEARCH METHODOLOGY

STEP 1 - Feature Extraction

STEP 2 - Cluster Analysis

STEP 3 - Spatial Exploratory Analysis
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