SUPPLY CHAIN TRANSPORTATION & LOGISTICS

UNIVERSITY of WASHINGTON

College of Engineering

URBAN COMMERCIAL TRAFFIC PATTERNS: BUILDING THE STORY OF URBAN FREIGHT

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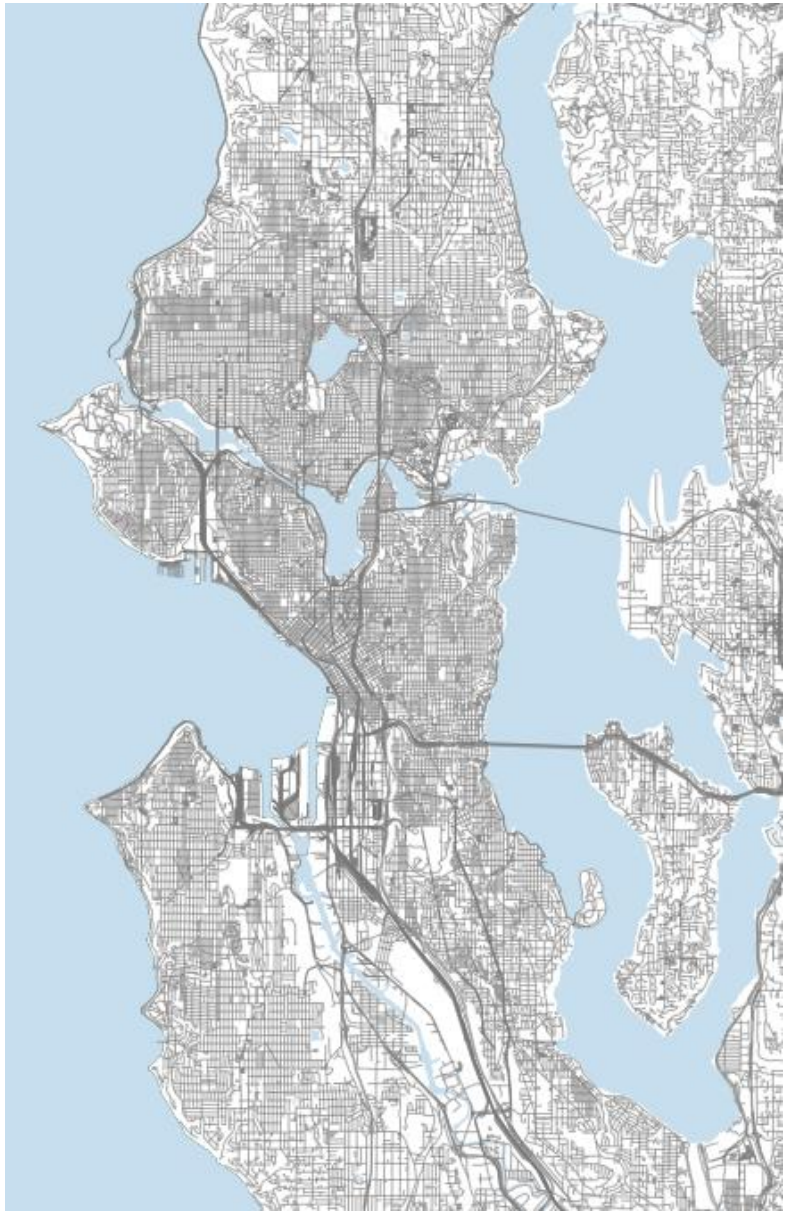
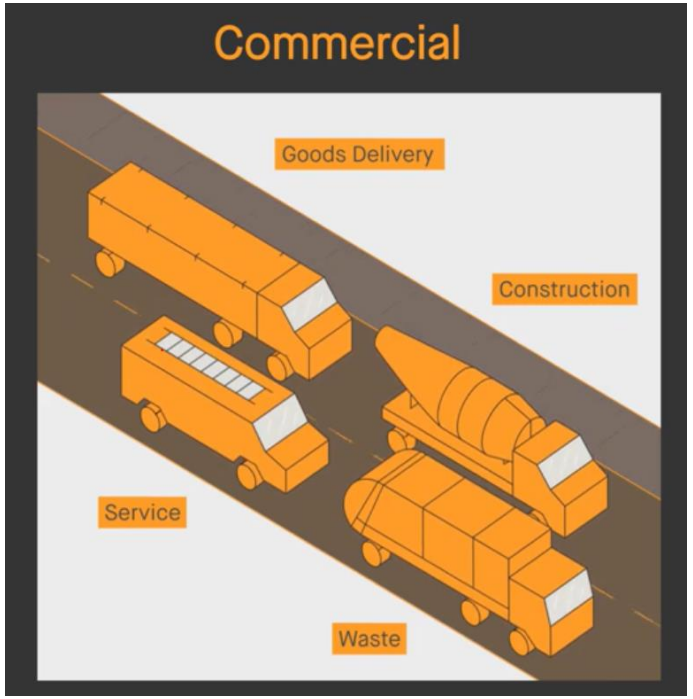
May 25th, 2022





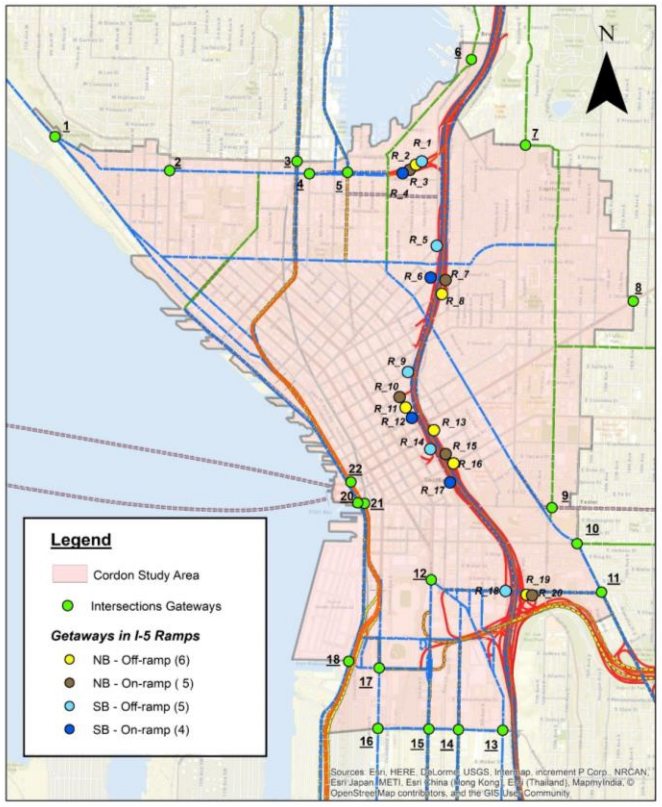
URBAN CV TRAFFIC IS DIFFERENT AND MORE COMPLEX THAN HIGHWAY TRAFFIC

RESEARCH OBJECTIVE

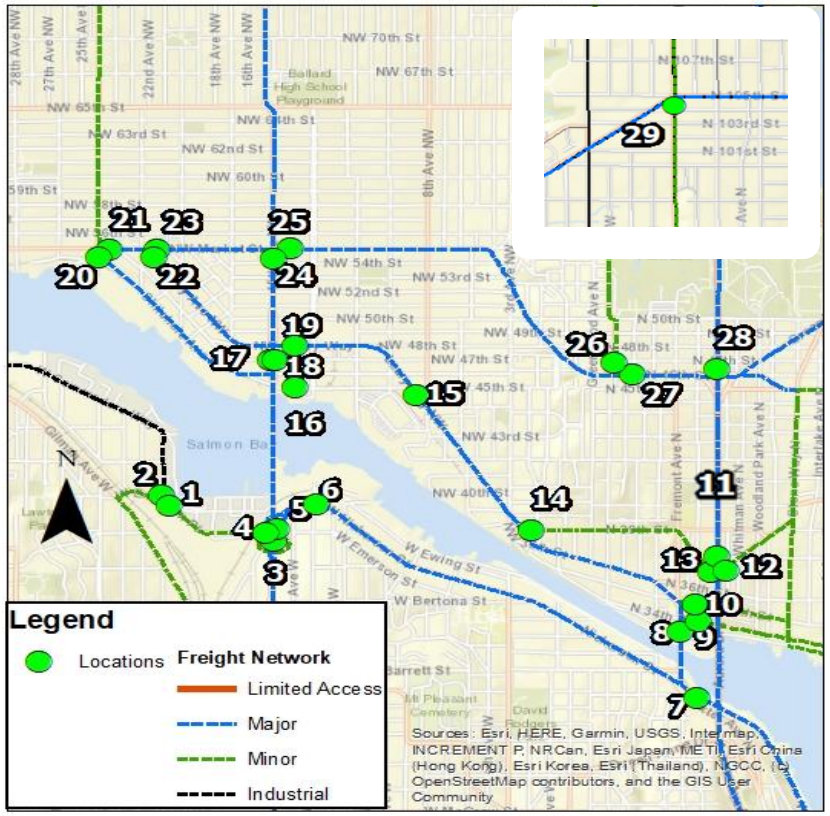
1. Identify and describe typical weekday **urban** commercial traffic flow patterns

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

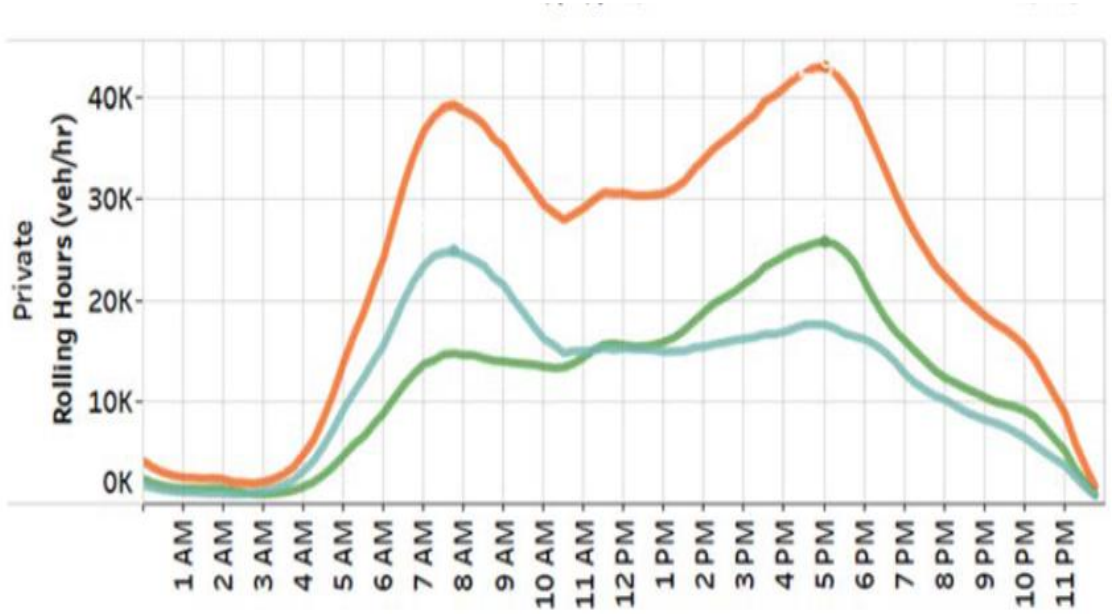
INSIGHTS INTO URBAN CV TRAFFIC FLOW

- ***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***

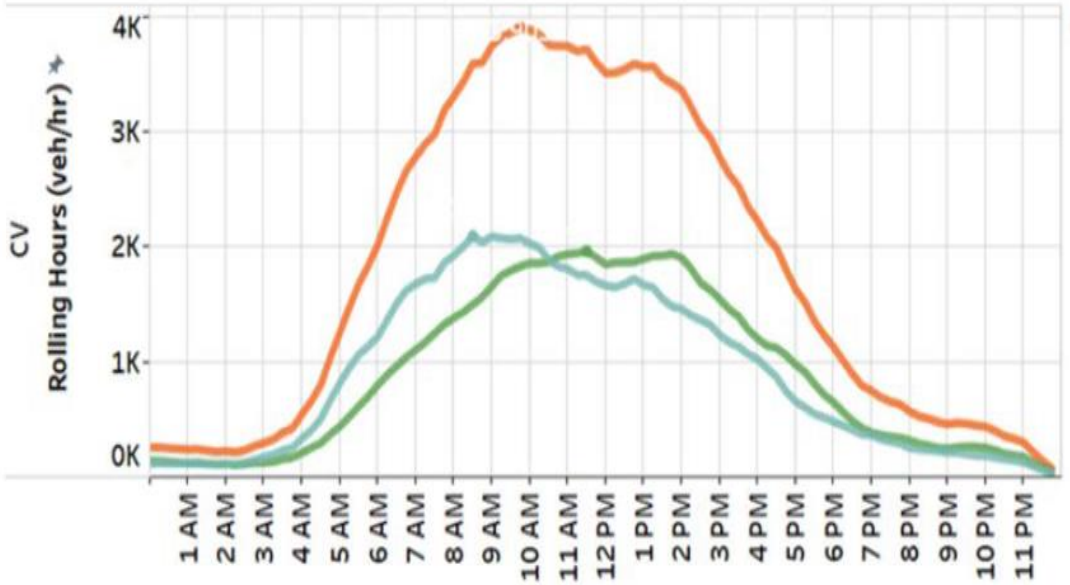
Smaller CV Fleet

GENERAL VS COMMERCIAL TRAFFIC DAILY PATTERNS

Vehicle rolling hour by the time of day based on Seattle's GDA Cordon Count



Private Vehicles

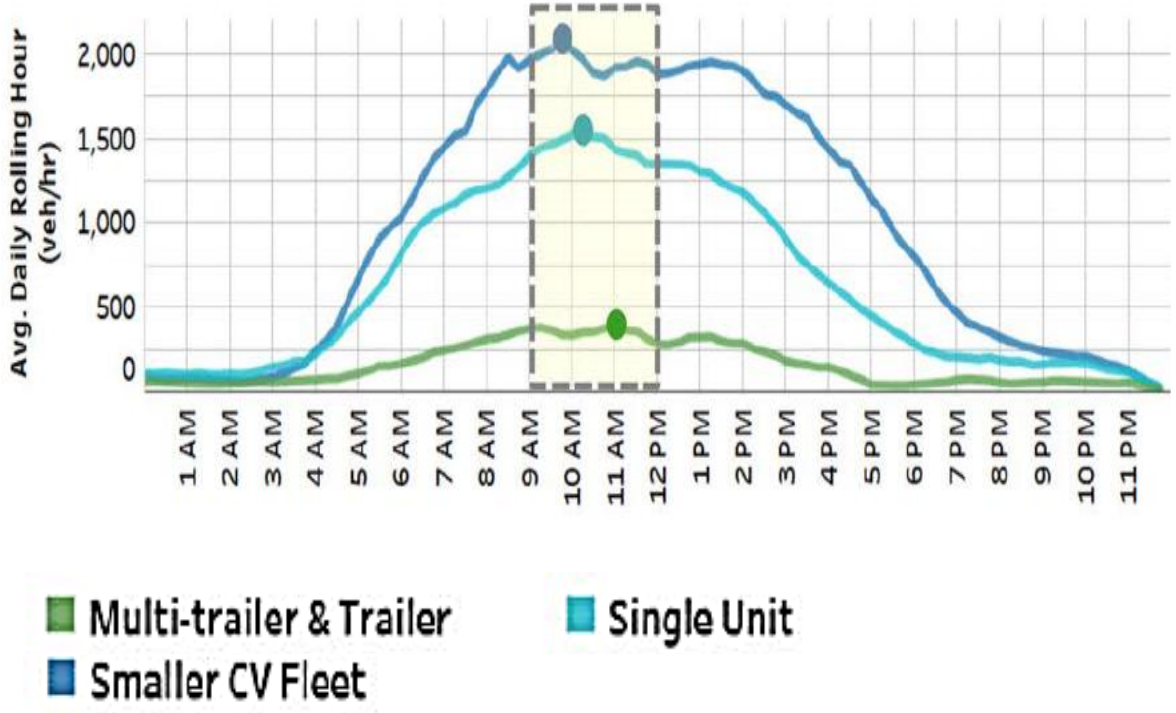


Commercial Vehicles

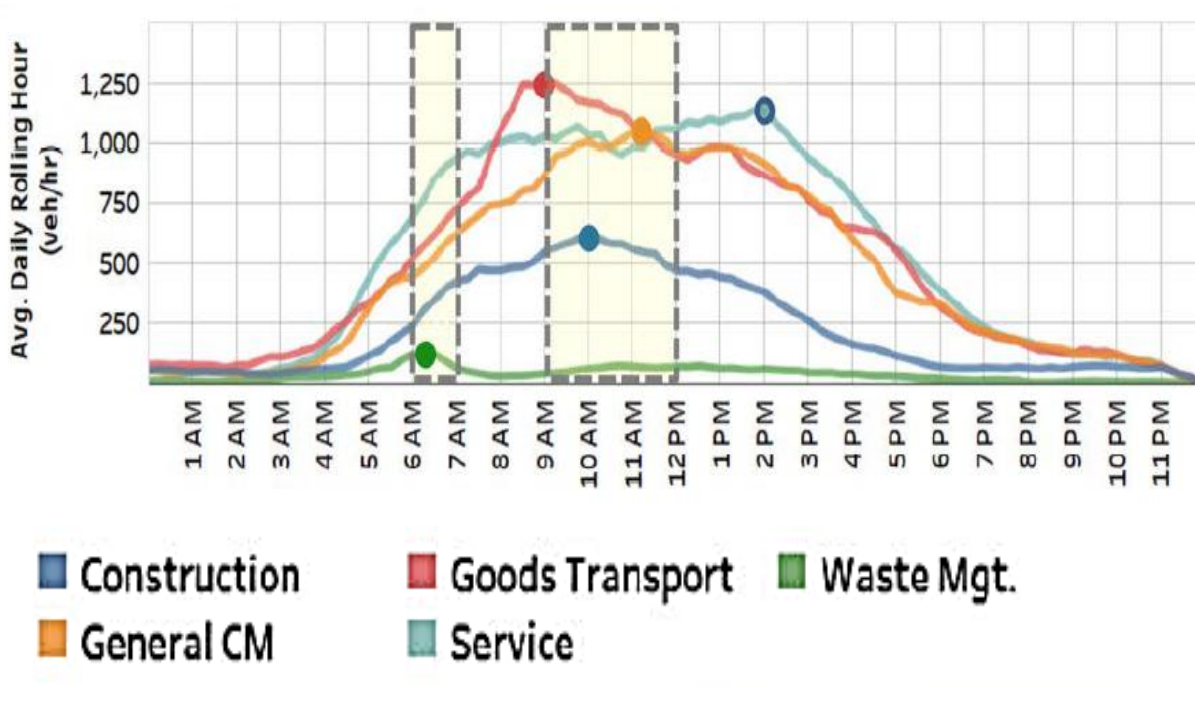
CV ACTIVITY CATEGORY IMPACTS DAILY TRAFFIC

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

CV body type

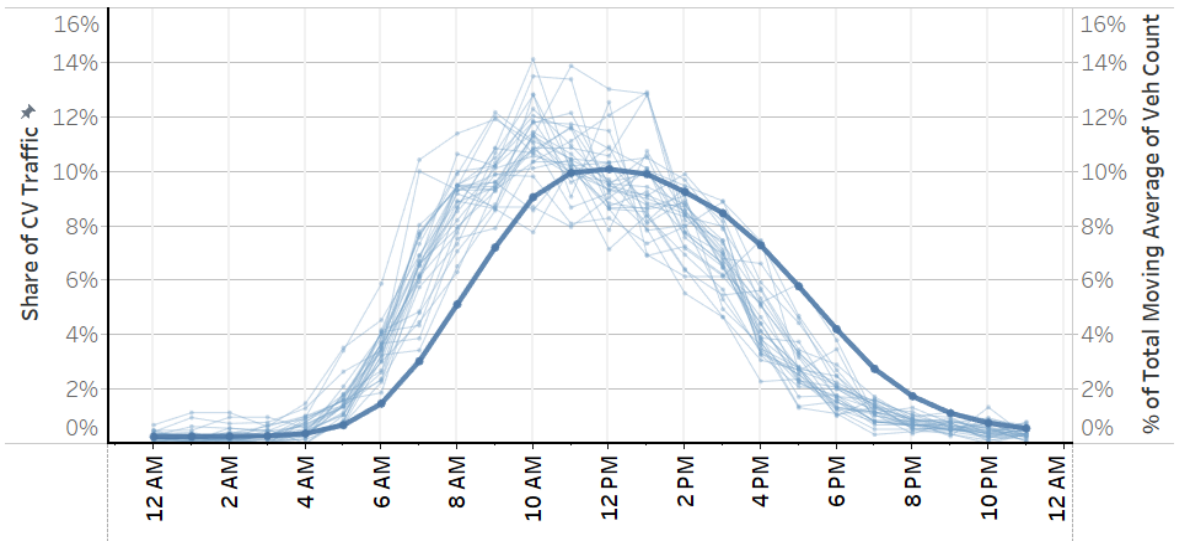


Activity type

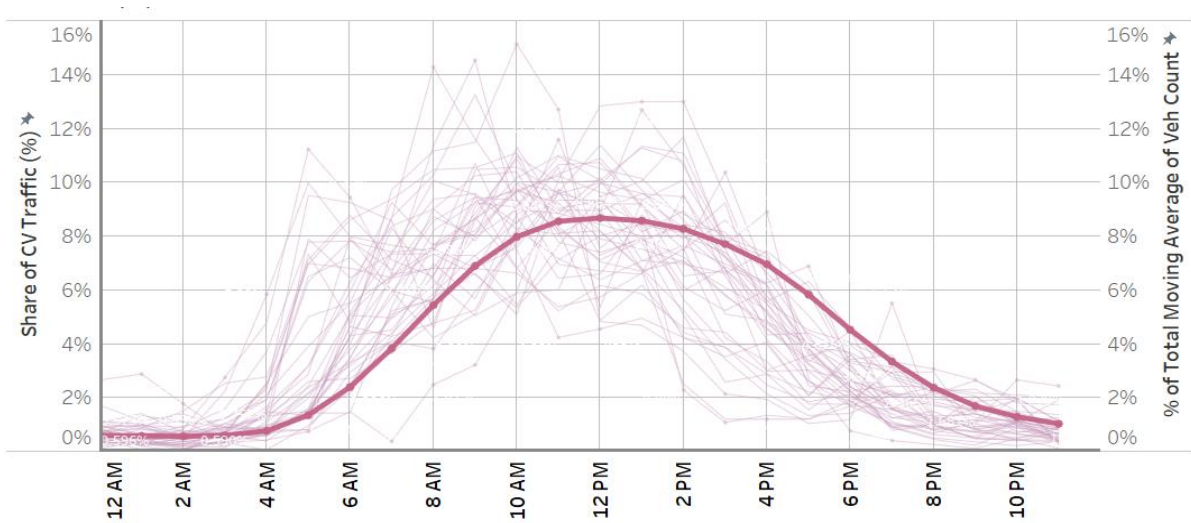


FINDING TYPICAL URBAN "CV" TRAFFIC PATTERNS

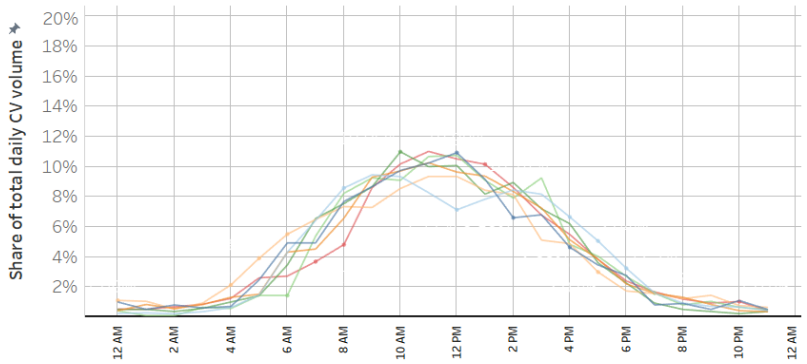
Daily traffic flow profile (i.e., average weekday flow at individual road segment)



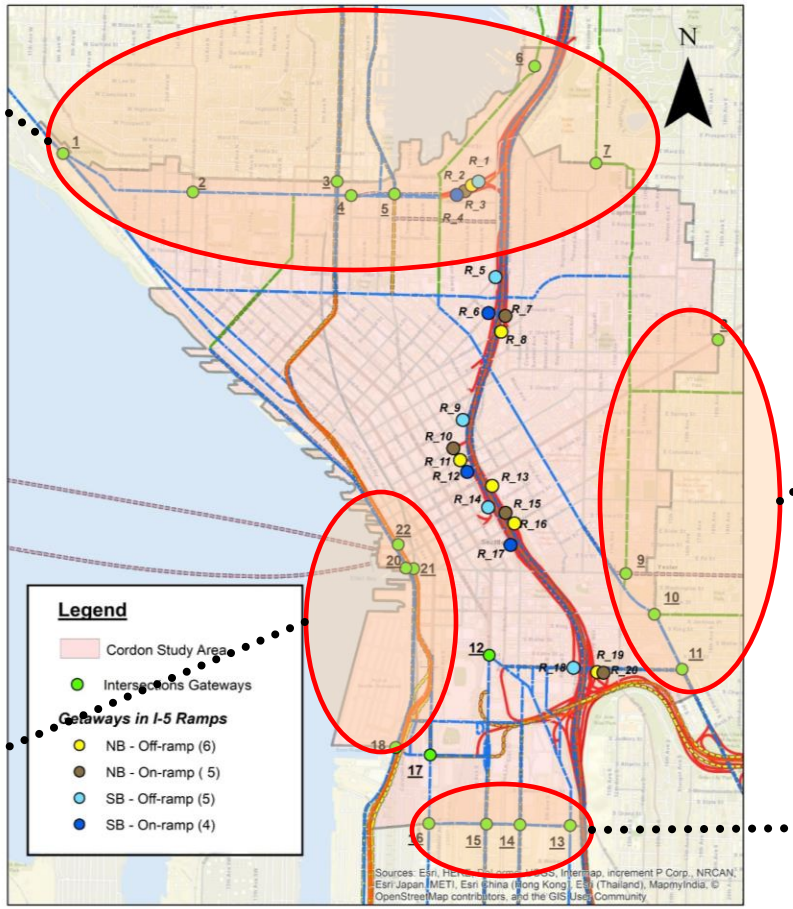
BINMIC

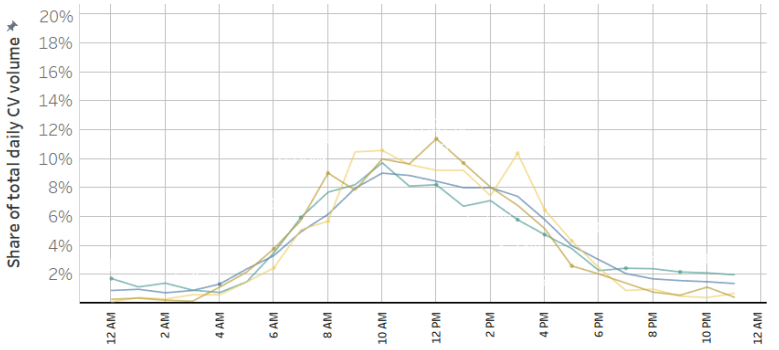


GDA

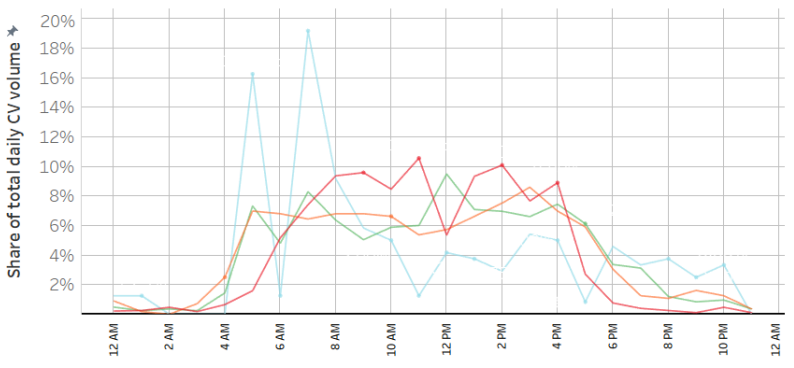


(a) CV share of total traffic for northern gateways.

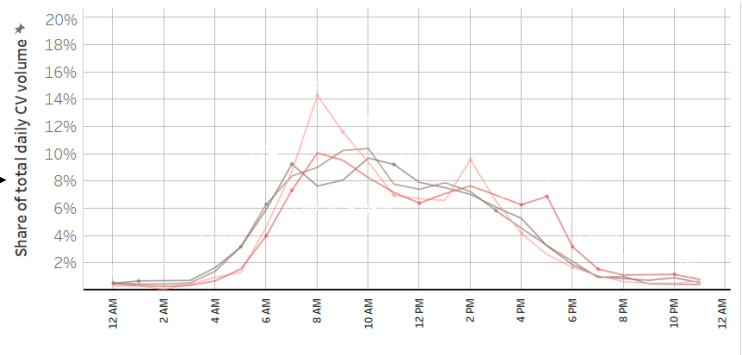




(b) CV share of total traffic for eastern gateways.



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



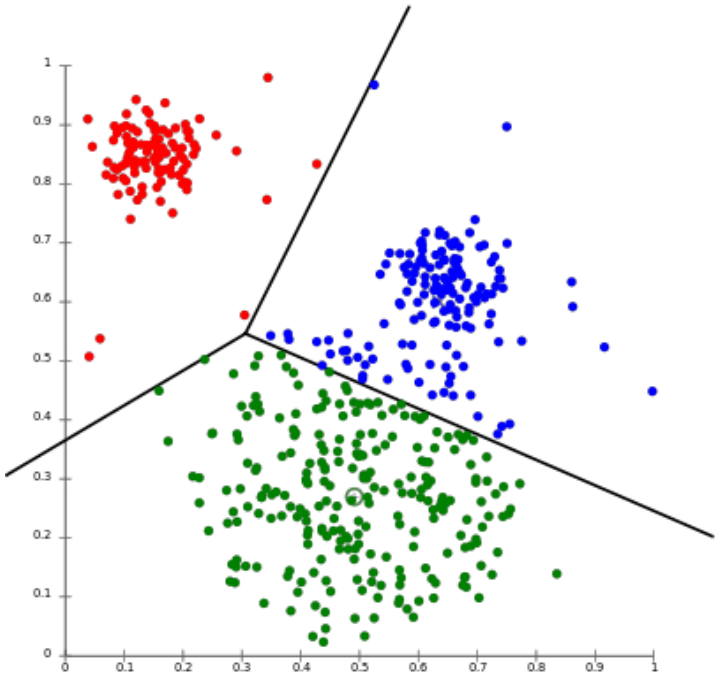
(d) CV share of total traffic for southern gateways.

ASSUMPTIONS

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

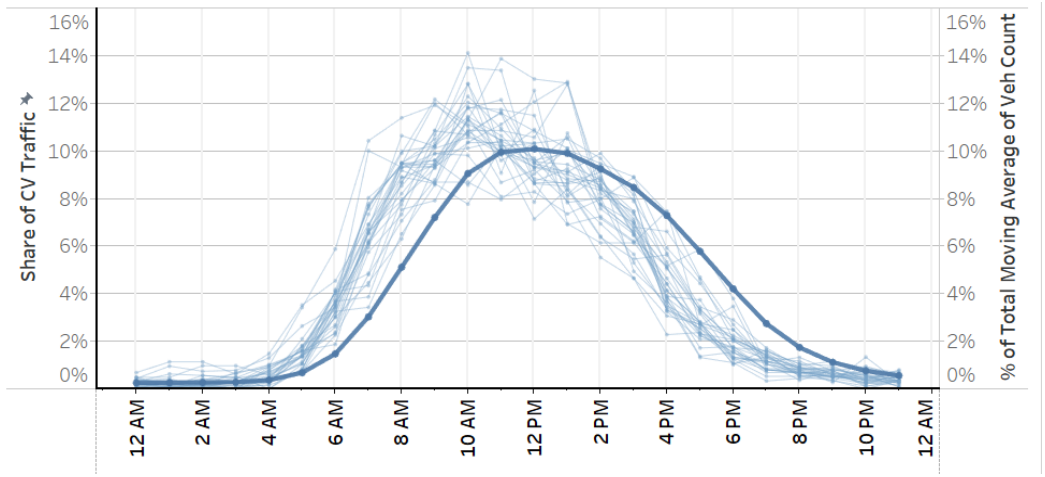
- Cluster Algorithm
  - K-means
  - HAC
  - DBSCAN
  - **Spectral Clustering**
    - Similarity Graph
    - Spectral Embedding
    - K-means

Clustering Parameters

- Definition of distance
  - Euclidean
  - Correlation-based
  - DTW
- Selection of K
- Size of K

FLOW-BASED CLUSTERS

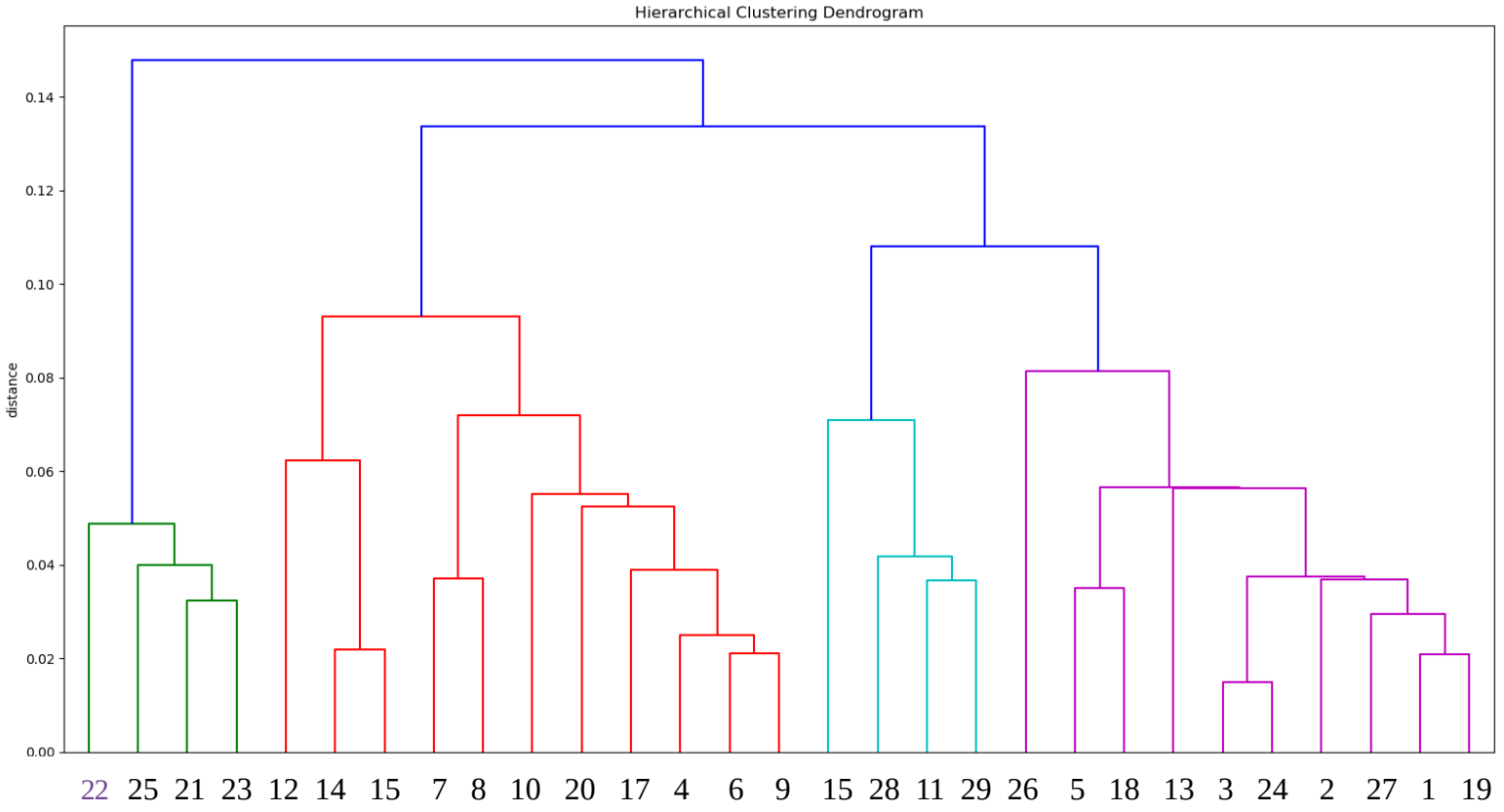
Shape-based

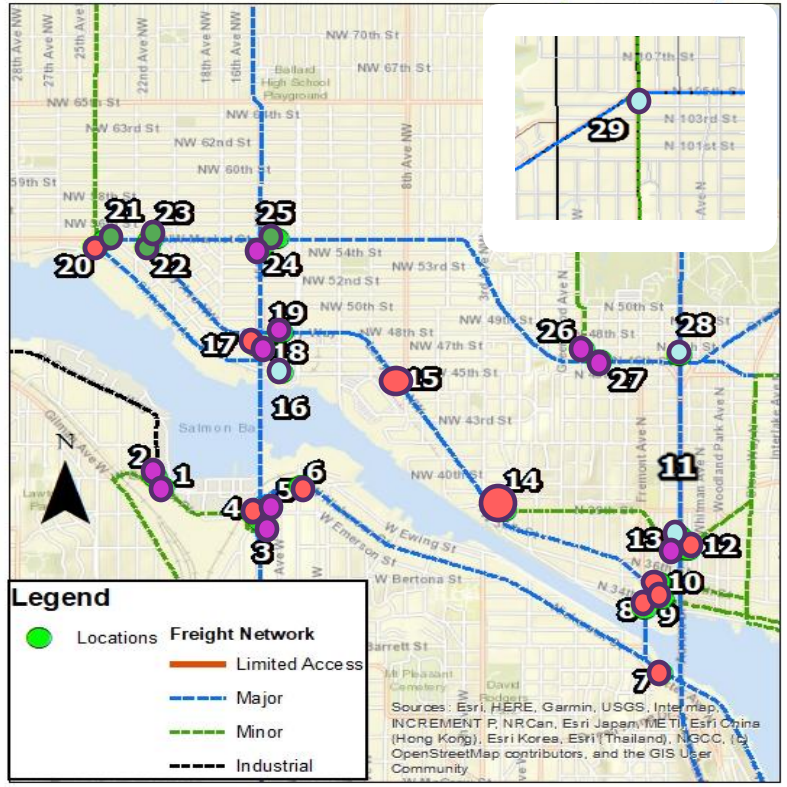


Feature-based

- CV Traffic flow descriptors
- Traffic Compositions
- Time Series Distribution

PRELIMINARY RESULTS: HCA FOR THE BALLARD/INTERBAY AREA





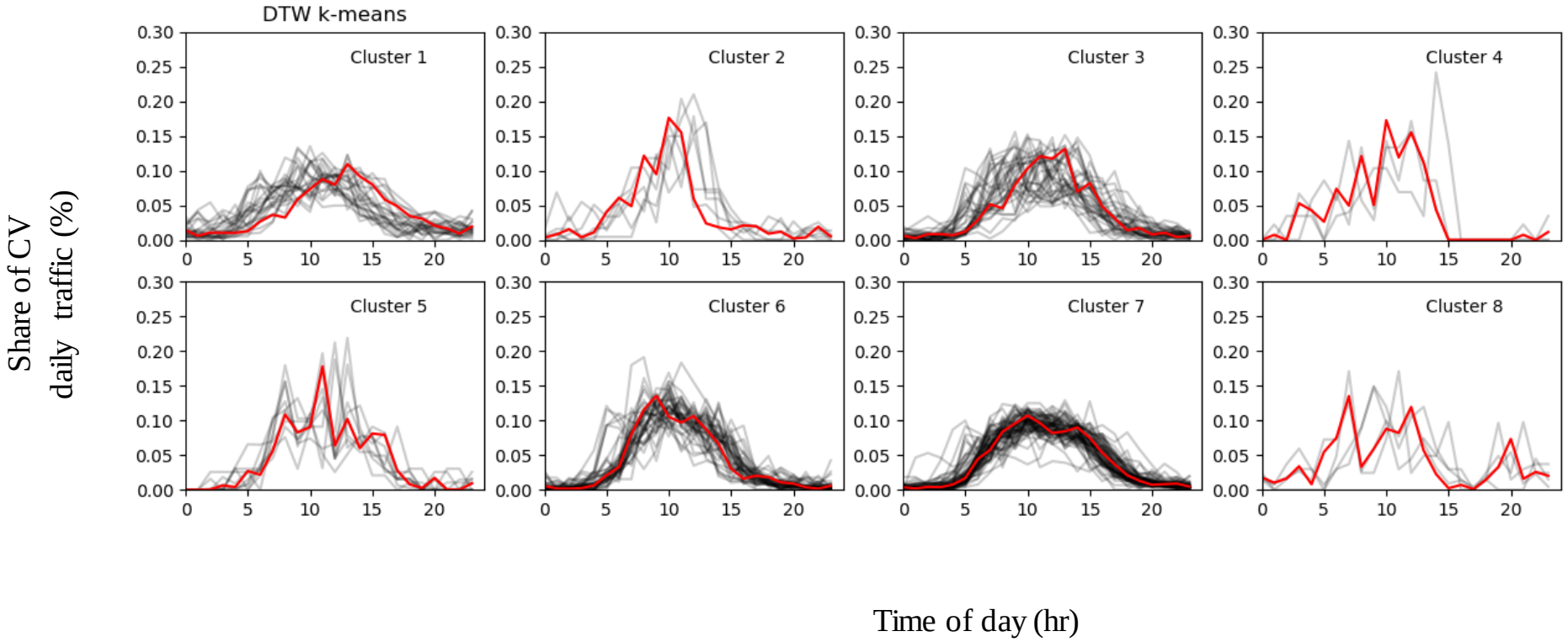
PRELIMINARY RESULTS: K-MEANS

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

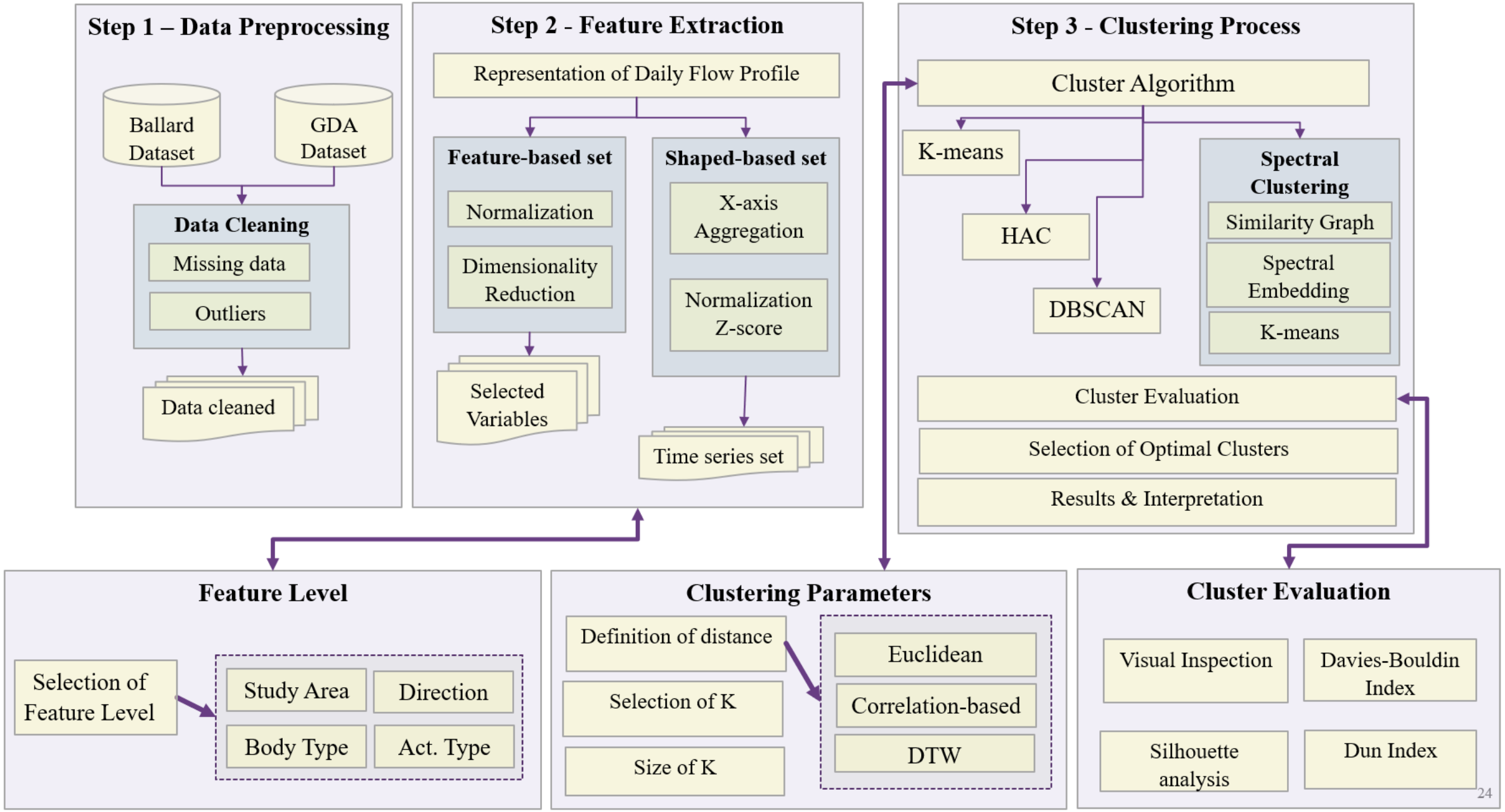
- Framework to support the evaluation of the heterogeneity of the urban CV traffic flow.
- Foundational knowledge about the CV urban travel demand patterns, and potential factors contributing to these flows' temporal and spatial variations
- Identification of temporal and spatial similarities/dissimilarities 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:

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

Features	Categories
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 +


Step 1 – Data Preprocessing
Ballard Dataset
GDA Dataset
Data Cleaning
Missing data
Outliers
Data cleaned
Step 2 - Feature Extraction
Representation of Daily Flow Profile
Feature-based set
Normalization
Dimensionality Reduction
Selected Variables
Shaped-based set
X-axis Aggregation
Normalization Z-score
Time series set
Step 3 - Clustering Process
Cluster Algorithm
K-means
HAC
DBSCAN
Spectral Clustering
Similarity Graph
Spectral Embedding
K-means
Cluster Evaluation
Selection of Optimal Clusters
Results & Interpretation
Feature Level
Selection of Feature Level
Study Area
Direction
Body Type
Act. Type
Clustering Parameters
Definition of distance
Selection of K
Size of K
Euclidean
Correlation-based
DTW
Cluster Evaluation
Visual Inspection
Davies-Bouldin Index
Silhouette analysis
Dun Index
24

FEATURE EXTRACTION

Summary Statistics for *Ballard locations* CV daily flow profiles

	Min	Max	Mean	Median	St. Deviation	Coefficient of variations
CV daily traffic flows descriptors						
Peak Hour	7	13	-	10	-	-
Peak Hr Volume	16	275	114	93	68	0.6
Mean Hr Volume	6	117	42	34	28	0.7
Median Hr Volume	4	86	25	17	20	0.8
St. deviation	6	107	40	33	26	0.6
CV ADT	150	2818	1014	815	673	0.7
Business Hr. Vol Share (%)	0.86	0.95	0.91	0.92	0.02	0.02
Time Series Distribution						
Autocorrelation (lag = 2)	0.64	0.74	0.72	0.73	0.02	0.0
Skew	0.23	0.94	0.60	0.62	0.18	0.3
Kurtosis	-1.86	-0.56	-1.25	-1.25	0.37	-0.3
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

NEXT STEPS - SPATIAL EXPLORATORY ANALYSIS

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*):

Independent features of the roadway segments

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

Regulations

- Controlled access
- Vehicle size restrictions

Topological features

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

Infrastructure Designation

- Freight network designation
- Roadway designation
- Seattle Street Classification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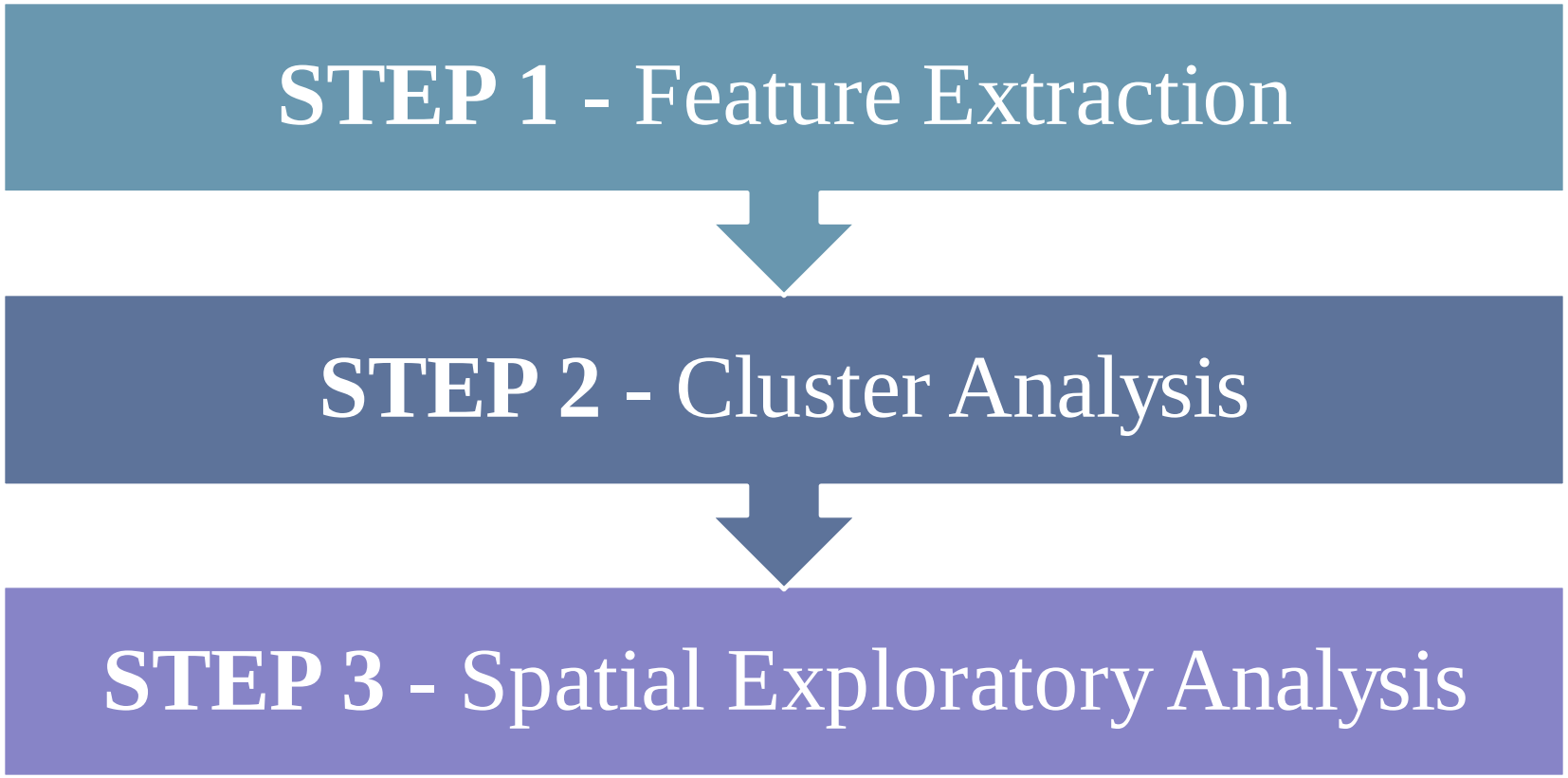
RESEARCH METHODOLOGY



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