Volunteer Network of Professionals Working Together to Support, Promote, and Improve Best Practices in the Application of Traffic Simulation and Capacity Analysis

Meeting Agenda

P1 Identifying Travel Conditions using Cluster Analysis: Illustrative Investigations

P2 Utilizing the NPMRDS for Model Calibration/Validation

D Mini Roundtable

Christopher Melson
Louisiana State University

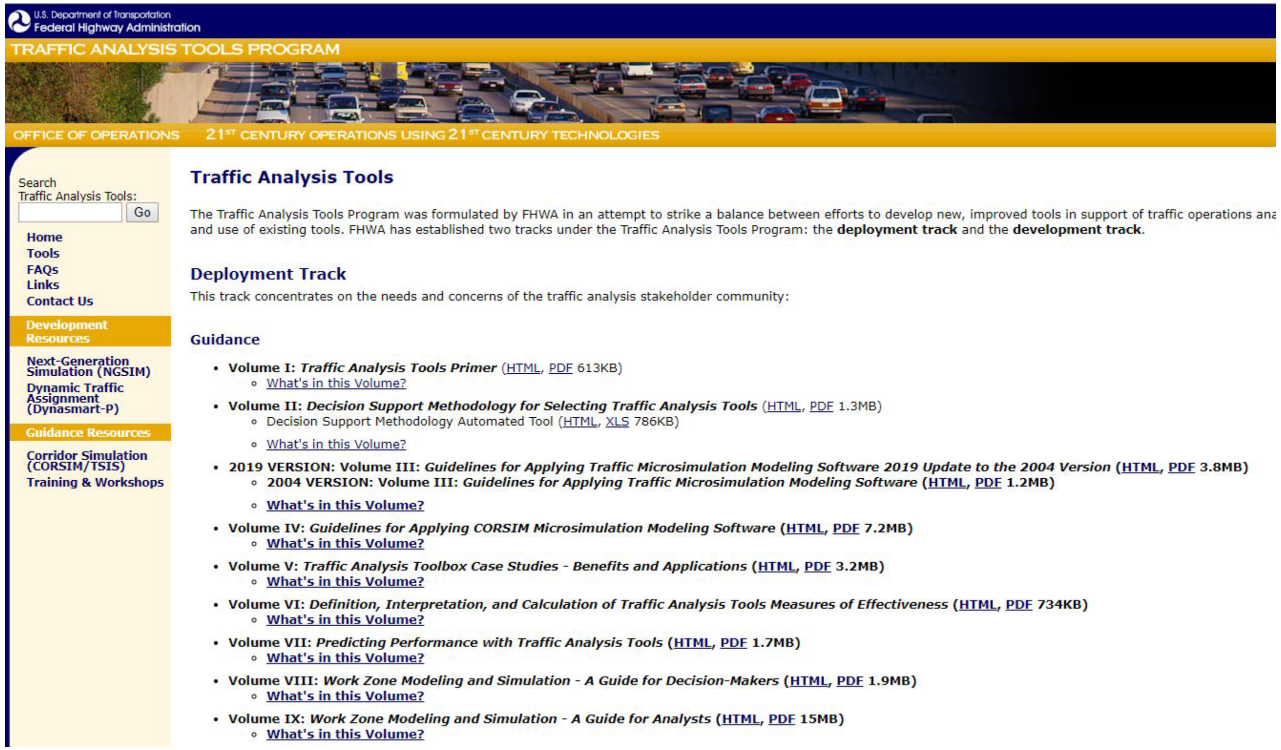
Identifying Travel Conditions using Cluster Analysis: Illustrative Investigations

Presentation Outline

- FHWA Guidance
- Case Study
- Investigations

FHWA Traffic Analysis Tools

- Traffic Analysis Tools
  - Volumes I-XIV
  - 5 additional guides
- Operational Clusters
  - Introduced in: *Scoping and Conducting Data-Driven 21st Century Transportation System Analyses* (Jan. 2017)
  - Better defined in: *Traffic Analysis Toolbox Volume III: Guidelines for Applying Traffic Microsimulation Modeling Software* (Apr. 2019)


U.S. Department of Transportation
Federal Highway Administration
TRAFFIC ANALYSIS TOOLS PROGRAM
OFFICE OF OPERATIONS 21ST CENTURY OPERATIONS USING 21ST CENTURY TECHNOLOGIES

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Development Resources

- Next-Generation Simulation (NGSIM)
- Dynamic Traffic Assignment (Dynasmart-P)

Guidance Resources

- Corridor Simulation (CORSIM/TSIS)
- Training & Workshops

Traffic Analysis Tools

The Traffic Analysis Tools Program was formulated by FHWA in an attempt to strike a balance between efforts to develop new, improved tools in support of traffic operations ana and use of existing tools. FHWA has established two tracks under the Traffic Analysis Tools Program: the **deployment track** and the **development track**.

Deployment Track

This track concentrates on the needs and concerns of the traffic analysis stakeholder community:

Guidance

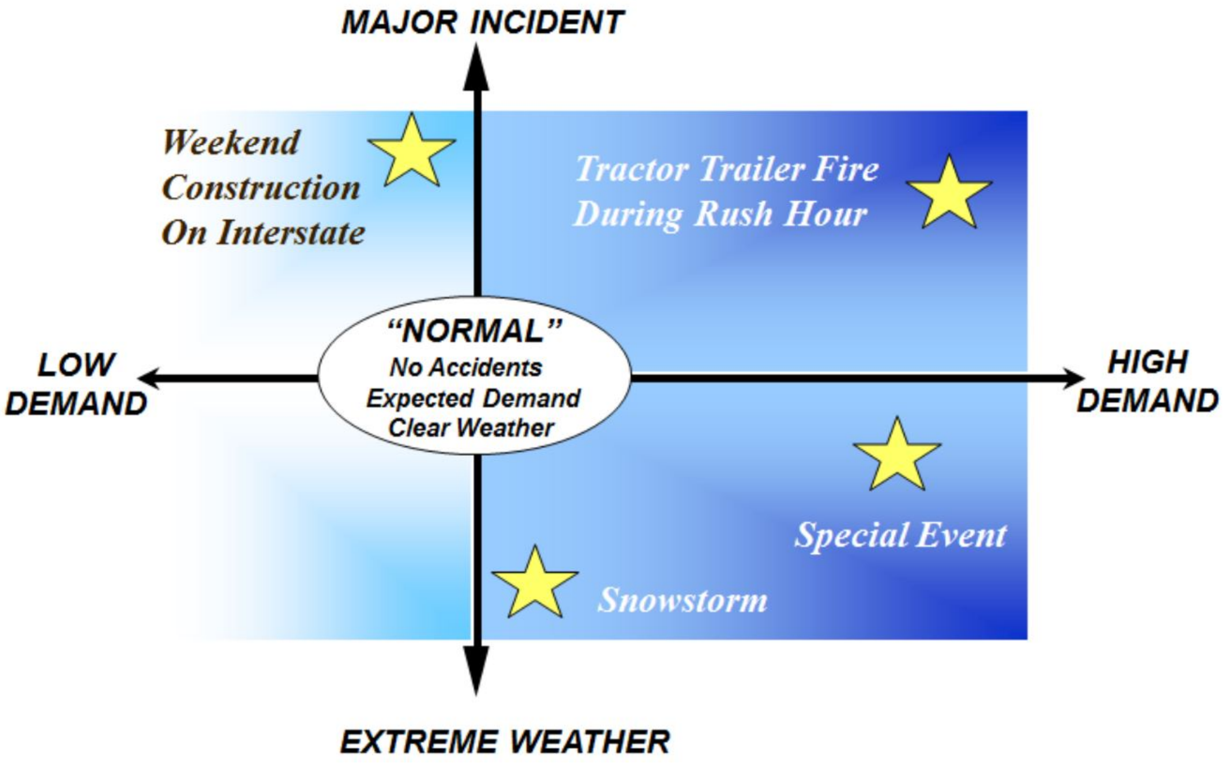
- **Volume I:** ***Traffic Analysis Tools Primer*** (HTML, PDF 613KB)
  - What's in this Volume?
- **Volume II:** ***Decision Support Methodology for Selecting Traffic Analysis Tools*** (HTML, PDF 1.3MB)
  - Decision Support Methodology Automated Tool (HTML, XLS 786KB)
  - What's in this Volume?
- **2019 VERSION: Volume III: *Guidelines for Applying Traffic Microsimulation Modeling Software 2019 Update to the 2004 Version* (HTML, PDF 3.8MB)**
  - **2004 VERSION: Volume III: *Guidelines for Applying Traffic Microsimulation Modeling Software* (HTML, PDF 1.2MB)**
  - **What's in this Volume?**
- **Volume IV: *Guidelines for Applying CORSIM Microsimulation Modeling Software* (HTML, PDF 7.2MB)**
  - **What's in this Volume?**
- **Volume V: *Traffic Analysis Toolbox Case Studies - Benefits and Applications* (HTML, PDF 3.2MB)**
  - **What's in this Volume?**
- **Volume VI: *Definition, Interpretation, and Calculation of Traffic Analysis Tools Measures of Effectiveness* (HTML, PDF 734KB)**
  - **What's in this Volume?**
- **Volume VII: *Predicting Performance with Traffic Analysis Tools* (HTML, PDF 1.7MB)**
  - **What's in this Volume?**
- **Volume VIII: *Work Zone Modeling and Simulation - A Guide for Decision-Makers* (HTML, PDF 1.9MB)**
  - **What's in this Volume?**
- **Volume IX: *Work Zone Modeling and Simulation - A Guide for Analysts* (HTML, PDF 15MB)**
  - **What's in this Volume?**

https://ops.fhwa.dot.gov/trafficanalysistools/index.htm

FHWA Guidance	Case Study	Investigations

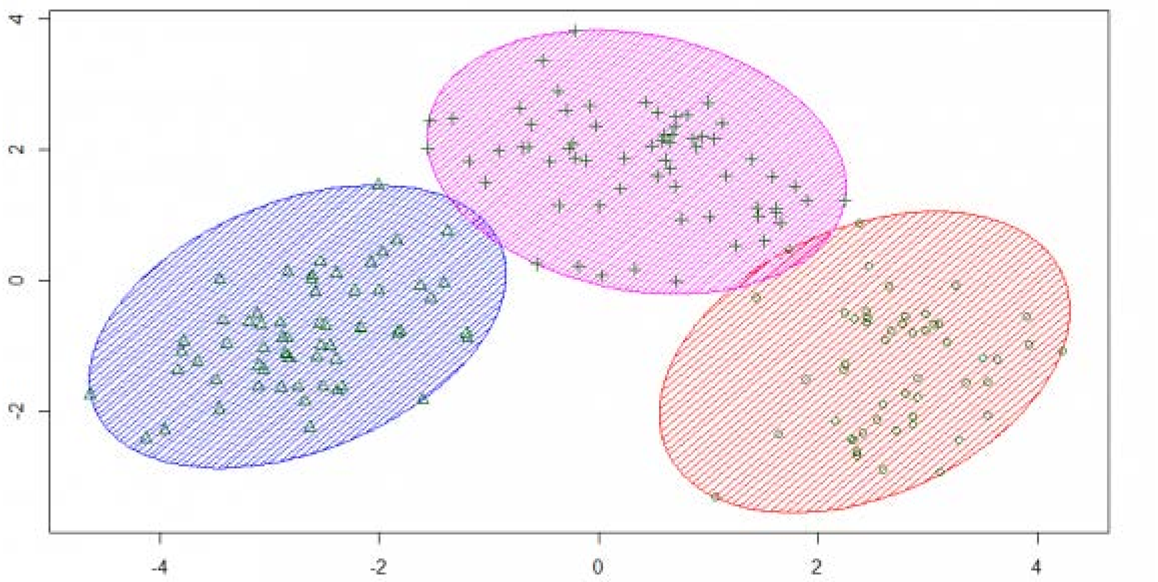
Scoping Guide: Defining Need

- Need to define "operational clusters":
  - Availability of more continuous data
  - Assess more complex alternatives, conditionally dependent
  - "Normal" operational condition is obsolete
  - Practical set of "representative" operational conditions required



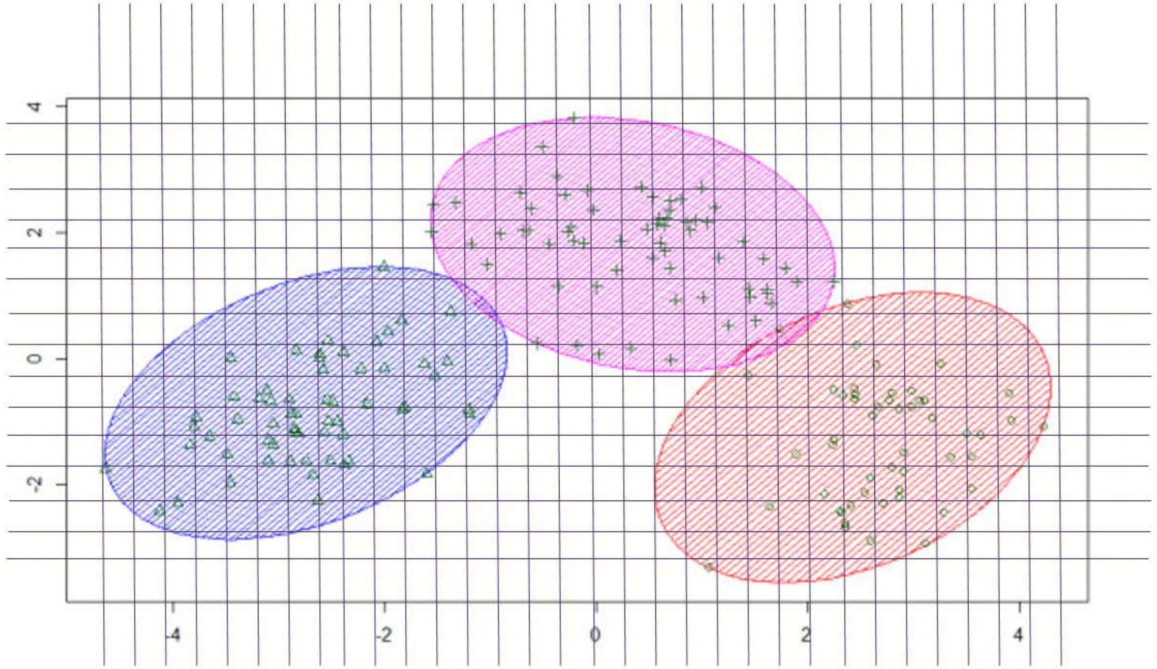
Scoping Guide: Defining Concept (1/2)

- Concept:
  - Cluster analysis
    - Time-variant traffic data
    - Min. of 30 days of contemporaneous data (required)
    - As many days as possible (uniformly drawn) from across a full calendar year (recommended)
  - Unit of observation
    - Component elements are not independent



Scoping Guide: Defining Concept (2/2)

- Concept (cont.):
  - Selecting attributes
    - Normalized attributes (travel demand, incident number, intensity and pattern, and weather conditions)
  - Enumerative or attribute stratification
    - Methods not recommended
  - Data-driven statistical methods
    - Finding a practical small set of representative operational conditions



Scoping Guide: Example

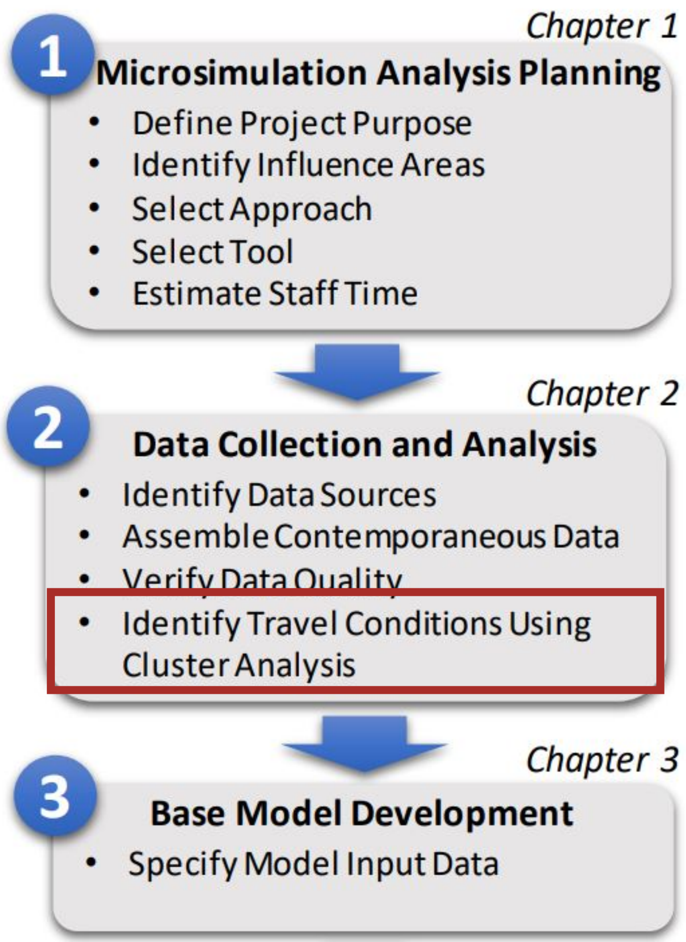
Data Summary	All	Op. Con. 1	Op. Con. 2	Op. Con. 3	Op. Con. 4	Op. Con. 5	Op. Con. 6
Periods/Days	196	40 (20%)	25 (13%)	6 (3%)	41 (21%)	28 (14%)	56 (29%)
Operational Condition Characterization		Low Demand	Low Visibility	Weather + Incidents	Many Incidents	Bottleneck Trouble	Few Incidents
Representative Day		9/6/2014	7/18/2014	2/15/2014	8/19/2014	11/1/2014	9/15/2014

Attributes	Avg.	Op. Con. 1	Op. Con. 2	Op. Con. 3	Op. Con. 4	Op. Con. 5	Op. Con. 6
North Bound Bottleneck Duration (minutes)	74.46	21.0	71.4	55.0	69.1	128.0	93.2
South Bound Bottleneck Duration (minutes)	113.6	39.4	127.2	112.5	149.3	190.7	95.9
North Bound Maximal Travel Time (minutes)	54.9	48.8	57.0	69.2	58.7	57.5	52.6
South Bound Maximal Travel Time (minutes)	63.2	45.5	69.7	90.3	67.6	74.7	61.0
Number of Incidents (count)	1.64	1.63	1.60	2.67	2.98	1.21	0.79
Maximal Incident Duration (minutes)	22.8	27.7	21.1	62.3	28.5	20.0	13.2
Visibility (miles)	8.45	9.53	2.25	3.33	9.48	9.03	9.96

Note: Operational Condition is denoted as “Op. Con.”

Vol. III: Defining Methodology (1/4)

- Step 1: Identify Attributes
  - Demand
  - Congestion sources
  - System performance
- Step 2: Process Data
  - Continuous data: leave as continuous!
  - Non-continuous data: numeric scale with all combinations



Vol. III: Defining Methodology (2/4)

- Step 3: Normalize Data
- Step 4: Down Select Attributes
  - Choose attributes highly correlated to system performance, low correlation with each other

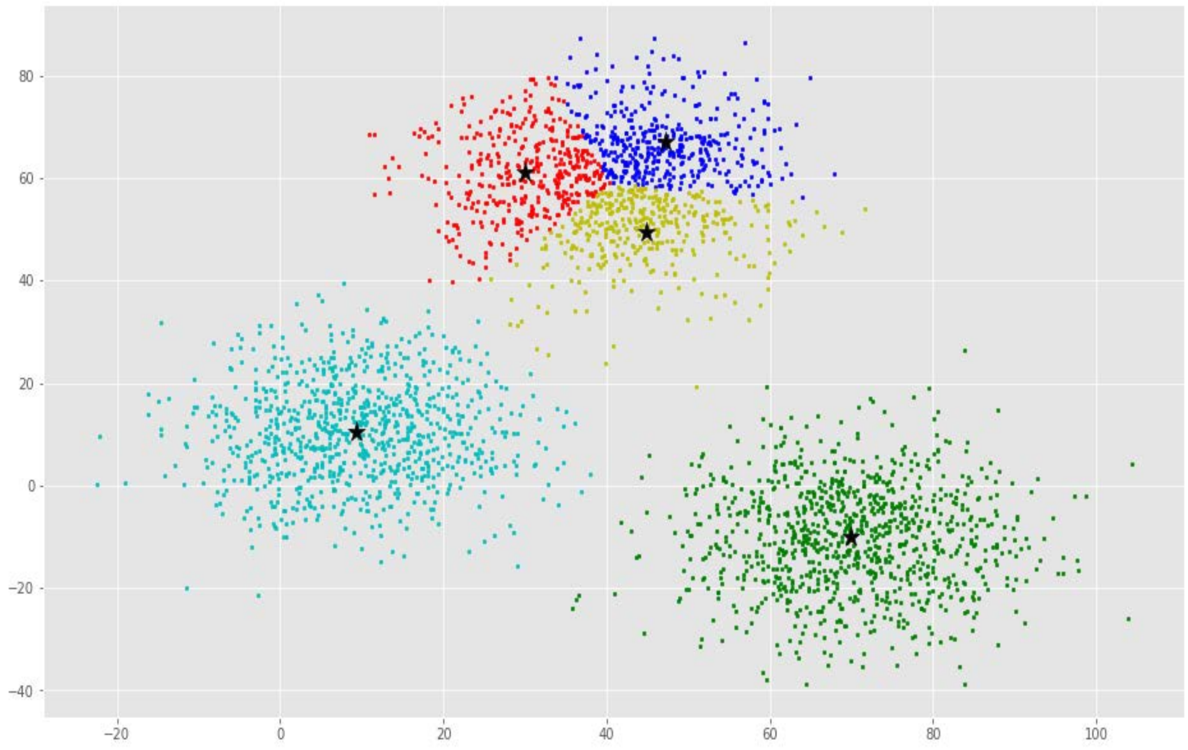
$$x' = a + \frac{(x - x_{min})(b - a)}{x_{max} - x_{min}}$$

where:

x':	normalized value of data x
x_{min}:	minimum value for the attribute (min over all x)
x_{max}:	maximum value for the attribute (max over all x)
a:	minimum value of common scale
b:	maximum value of common scale

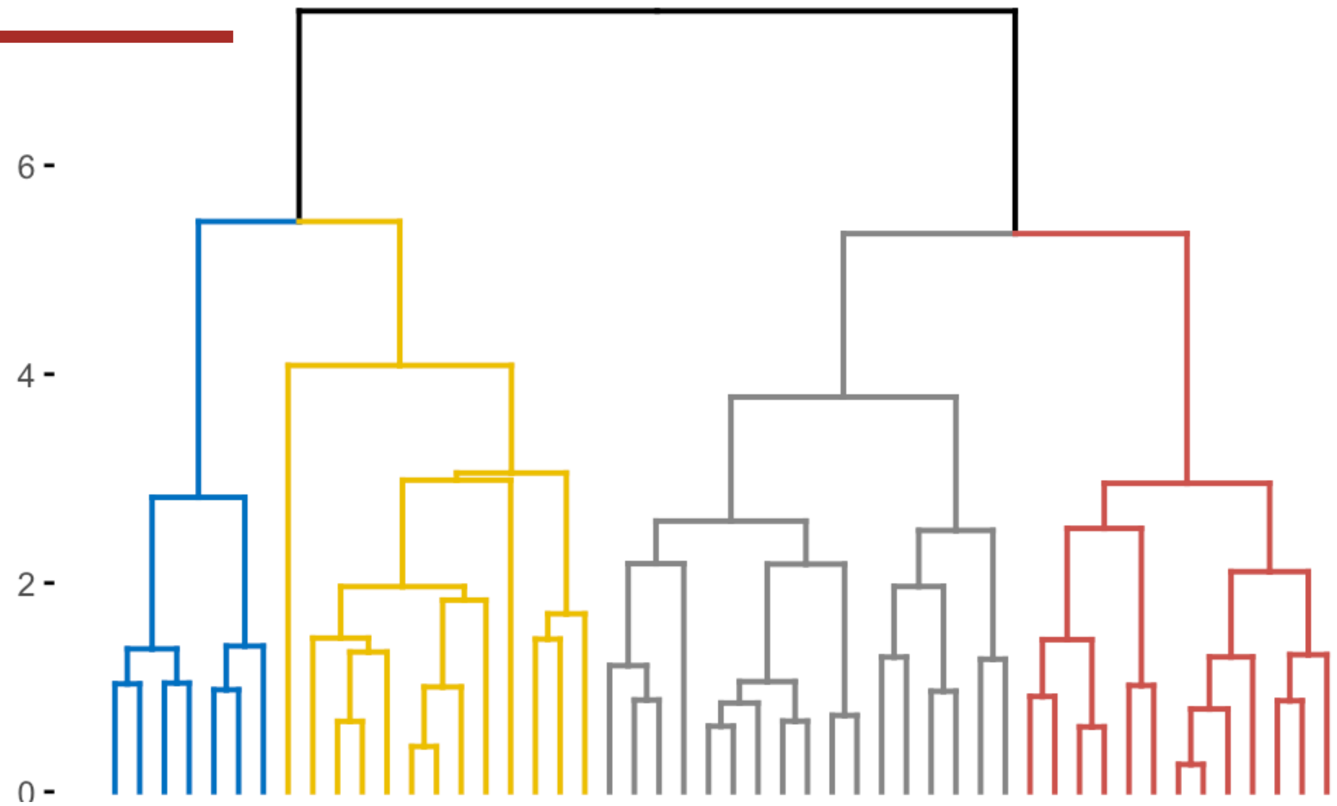
Vol. III: Defining Methodology (3A/4)

- Step 5: Perform Clustering
  - K-Means
  - Hierarchical clustering
  - Expectation maximization



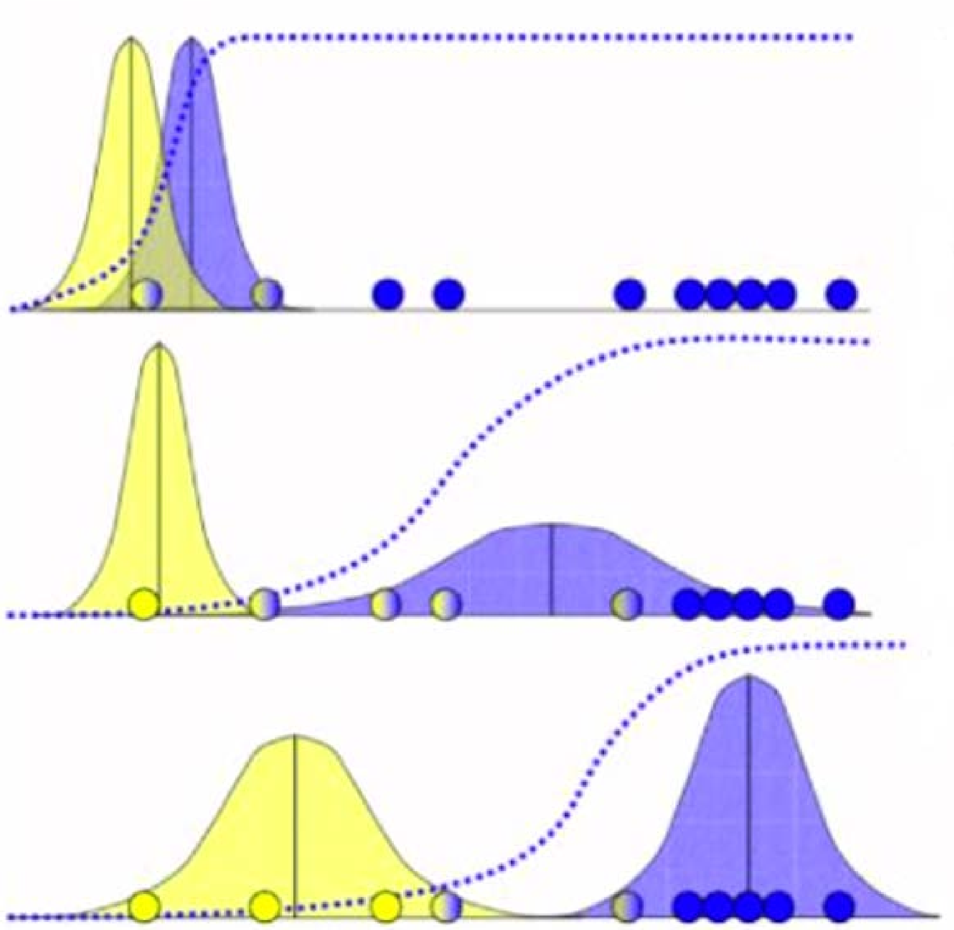
Vol. III: Defining Methodology (3B/4)

- Step 5: Perform Clustering
  - K-Means
  - Hierarchical clustering
  - Expectation maximization



Vol. III: Defining Methodology (3C/4)

- Step 5: Perform Clustering
  - K-Means
  - Hierarchical clustering
  - Expectation maximization



Vol. III: Defining Methodology (4A/4)

- Step 6: Identify Stopping Criterion

1. Set the maximum cluster size as $2 \times \sqrt{n/2}$ where n is the number of days.
2. Set k= 3 (initial cluster size).
3. Perform clustering using k clusters.
4. Calculate either of the following functions for the key measure of interest (e.g., travel times, bottleneck throughput).
   Option 1:
   $$\text{Within Cluster Variance} / \text{Between Cluster Variance} \qquad (2)$$

   Option 2:
   $$\text{Coefficient of Variation Normalized over all clusters} \times \\ \text{\# of Clusters Normalized between 3 and } 2 \times \sqrt{n/2} \qquad (3)$$
5. Repeat steps 3 and 4 by systematically incrementing k by 1 until the maximum cluster size is reached.
6. Select the optimal cluster size as the size of the cluster that minimizes the function in step 4.

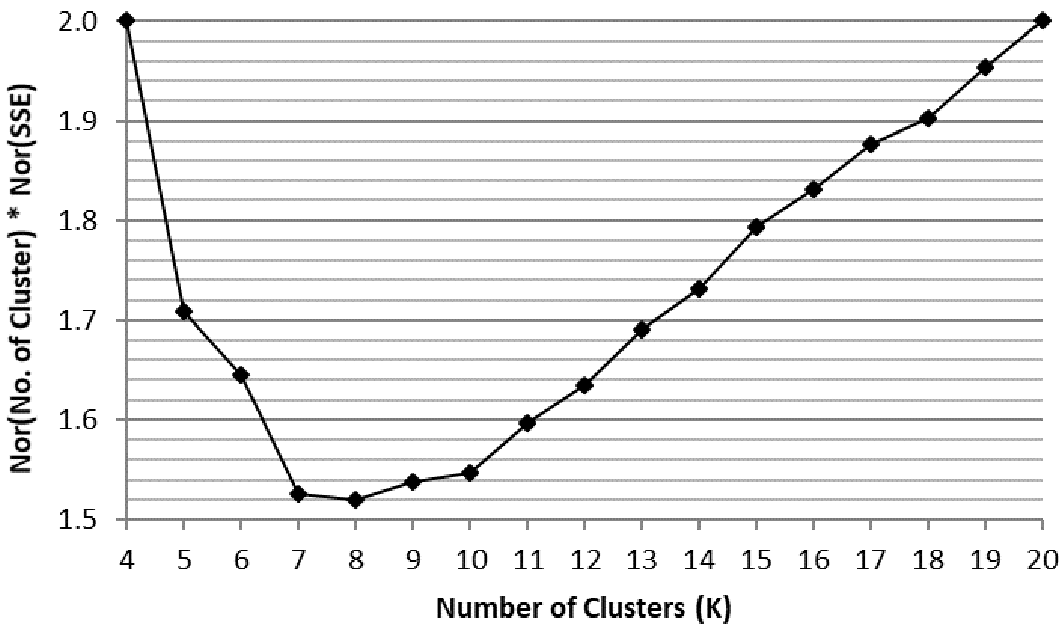
Vol. III: Defining Methodology (4B/4)

- Step 6: Identify Stopping Criterion

Option 2:

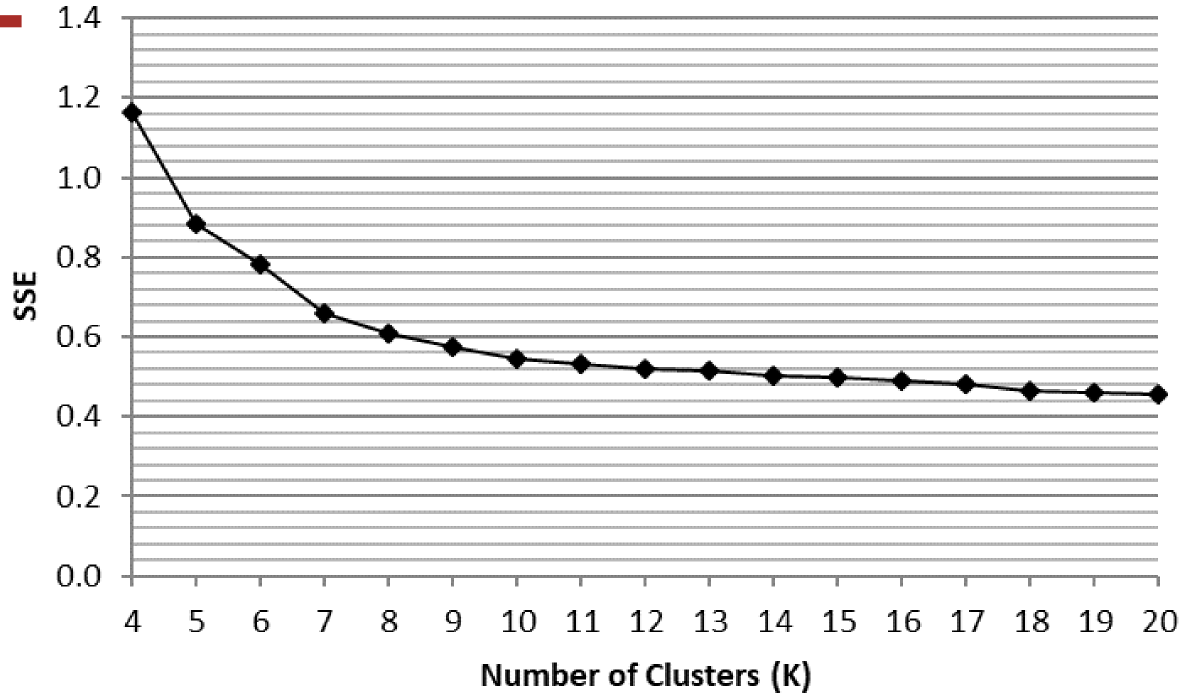
Coefficient of Variation Normalized over all clusters ×
# of Clusters Normalized between 3 and $2 \times \sqrt{n/2}$

k	SSE	Nor(k)	Nor(SSE)	Index
4	1.161	1.000	2.000	2.000
5	0.885	1.063	1.608	1.709
6	0.782	1.125	1.463	1.646
7	0.657	1.188	1.285	1.526
8	0.608	1.250	1.216	1.520
9	0.576	1.313	1.171	1.537
10	0.544	1.375	1.125	1.547
11	0.534	1.438	1.111	1.597
12	0.519	1.500	1.090	1.635
13	0.513	1.563	1.082	1.690
14	0.502	1.625	1.065	1.731
15	0.500	1.688	1.062	1.793
16	0.488	1.750	1.046	1.831
17	0.481	1.813	1.036	1.877
18	0.466	1.875	1.014	1.902
19	0.461	1.938	1.008	1.954
20	0.456	2.000	1.000	2.000



Focus of Research (1/2)

- Step 6: Identify Stopping Criterion
  - Heuristic fitness index (proposed)
  - Elbow method (common)
  - Cluster validity indices
    - Silhouette Index
    - Davies-Bouldin (DB) Index
    - Dunn's Index
    - Calinski Harabasz (CH) Index
    - Others



Focus of Research (2/2)

- Step 6: Identify Stopping Criterion
  - Heuristic fitness index (proposed)
  - Elbow method (common)
  - Cluster validity indices
    - Silhouette Index
    - Davies-Bouldin (DB) Index
    - Dunn's Index
    - Calinski Harabasz (CH) Index
    - Others

$$S_i = \frac{1}{|C_i|} \sum_{X \in C_i} \{||X - Z_i||\} \quad (1)$$

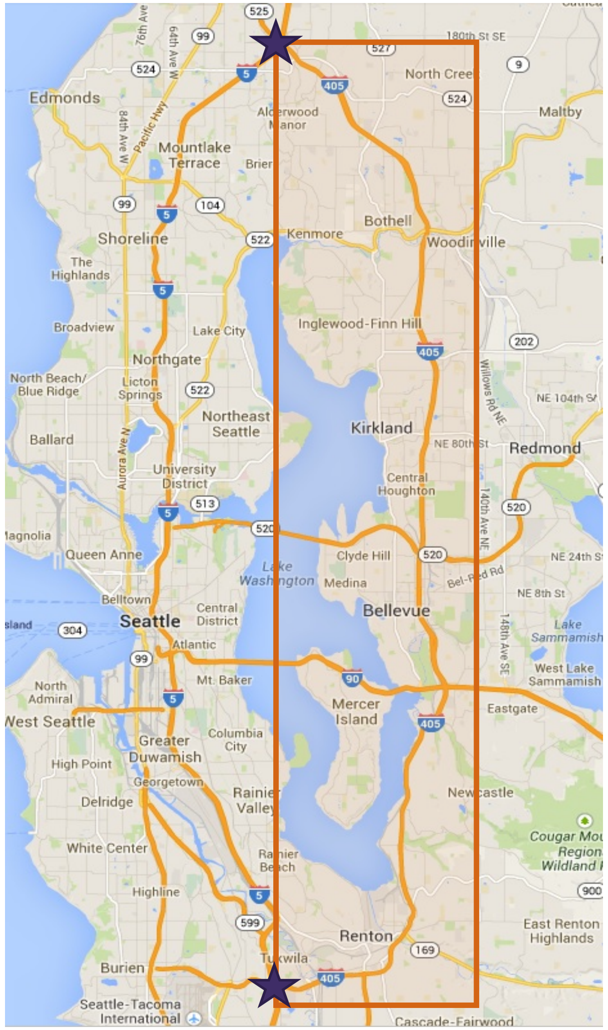
$$d_{ij} = \{||Z_i - Z_j||\} \quad (2)$$

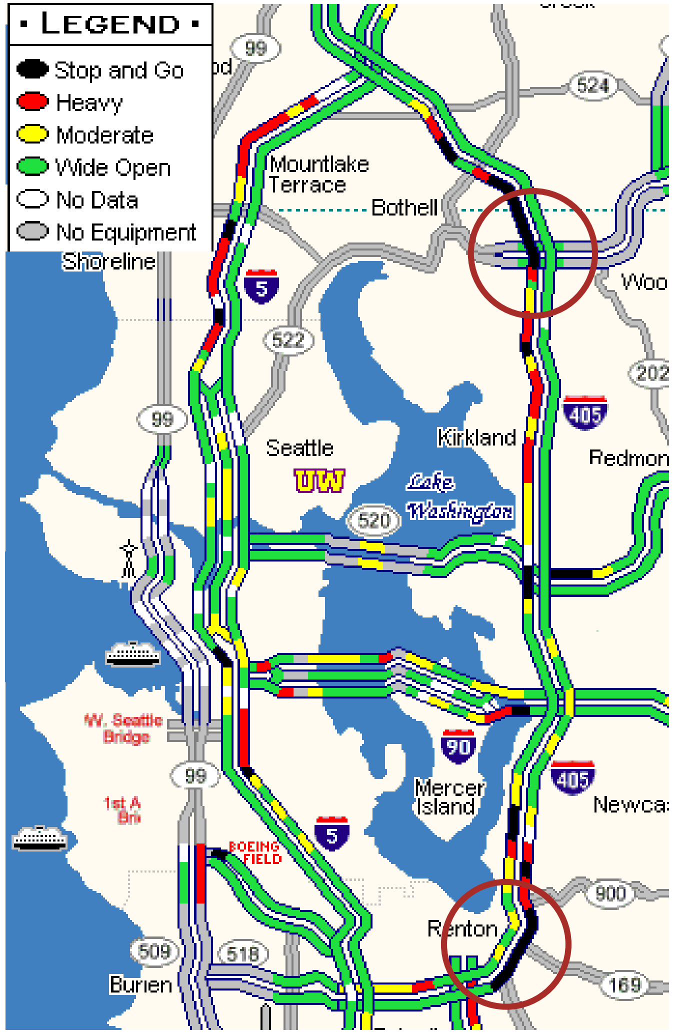
$$R_i = \max_{j, j \neq i} \{\frac{S_i + S_j}{d_{ij}}\} \quad (3)$$

$$I_{DB} = \frac{1}{D} \frac{1}{K} \sum_{i=1}^{K} R_i \quad (4)$$

Case Study

- I-405 Corridor
  - Major congested corridor in Seattle area
  - Subject to frequent rain/fog
  - Identified bottlenecks
    - Weaving area/complex interchange/merging traffic
- Utilized 2012 data





Data and Possible Attributes (1/2)

Volume
Each detector
Total throughput (w/in peak)
Avg. throughput (per 15 min)
Max. 15-min throughput
Min. 15-min throughput
Corridor-level (all detectors)
Avg. total throughput (per detector)
Std. dev. of total throughput
Other "distance" function

* 15 directional, mainline traffic detectors (roughly 2 miles apart)
** 15-min resolution

Speed
Each detector
Avg. speed (over the peak period)
Max. speed
Min. speed
Std. dev.
Bottleneck location
Avg. speed
Min. speed
Total bottleneck duration
# of times (# of intervals) speeds drop below threshold
Corridor-level (using all detectors)
Avg. of avg. speed (per detectors)
Std dev. of avg. speed
Other "distance" function

* Only 9 NB and 10 SB had quality speed data
** 15-min resolution

Travel Time
Corridor-level
Avg.
Min.
Max.
Std. dev.
Median

* Entire corridor, directional
** 5-min resolution

Data and Possible Attributes (2/2)

Weather
Precipitation
Total (w/in peak)
Avg. (hourly rate)
Max. (hourly rate)
Min. (hourly rate)
Visibility
Avg.
Max.
Min.
Wind speed
Avg.
Max.
Min.
Temperature
Avg.
Max.
Min.

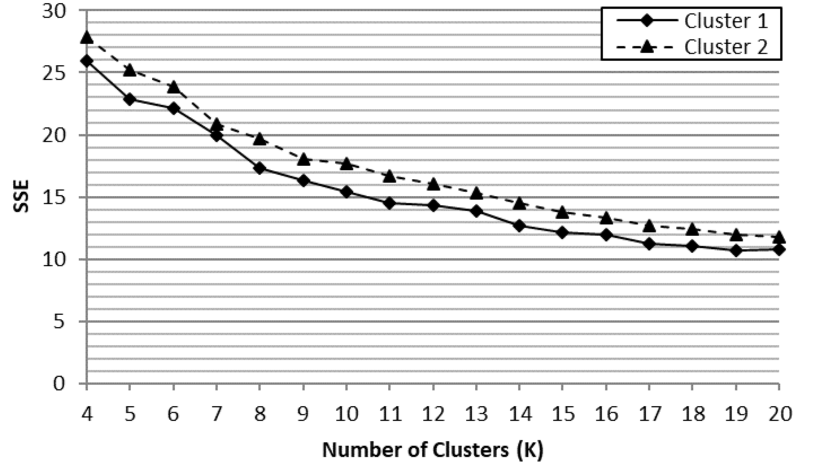
Incidents
All incidents
Total number (w/in peak)
Total duration (w/in peak)
Avg. duration (per incident)
Max incident duration
Total number of vehicles (w/in peak)
Avg. number of vehicles (per incident)
Max number of vehicles (per incident)
Incident involving a closure
Total number (w/in peak)
Total duration (w/in peak)
Avg. duration (per incident)
Total vehicles involved (per incident)
Max. vehicles involved (in incident)
Incidents involving a multi-lane closure
Total number (w/in peak)
Total duration (w/in peak)
Avg. duration (per incident)
Max. incident duration

* Many other variables
** Approx. 1-hr resolution

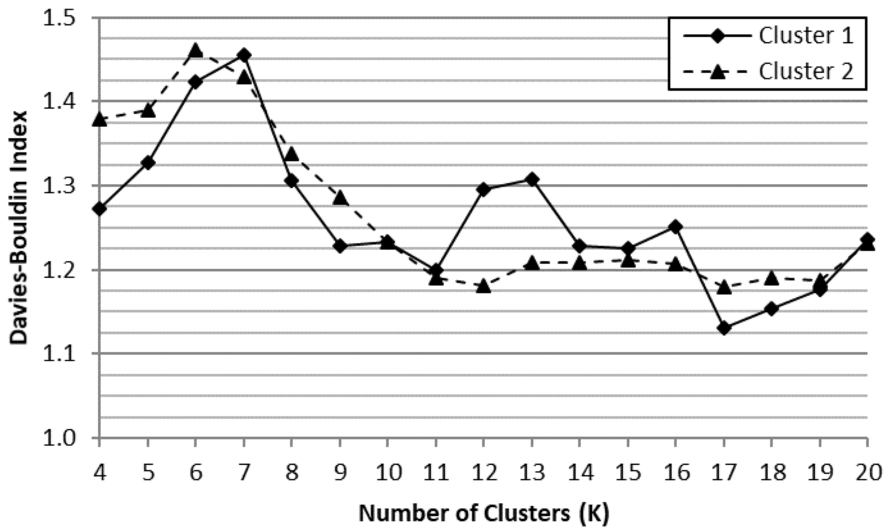
* Also incident and lane closure type
** Non-continuous variable

Investigations (1/4)

Cluster 1	Cluster 2
*Avg. travel time	"
*Total # of incidents	"
*Total incident duration (lane closure)	"
*Avg. visibility	*Min. visibility
*Total precipitation	"



1: 8
2: 7



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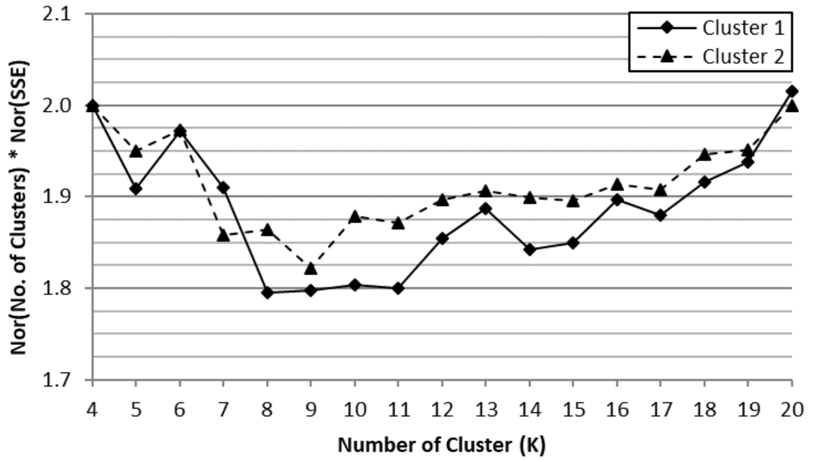
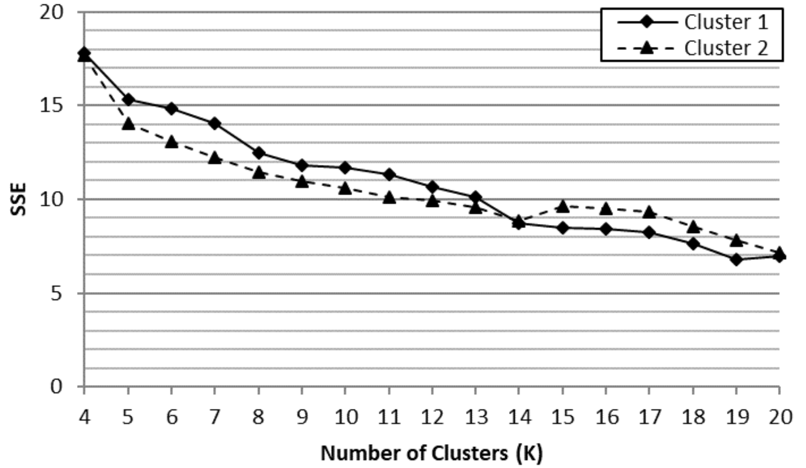


1: 8
2: 9

Investigations (2/4)

Cluster 1	Cluster 2
*Max. travel time	"
*Total # of incidents	"
*Total incident duration	"
*Min. visibility	*Avg. visibility
*Total precipitation	*Max. precipitation



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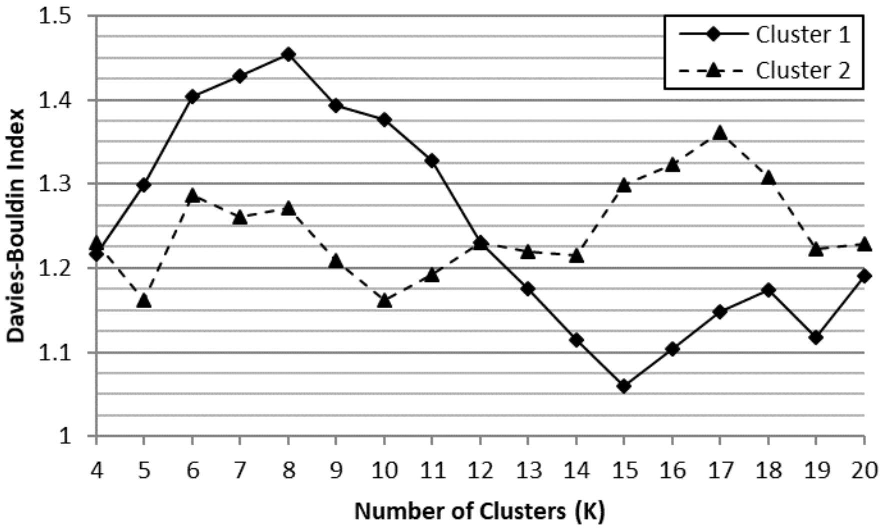

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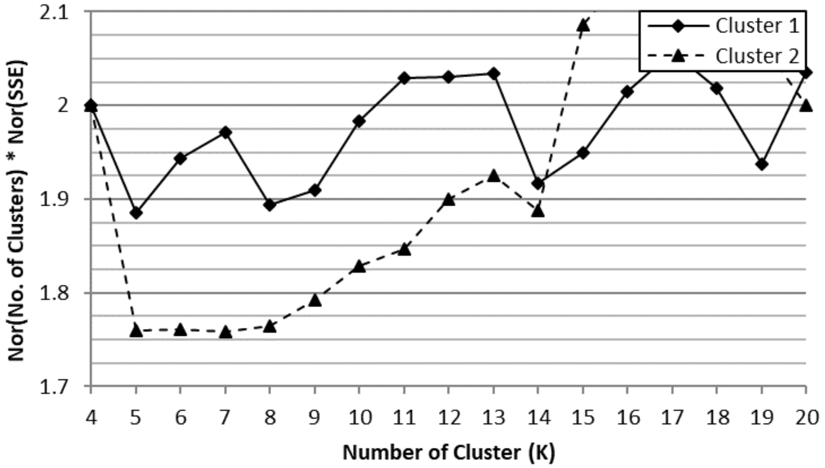
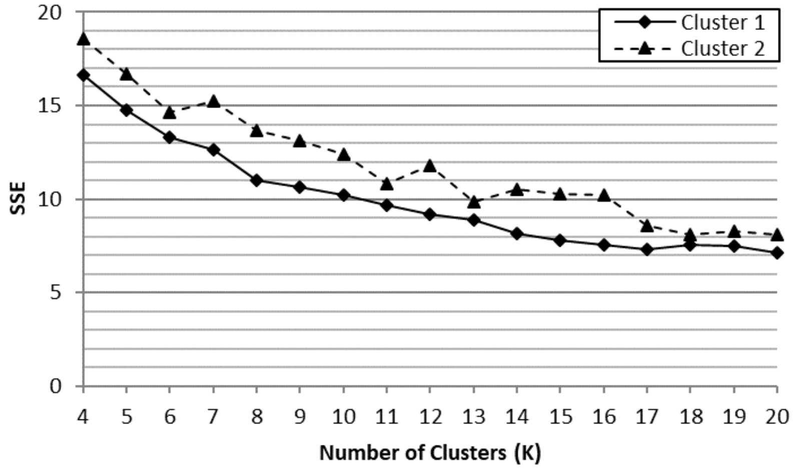


1: 5
2: 5

Investigations (3/4)

Cluster 1	Cluster 2
*Avg. travel time	"
*Avg. incident duration	*Max. incident duration
*Total number of incidents w/ lane closure	"
*Min. visibility	"
*Total precipitation	"



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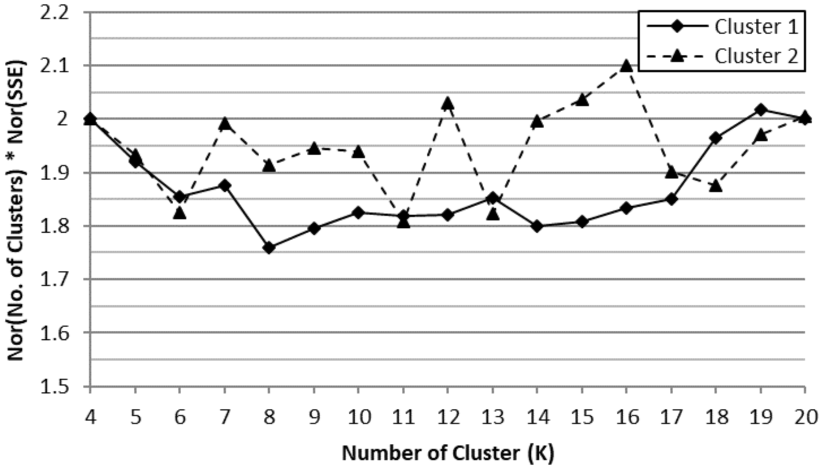

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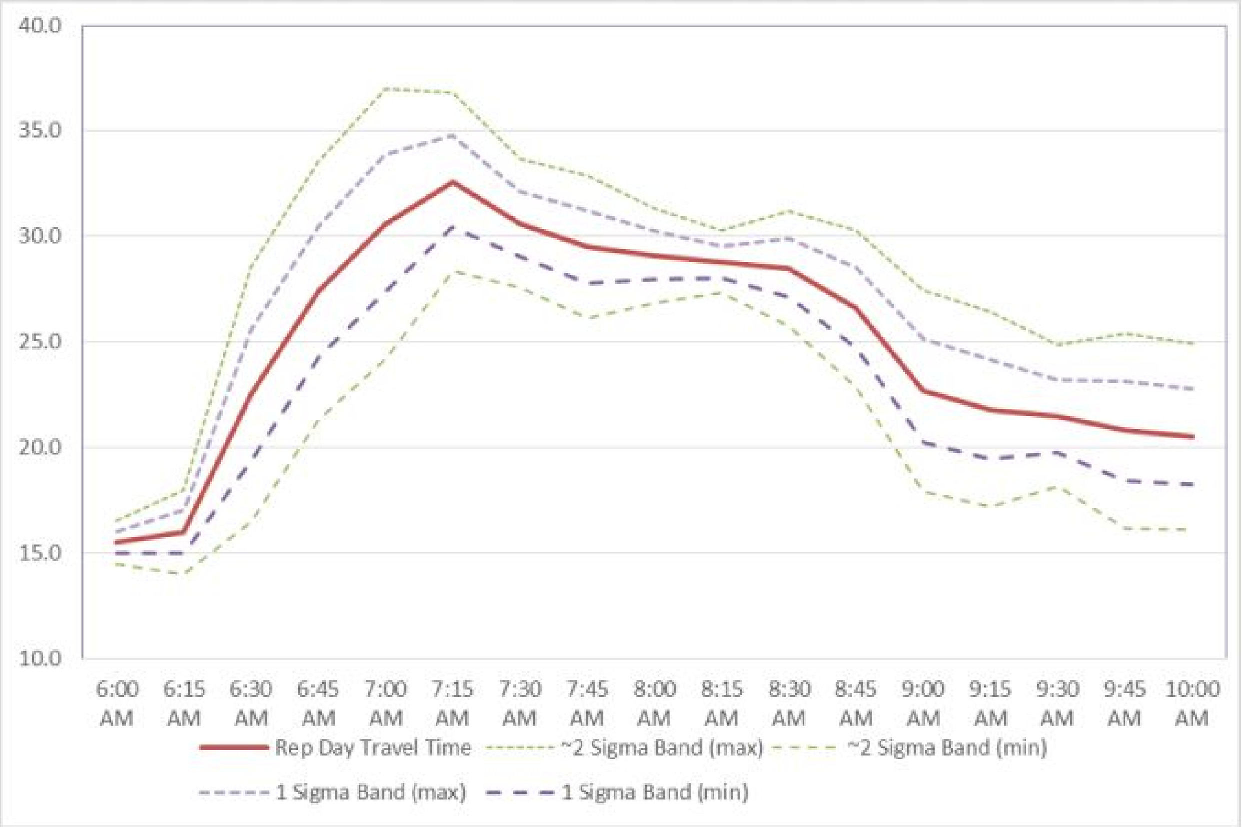
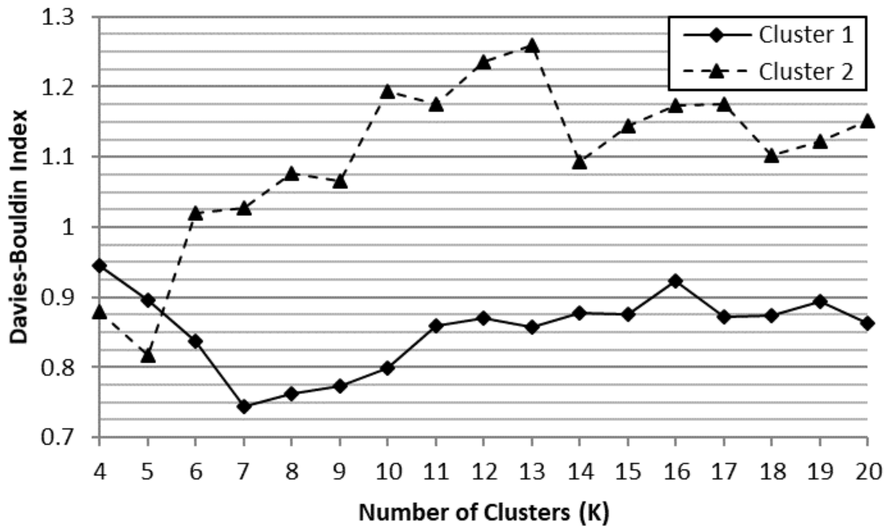
Ensuring Representation

- Profile vs. aggregate data
  - Assume distribution (Avg., std. dev).



Investigations (4/4)

Cluster 1	Cluster 2
*Travel time readings (48)	*Avg. travel time *Std. dev. (of travel time)



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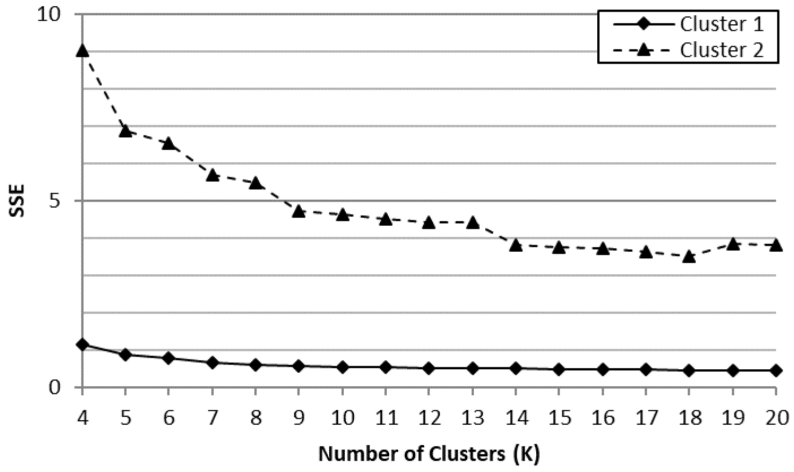

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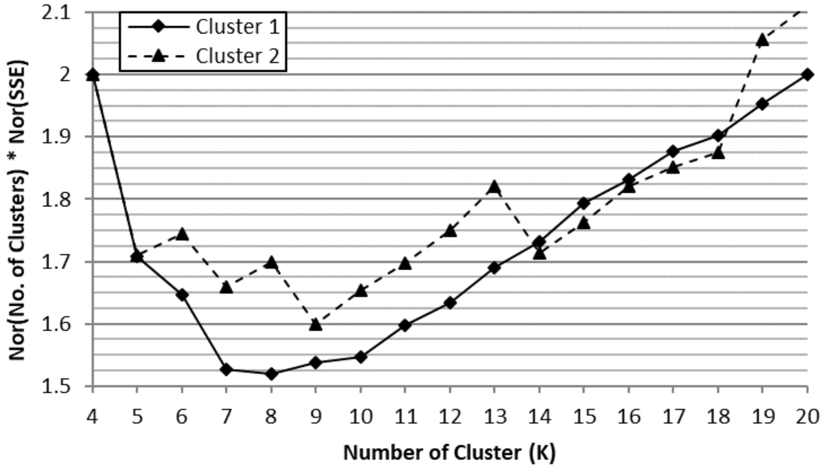

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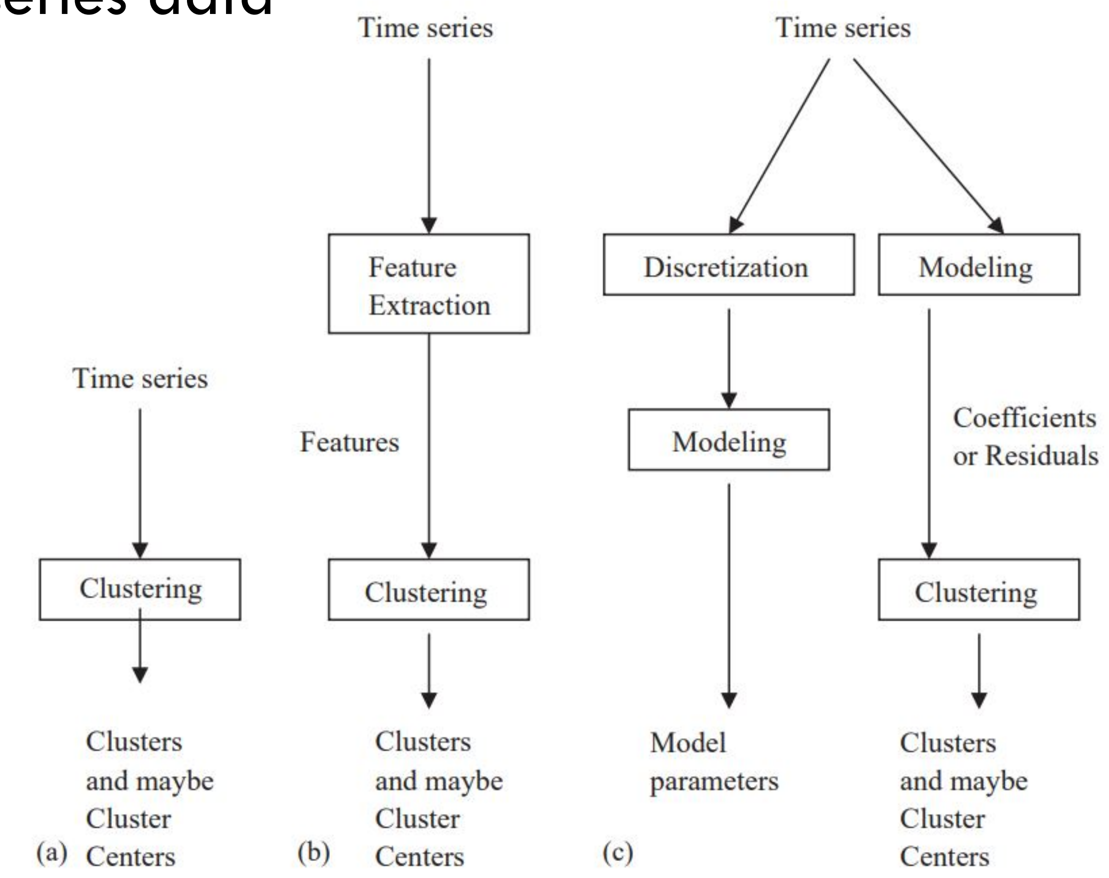
Further Research

- Clustering time-series data



Questions?

Pong Wu
Capital Region Planning Commission

CRPC Transportation

Regional Model Update & Development

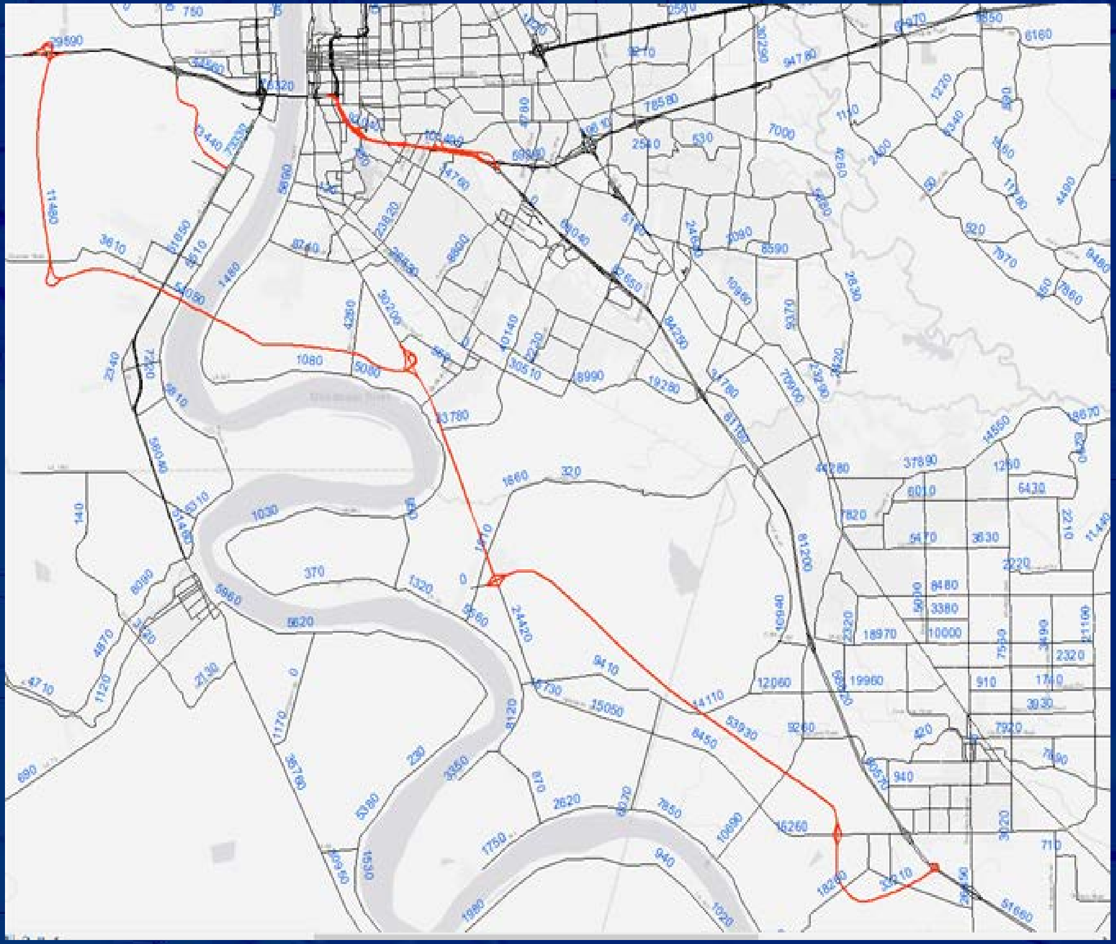
September 12, 2019

Preliminary Scenarios Analysis for New Bridge Locations

North Option (Brusly to Baton Rouge)

Scenario 1: **Conventional - North Bridge**

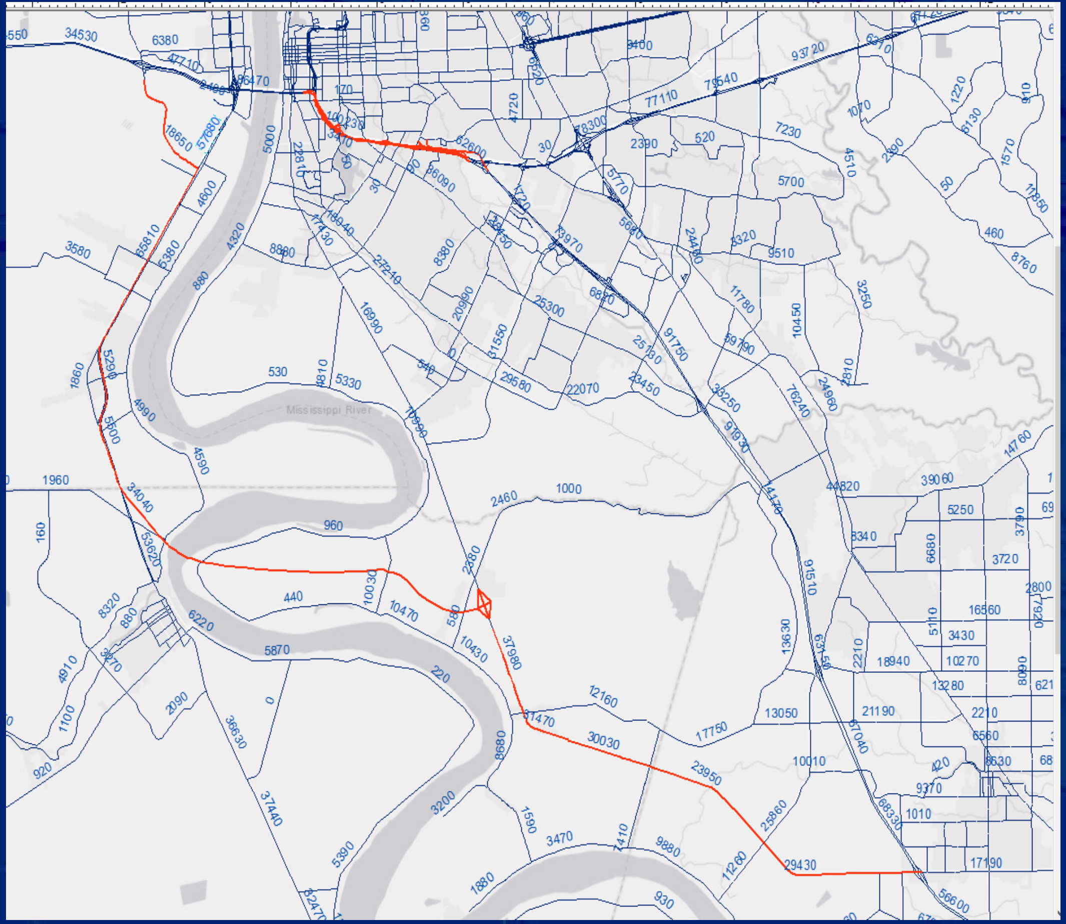
Scenario 4: **Freeway - North Bridge**



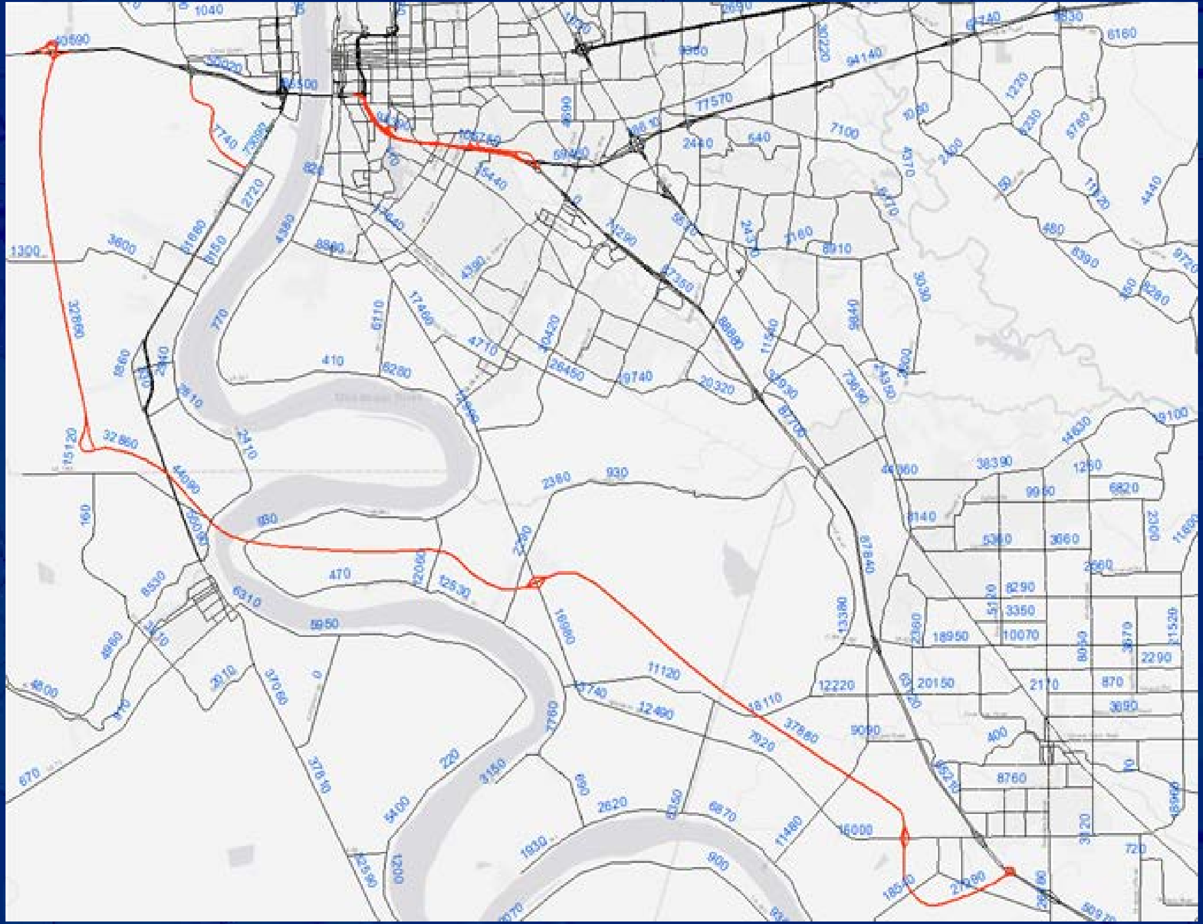
Preliminary Scenarios Analysis for New Bridge Locations

Middle Option (Plaquemine to St. Gabriel)

Scenario 2: **Conventional – Mid-Bridge**



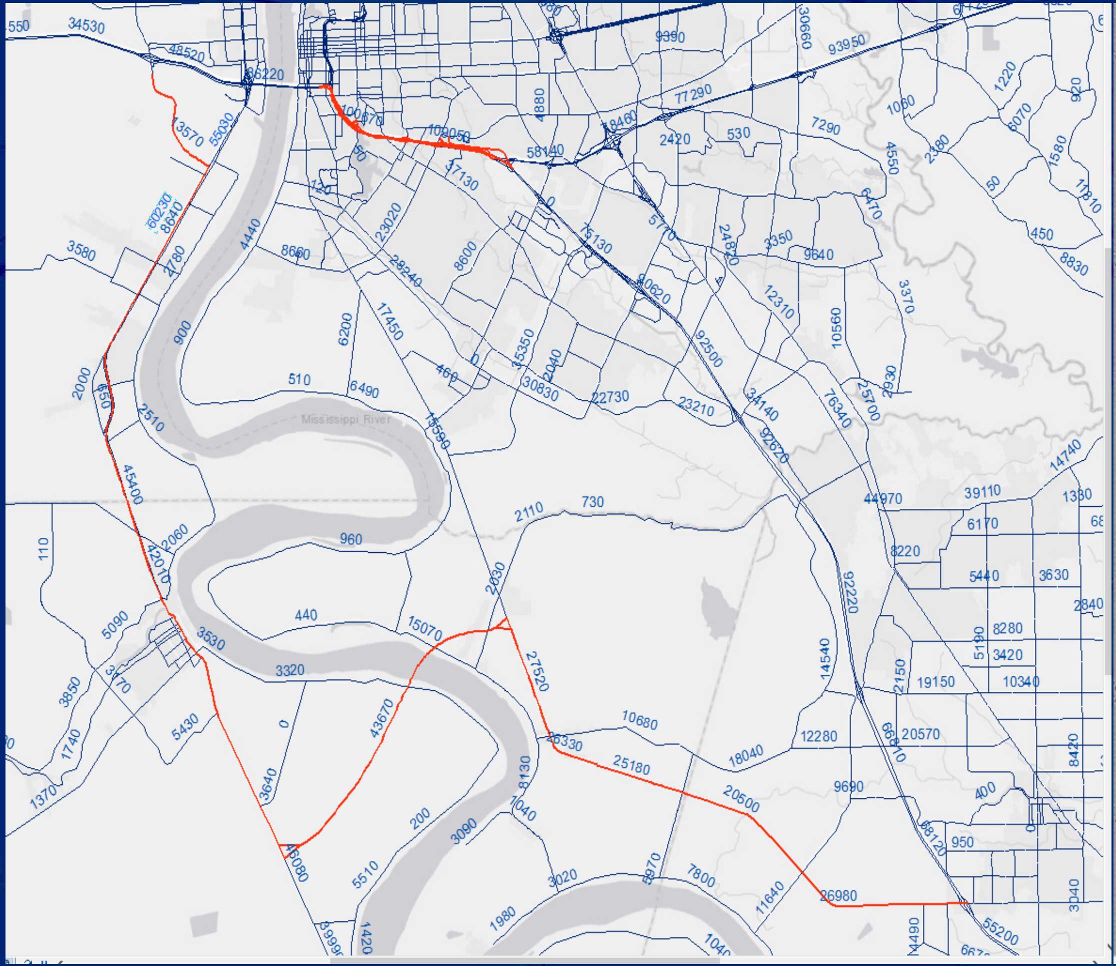
Scenario 5: **Freeway – Mid-Bridge**



Preliminary Scenarios Analysis for New Bridge Locations

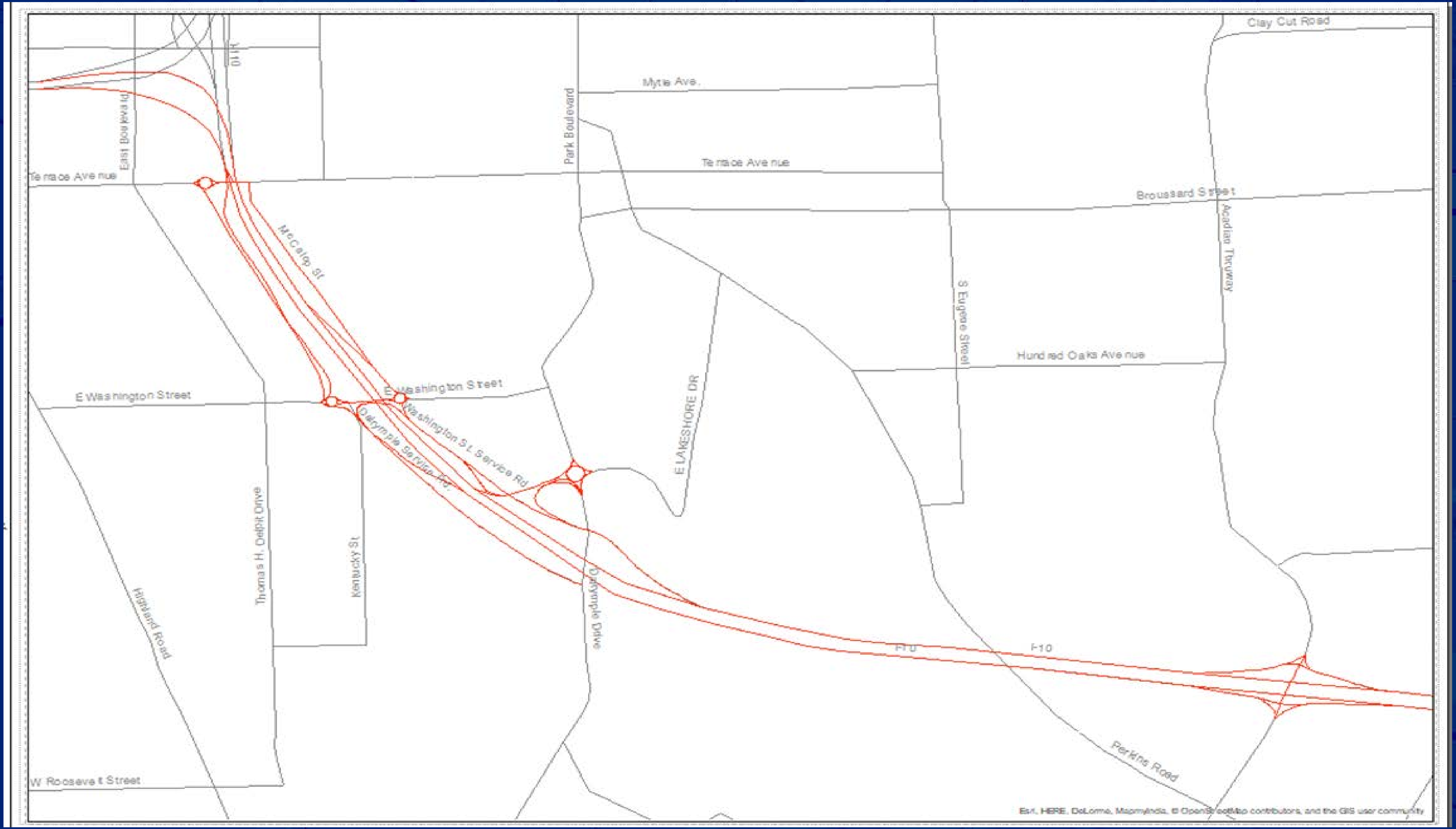
South Option (South of Plaquemine to St. Gabriel)

Scenario 3: **Conventional - South Bridge**



Scenario 6: **Freeway - South Bridge**

Preliminary Scenarios Analysis for New Bridge Locations



Preliminary Scenarios Analysis for New Bridge Locations

Preliminary Scenarios Analysis for New Bridge Locations

For the purpose to compare the improvement of roadway congestion by scenario, following seven scenarios were used in the bridge location and modeling analysis:

Base Network Condition:

A. 2042 Existing network condition + Committed improvements + I-10 Expansion Projects

Conventional Option:

B. A + Scenario 1 (Conventional North-Bridge) + LA415 Extension
C. A + Scenario 2 (Conventional Mid-Bridge) + LA415 Extension
D. A + Scenario 3 (Conventional South-Bridge) + LA415 Extension

Freeway Option (West Expway):

E. A + Scenario 4 (Freeway North-Bridge) + LA415 Extension
F. A + Scenario 5 (Freeway Mid-Bridge) + LA415 Extension
G. A + Scenario 6 (Freeway South-Bridge) + LA415 Extension

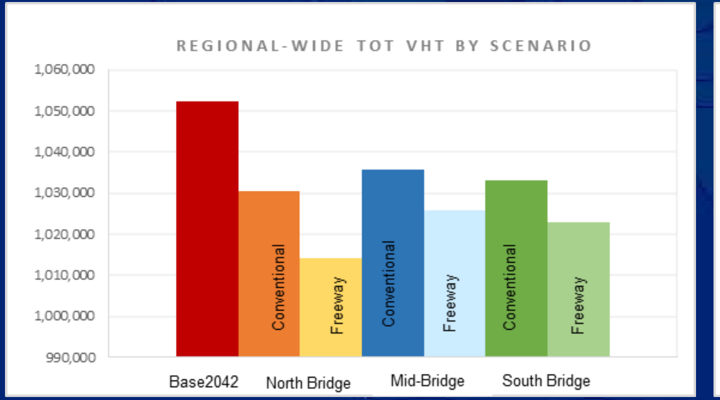
Preliminary Scenarios Analysis for New Bridge Locations

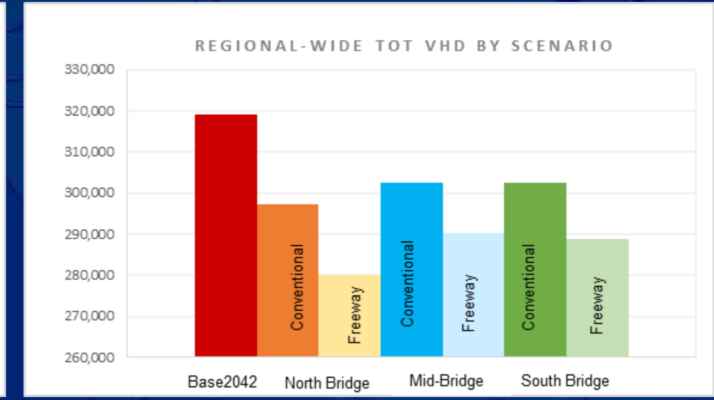
Comparing Daily Traffic Reduction at Targeted Locations

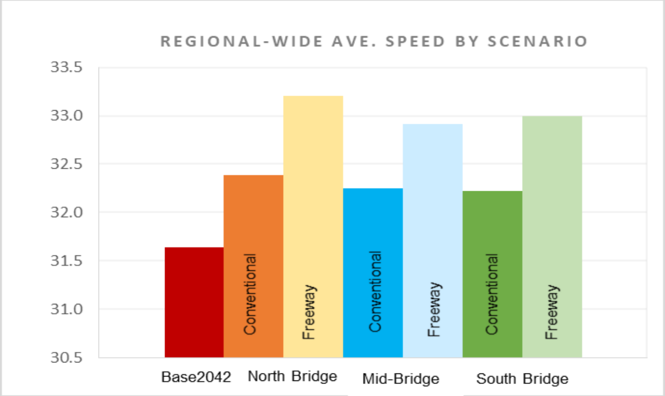
Segment Daily Volume	Forecasted 2042 Base-Network Condition (A)	North Bridge				Mid-Bridge				South-Bridge			
		Conventional (1)	% Reduction	Freeway (4)	% Reduction	Conventional (2)	% Reduction	Freeway (5)	% Reduction	Conventional (3)	% Reduction	Freeway (6)	% Reduction
I10 (Pecue Ln to Highland)	93,950	90,630	-4%	84,250	-10%	91,750	-2%	88,880	-5%	92,500	-2%	89,890	-4%
Existing MRB	95,360	80,920	-15%	76,320	-20%	86,470	-9%	85,550	-10%	86,220	-10%	85,760	-10%
I10 (E of LA 415)	51,800	46,960	-9%	44,560	-14%	47,710	-8%	50,020	-3%	48,520	-6%	51,570	0%
Airline (Pecue Ln to Antioch Rd)	74,150	72,290	-3%	68,630	-7%	72,750	-2%	71,120	-4%	73,200	-1%	71,590	-3%
I10 off-ramp to Corporate Blvd	7,440	7,110	-4%	7,240	-3%	7,100	-5%	7,270	-2%	7,220	-3%	7,270	-2%
I10 off-ramp to College	16020	15740	-2%	15180	-5%	16060	0%	15810	-1%	15890	-1%	15870	-1%

Preliminary Scenarios Analysis for New Bridge Locations

Measurement	Forecasted 2042 Base-Network Condition (A)	North Bridge				Mid-Bridge				South-Bridge			
		Conventional (1)	% Change	Freeway (4)	% Change	Conventional (2)	% Change	Freeway (5)	% Change	Conventional (3)	% Change	Freeway (6)	% Change
TOT_VMT (Mile)	33,294,731	33,375,470	0.24%	33,678,477	1.15%	33,401,455	0.32%	33,764,819	1.41%	33,295,674	0.00%	33,751,854	1.37%
TOT_VHT (Hour)	1,052,217	1,030,630	-2.05%	1,014,193	-3.61%	1,035,651	-1.57%	1,025,856	-2.51%	1,033,188	-1.81%	1,023,033	-2.77%
TOT_VHD (Hour)	319,264	297,435	-6.84%	280,113	-12.26%	302,497	-5.25%	290,294	-9.07%	302,584	-5.22%	288,951	-9.49%
Ave. Speed (Mi/H)	31.6	32.4	2.34%	33.2	4.94%	32.3	1.93%	32.9	4.02%	32.2	1.84%	33.0	4.26%

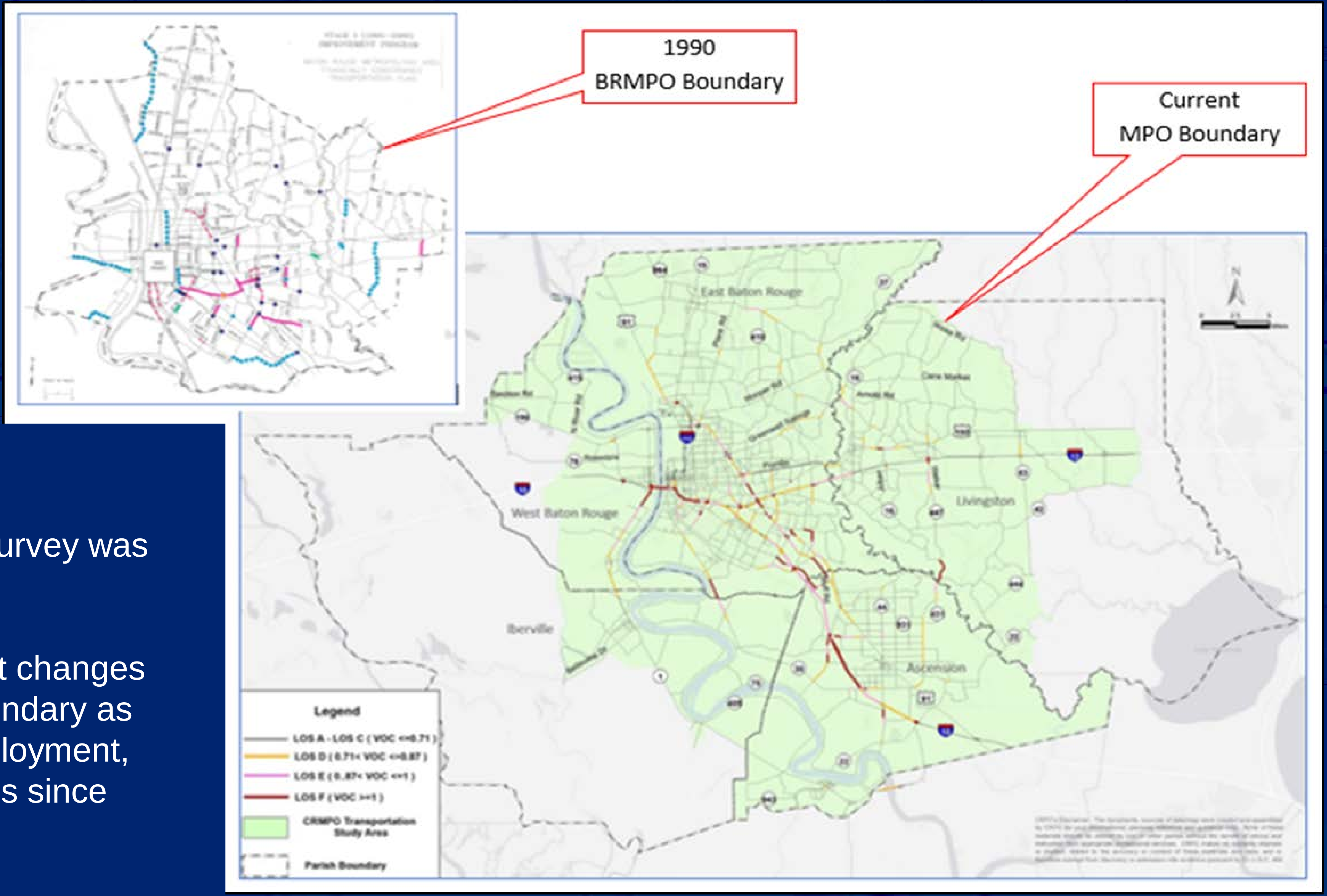






CRPC Transportation

Regional Model Update & Development



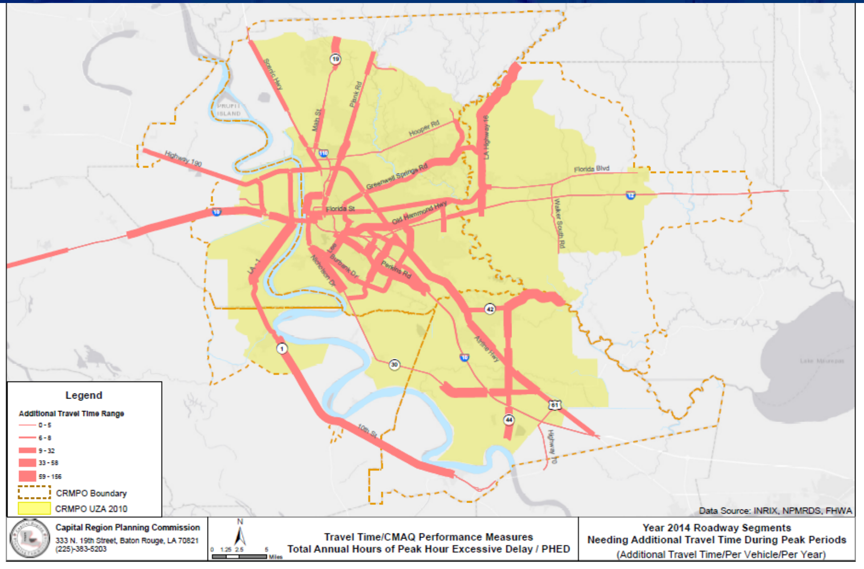
The last household travel survey was conducted in 1990.

There have been significant changes in Capital Region MPO boundary as well as demographics, employment, land use, and travel patterns since 1990

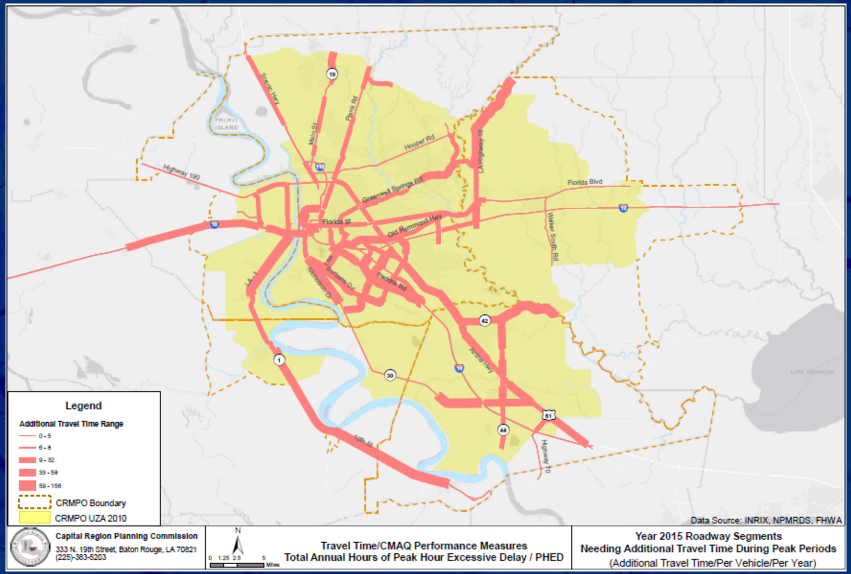
Regional Model Development – Calibration/Validation Using NPMRDS Observed link-based Speed & Travel Time Data

1-NPMRDS Observed Network Segments Speeds, Additional Travel Time on Segment Per Vehicle by Year were analyzed

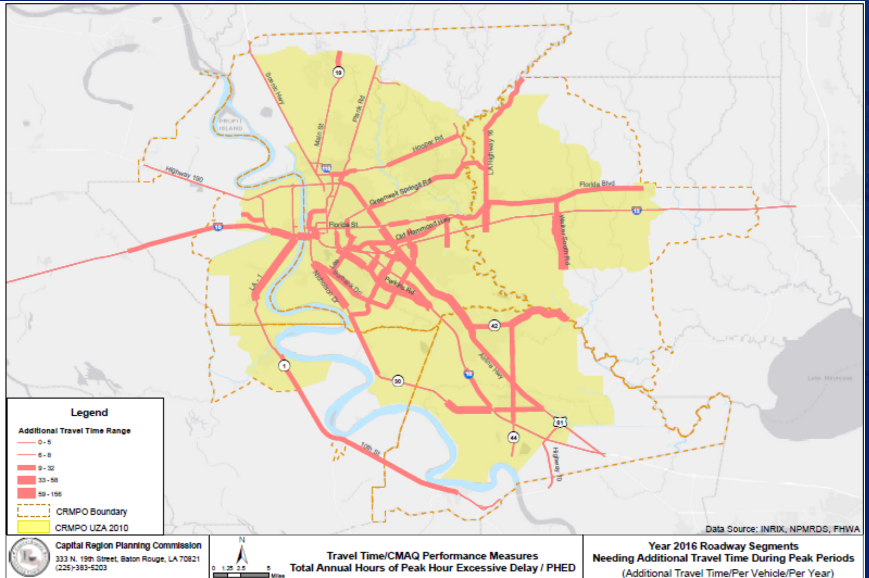
2014



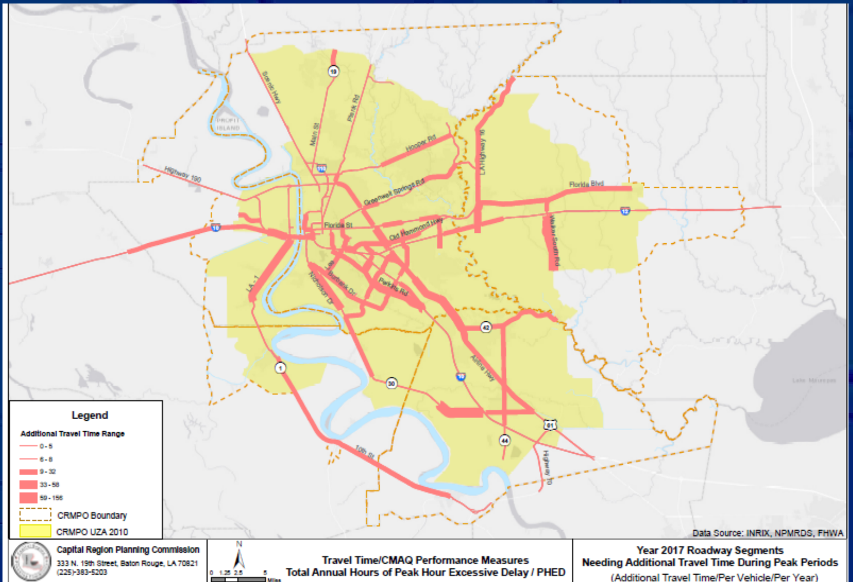
2015



2016



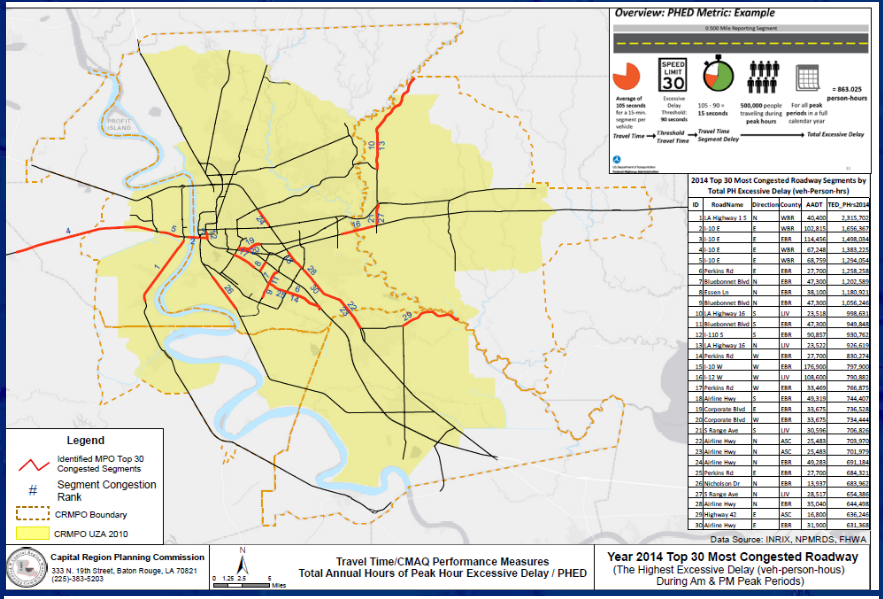
2017



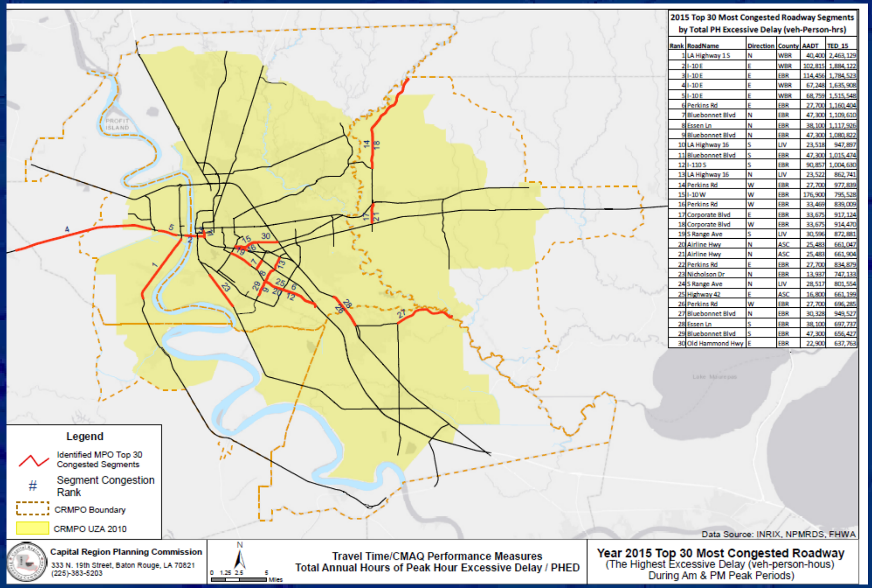
Regional Model Development – Calibration/Validation Using NPMRDS Observed link-based Speed & Travel Time Data

2- Roadway Segments Peak-Hour Excessive Delay (PHED) /Veh-person-hours by Year were analyzed and the most congested roadway segments during year were identified

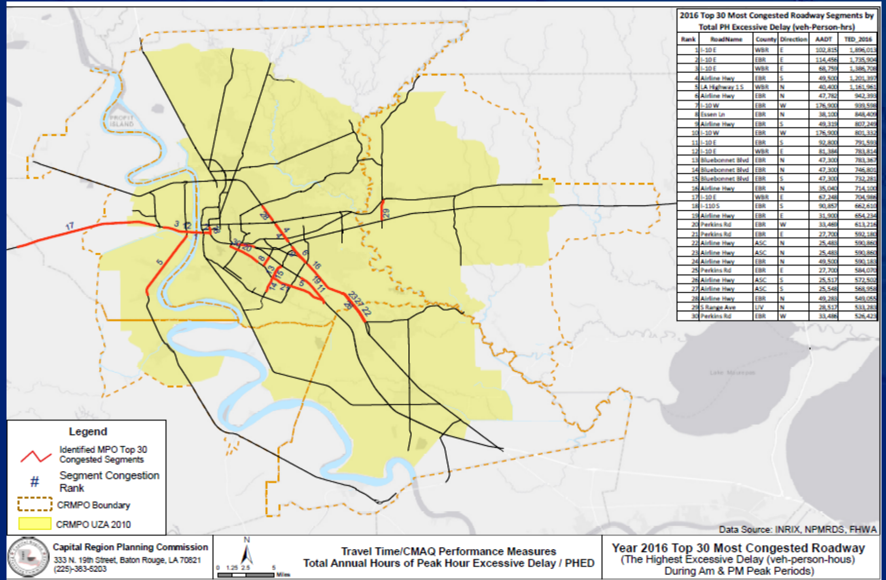
2014



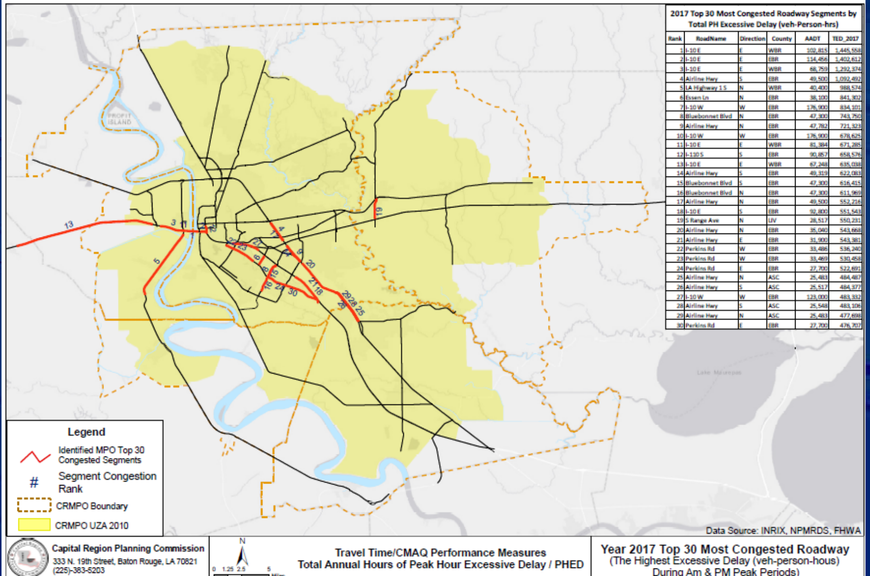
2015



2016



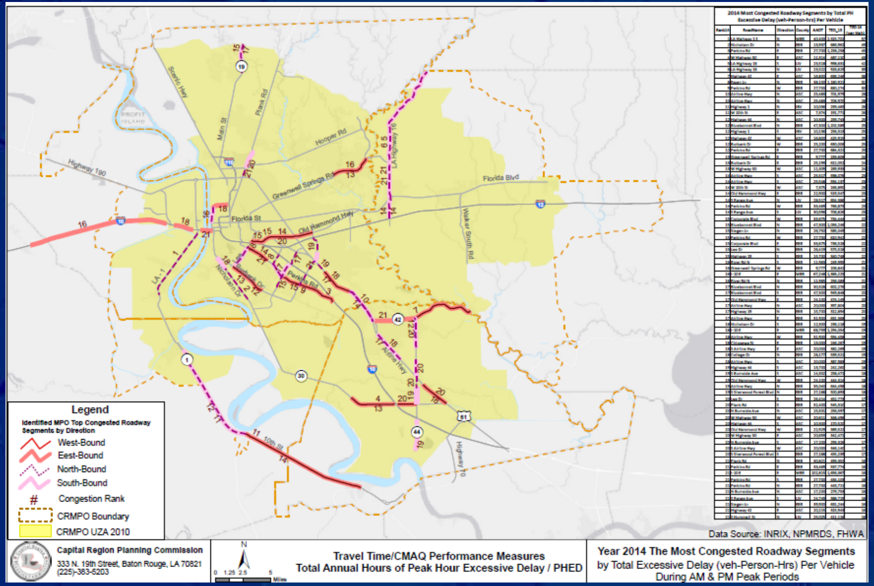
2017



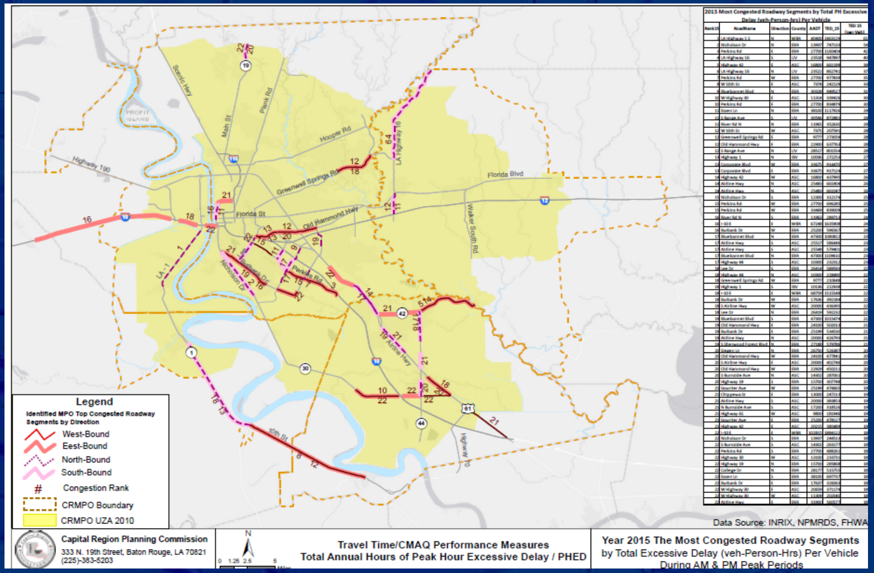
Regional Model Development – Calibration/Validation Using NPMRDS Observed link-based Speed & Travel Time Data

3- Roadway Segments Total Excessive Delay (PHED) per Vehicle by Year were analyzed and the most congested roadway segments during year were identified

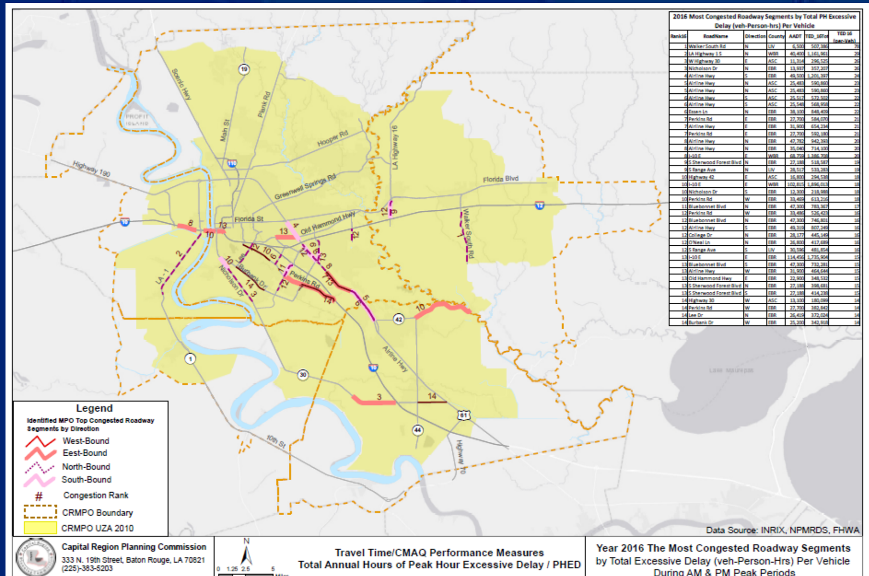
2014



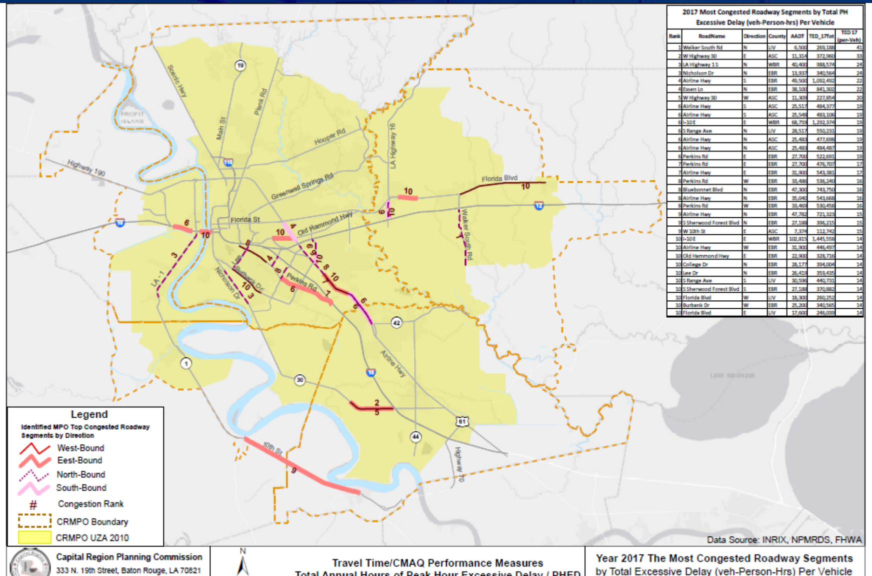
2015



2016

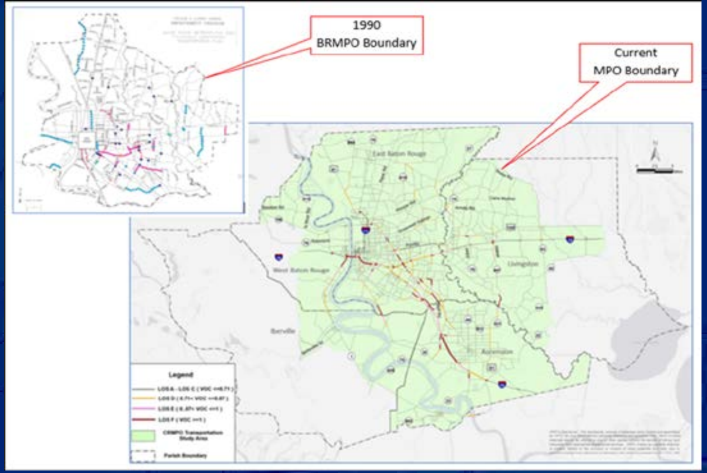


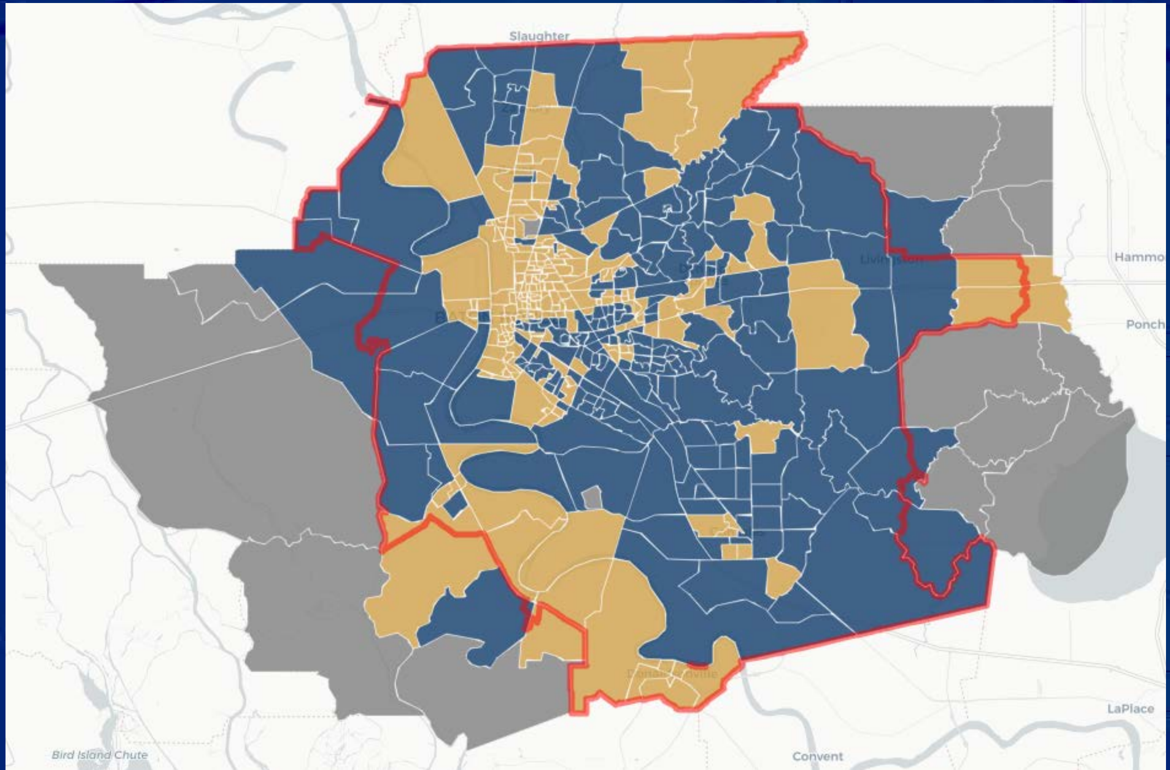
2017



CRPC Transportation

Capital Region Household Travel Survey



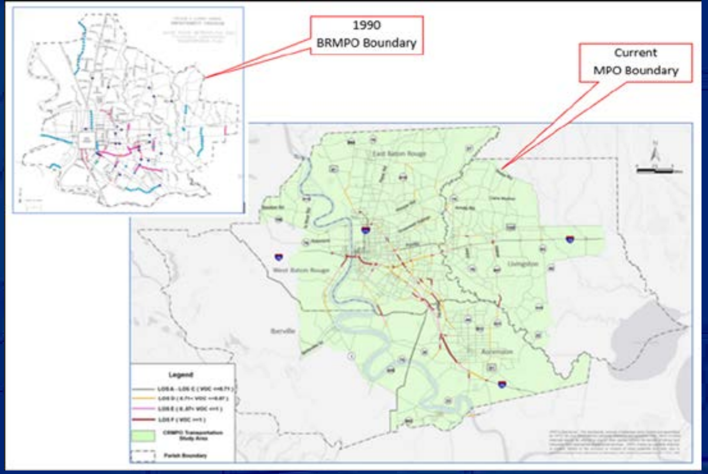


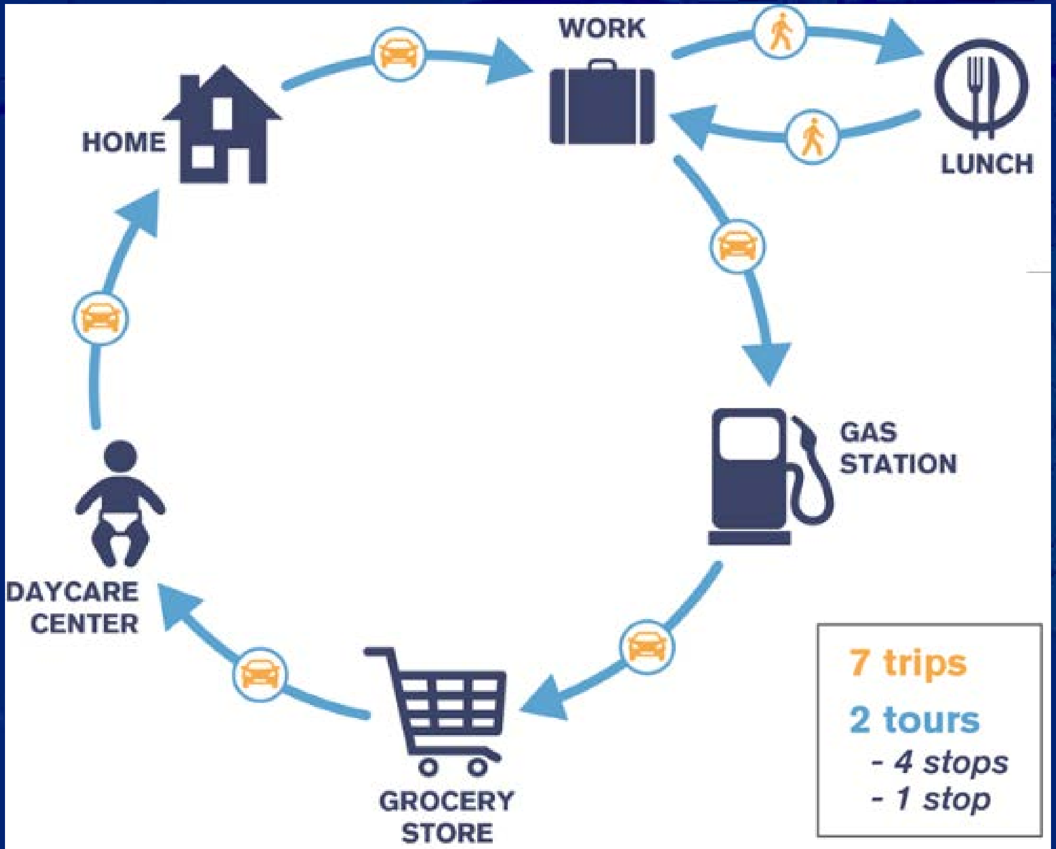
The survey collects demographic and travel information from a randomly-selected representative sample of households in the Capital Region modeling area.

It is the primary source of observed data that will be used to estimate, calibrate, and validate the regional travel demand model.

CRPC Transportation

Capital Region Household Travel Survey





- The survey is to better understand daily travel and activities in the region: how we travel, where we go, how long it takes us, and what we do when we arrive. The survey will be summarized to describe the travel behaviors of all households in the region.

- With more jobs and people coming to the region all the time, the data will also help guide future transportation planning and assist local governments in determining which transportation improvements will benefit their citizens the most.

CRPC Transportation

Capital Region Household Travel Survey

Sample Plan

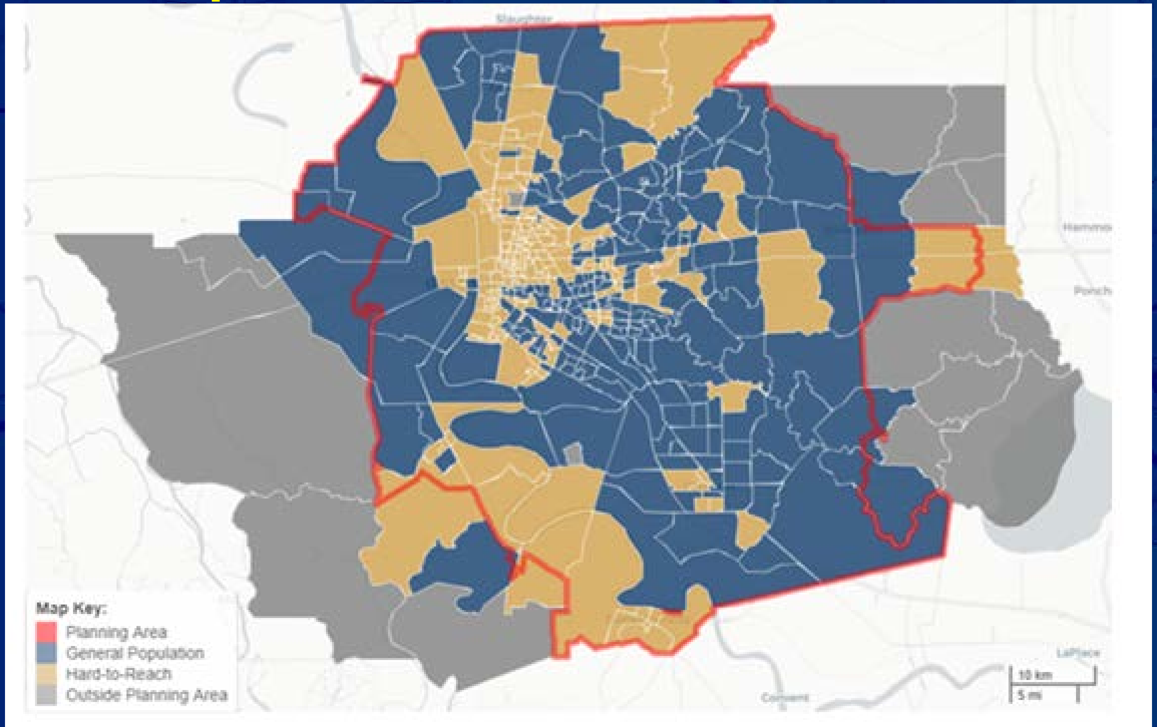


TABLE 2: SURVEY REGION HOSUEHOLDS AND PERSONS, BY SAMPLE GROUP

SAMPLE GROUP	CENSUS BLOCK GROUPS	TOTAL HOUSEHOLDS	TOTAL PERSONS
General Population	205 (49%)	158,670 (59%)	438,568 (60%)
Hard-to-Reach	214 (51%)	110,906 (41%)	296,044 (40%)
Total	**419**	**269,576**	**734,612**

- 419 Census Block Group
- 269,600 households,
- 734,600 persons,

CRPC Transportation

Capital Region Household Travel Survey

Sample Plan

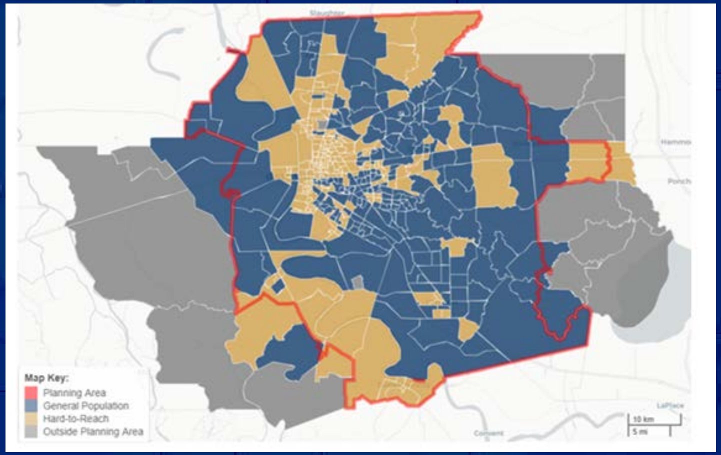


TABLE 3: SAMPLE RATES AND EXPECTED DATASET COMPOSITION

SAMPLE SEGMENT	INVITED HHS	INVITE RATE[4]	ESTIMATED SAMPLE RATE[5]	ESTIMATED COMPLETE HHS
General Population	79,539 (51%)	50%	0.93%	1,471
Hard-to-Reach	76,187 (49%)	69%	0.93%	1,029
Total	155,726	58%	0.93%	2,500

Overall, this proposed sample plan should achieve the desired dataset composition of a generally representative sample while compensating for the low response rates among low-income and limited English-speaking households.

Recruit and retrieval by phone, mail, or web

Address-based random sample, stratified by household size, income and auto ownership

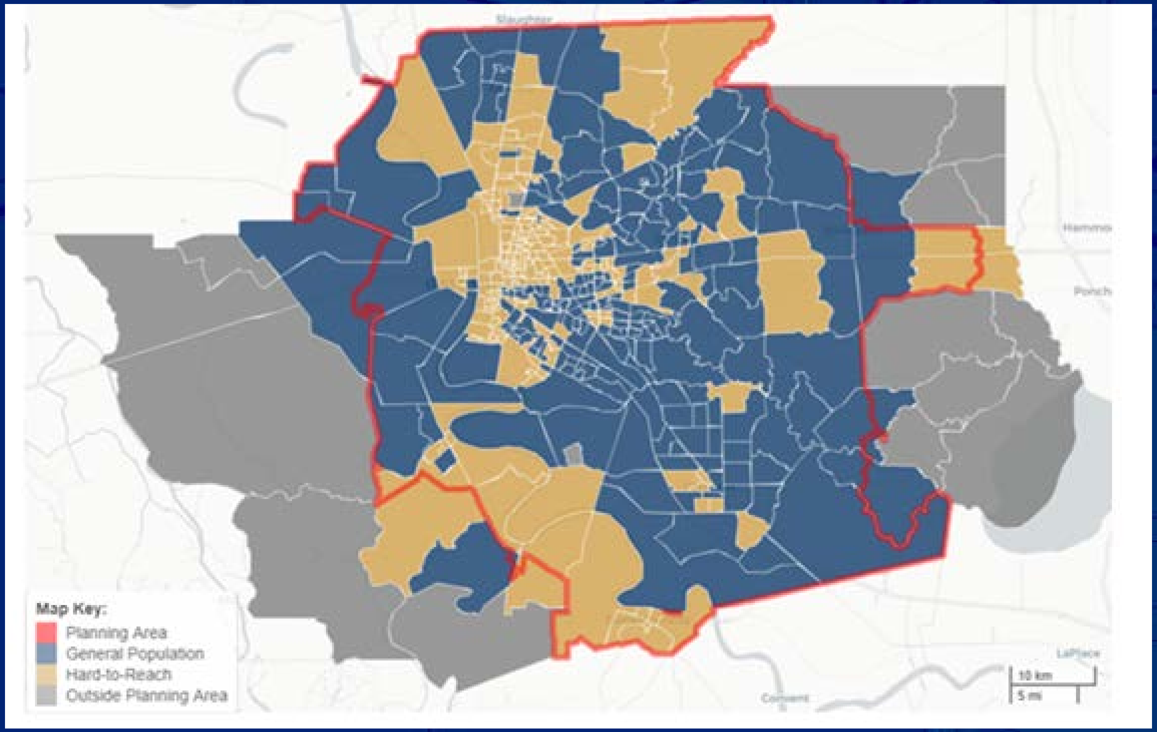
Some oversamples (Walk, Bike, Transit Traveler, University, other smaller populations)

Utilization of phone-based GPS data collection (rMove)

CRPC Transportation

Capital Region Household Travel Survey

Survey Instrument



Survey Data Levels Collected:

- Demographic: Household, Person, Vehicle
- Diary- Trip Data:
  - Location Data
    - Time of Arrival/Departure, address, activity
  - Trip Data
    - Type of transportation
    - Amount paid (parking cost, toll, transit fare) and how it was paid (subsidized parking, monthly payment for parking/transit)
    - Mode, accompanying travelers

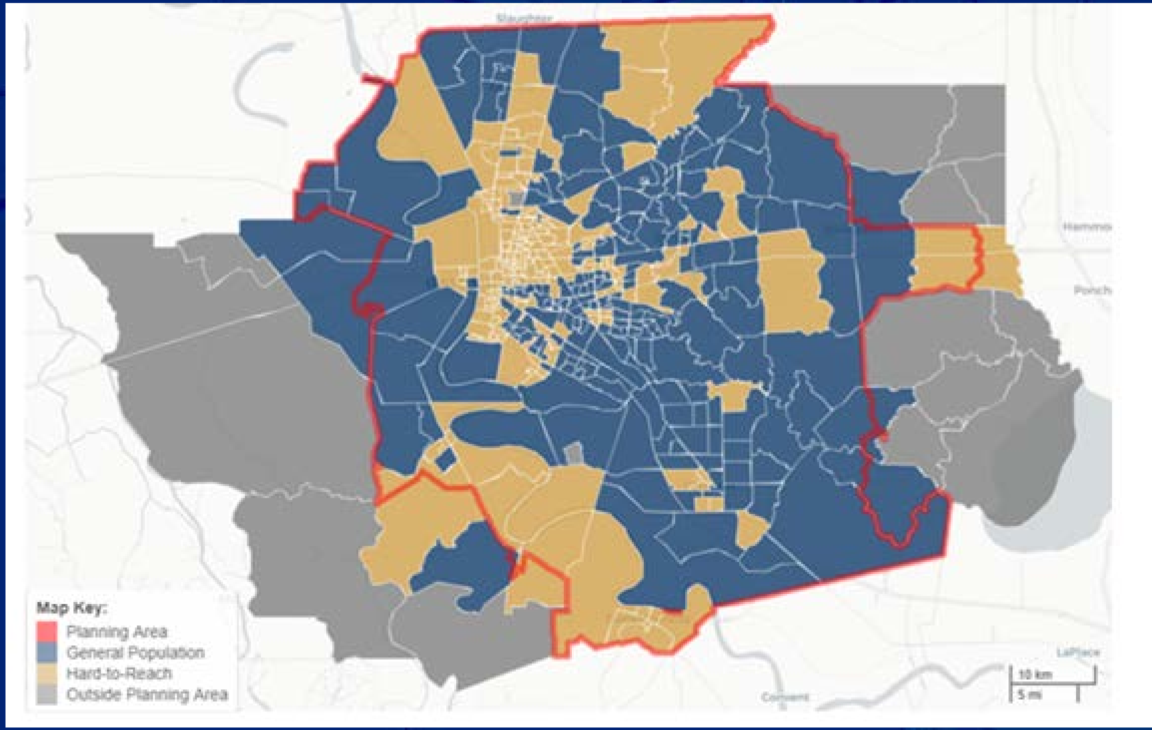
Survey Participation:

- Entire household (HH) invited to participate by mail.
- HH lives within the CRPC study model region.
- All HH members comprehensively report their travel that occurs over an assigned travel period (a minimum of one weekday, and up to seven consecutive days).

CRPC Transportation

Capital Region Household Travel Survey

Schedule



- Pre-test (internal), September 9, 2019
- Full Survey (Invite 155,726 households for estimated 2,500 completed),
  September 27, 2019 – December 1, 2019

Details:

Friday, September 27: Mail wave 1 letter drop

Monday, October 7: Start of travel week 1

Monday, November 18: Start of travel week 7

Sunday, November 24: Last day of travel

Thursday, November 28: Thanksgiving Day

Sunday, December 1: Final diary closes (last day to report travel for week 7)

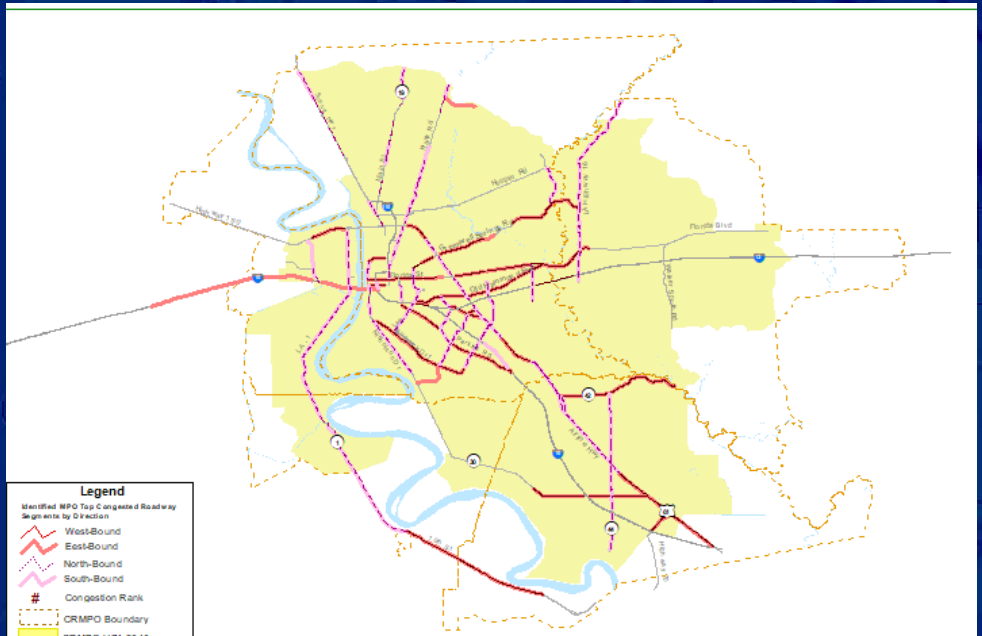
CRPC Transportation

Capital Region Household Travel Survey

Regional Model Development

NPMRDS – Observed Network Real Speeds, Travel Time and Peak Period Congestion

Together with collection of vehicle classification counts that will be used as control data for the expansion of the passive data. CRPC will update the model network to better represent observed speeds and roadway congestions from NPMRDS.



CRPC will then update various components of the model and re-validating the complete model system including peak period models

Capital Region Household Travel Survey

Questions?

SimCap

Simulation and Capacity Analysis User Group

Louisiana

user group

Mini Roundtable

THANK YOU FOR ALL ATTENDING!!