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Federal Highway Administration

Application of TRANSIMS for Highway Work Zones: Travel Pattern and Mobility Impacts

TRANSIMS DEPLOYMENT CASE STUDIES

APRIL 9 2010

TRANSIMS Open-Source

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Agenda

1. Introduction
2. Data Conversion
3. Model Implementation
4. Work Zone Application

Problem Statement

- Conventional travel demand forecasting models lacks in analyzing impacts of highway work zones
- Microsimulation models are capable of analyzing work zone impacts; however, they have limitations:
  - Scalability
  - Network equilibrium
- Any other way to overcome weaknesses?

Objectives

- Objective
  - to demonstrate TRANSIMS capability in analyzing network-wide impacts of lane or highway closure during highway constructions
  - to compare TRANSIMS capability with existing analysis models (TransCAD & Paramics)

- Proposed Case Study
  - I-75/I-96 Ambassador Bridge Gateway Maintenance of Traffic
    - Maintenance of Traffic Simulation (MOTSIM) study is reexamined using TRANSIMS

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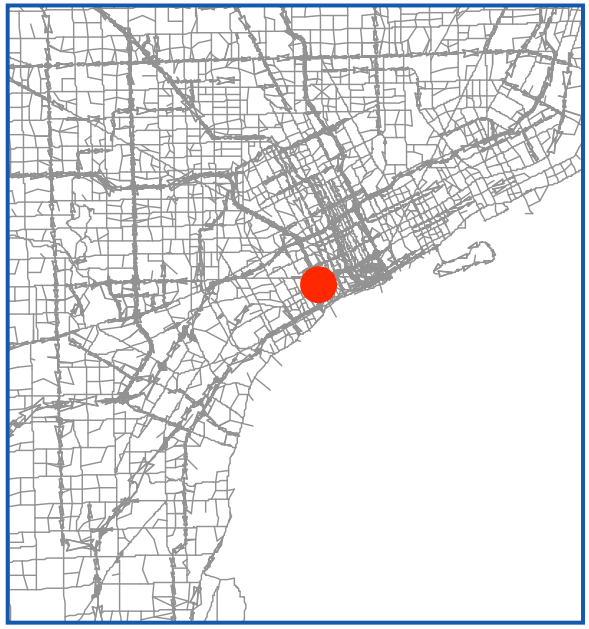
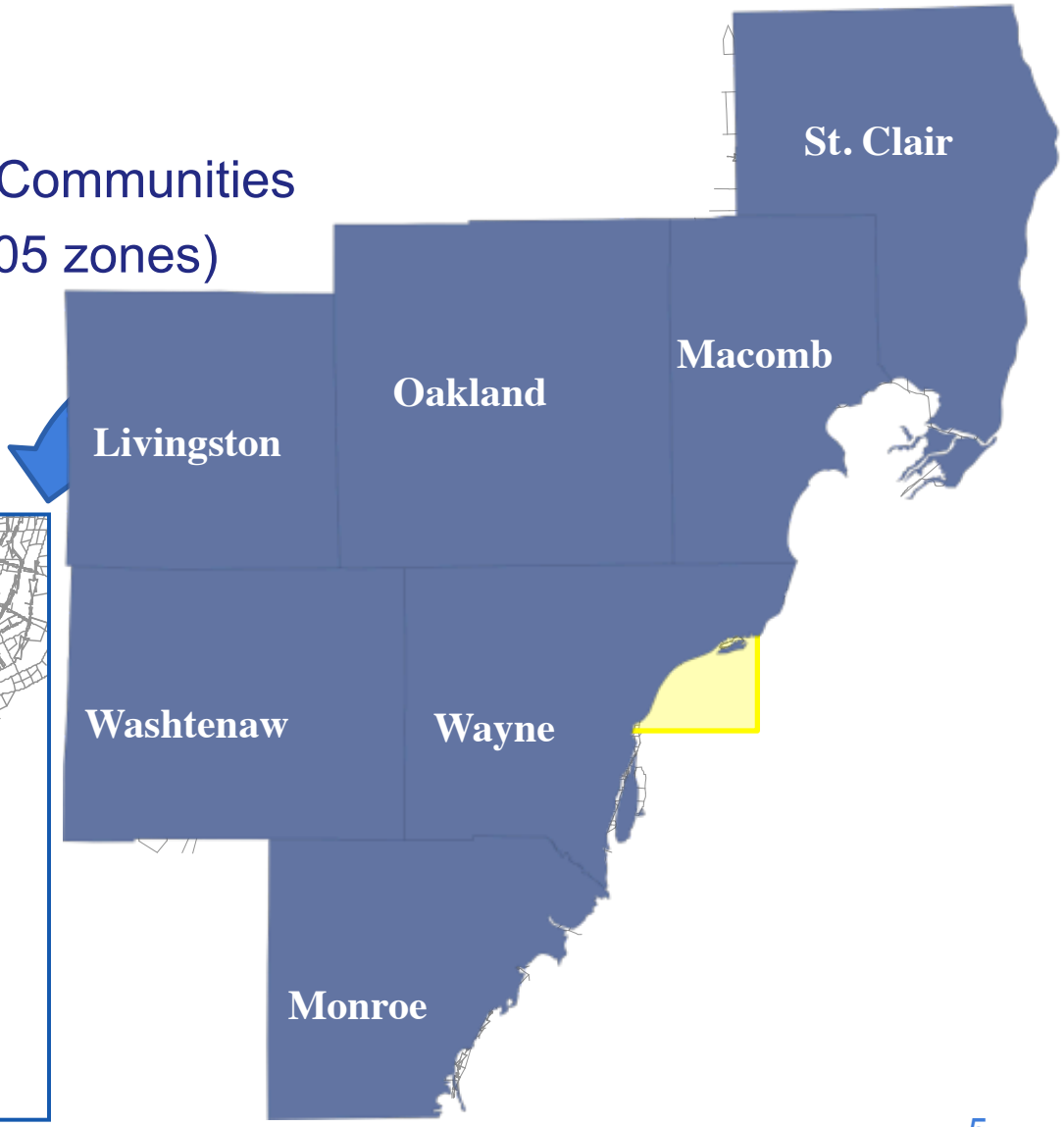
Study Site

- SEMCOG Area
  - Seven Counties, 234 Communities
  - 4.9 million people (1505 zones)
- Study Focus Area
  - Downtown Detroit





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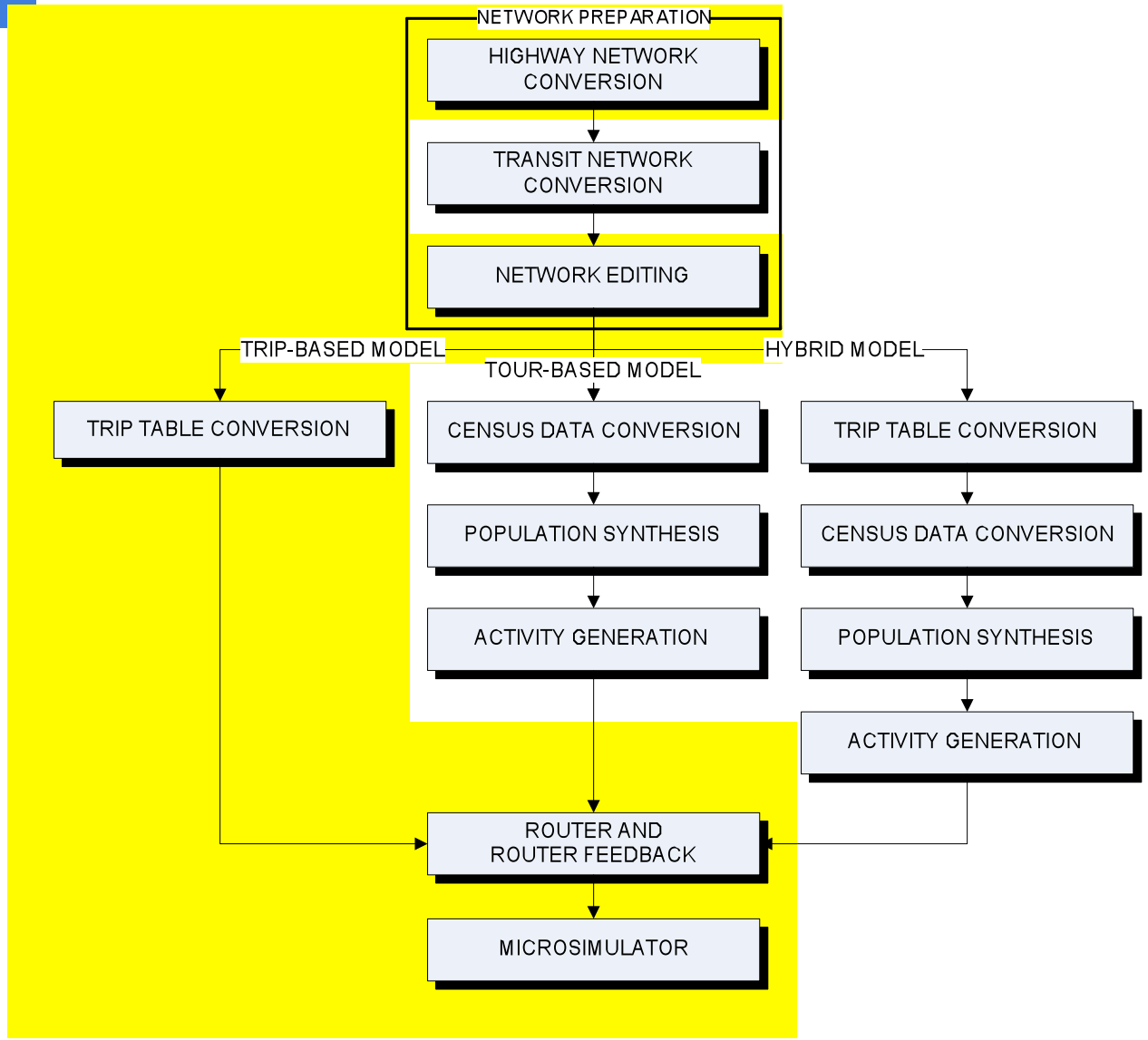
Approach: Trip-based TRANSIMS



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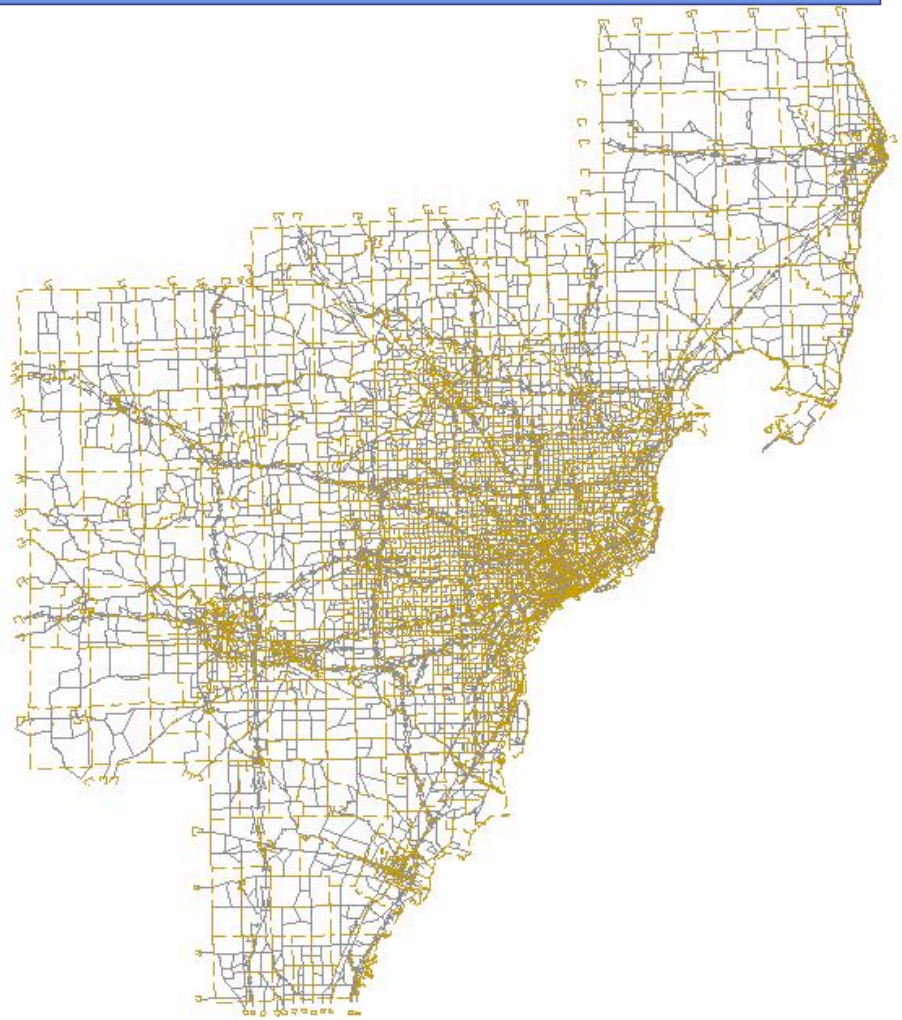
Regional Travel Demand Model

SEMCOG (South East Michigan Council of Governments)

- SEMCOG Travel Model
  - 7 counties, 234 communities
    - Population: 4,938,807
    - Households: 1,926,818
    - Employment: 2,282,240
  - TransCAD
    - 1505 zones
  - Four periods
    - AM, MD, PM, OP
  - Six trip purposes
    - HBW, HBSH, HBSC, HBO
    - NBHW, NHBO
  - Truck data: LT, MT, HT



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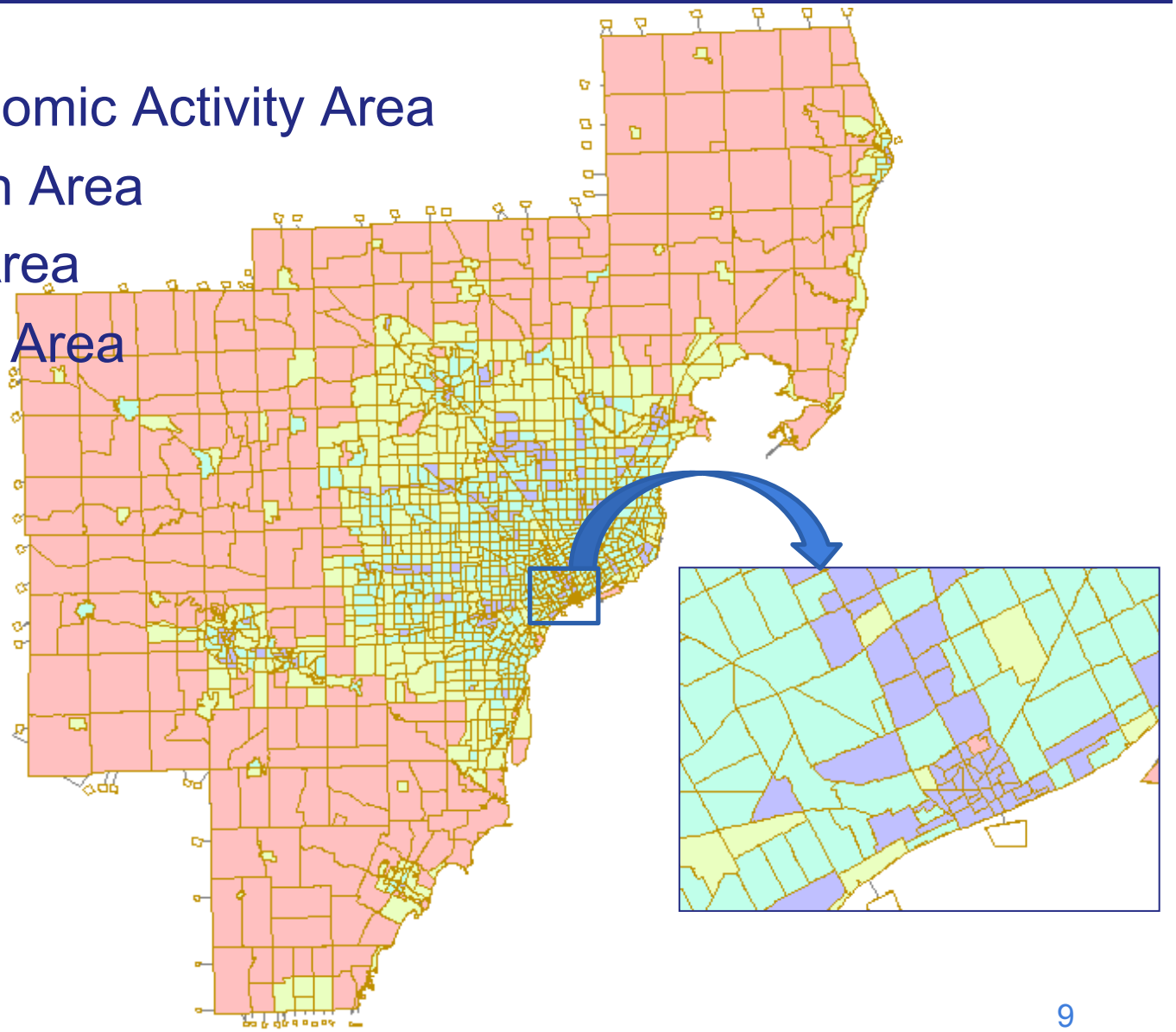
Zone Area Type

1. Urban Economic Activity Area
2. Other Urban Area
3. Suburban Area
4. Rural Place Area
5. Rural Area



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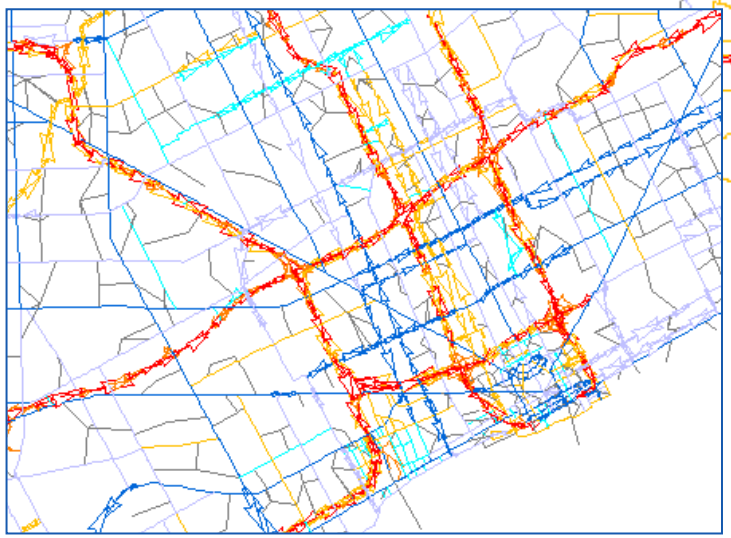
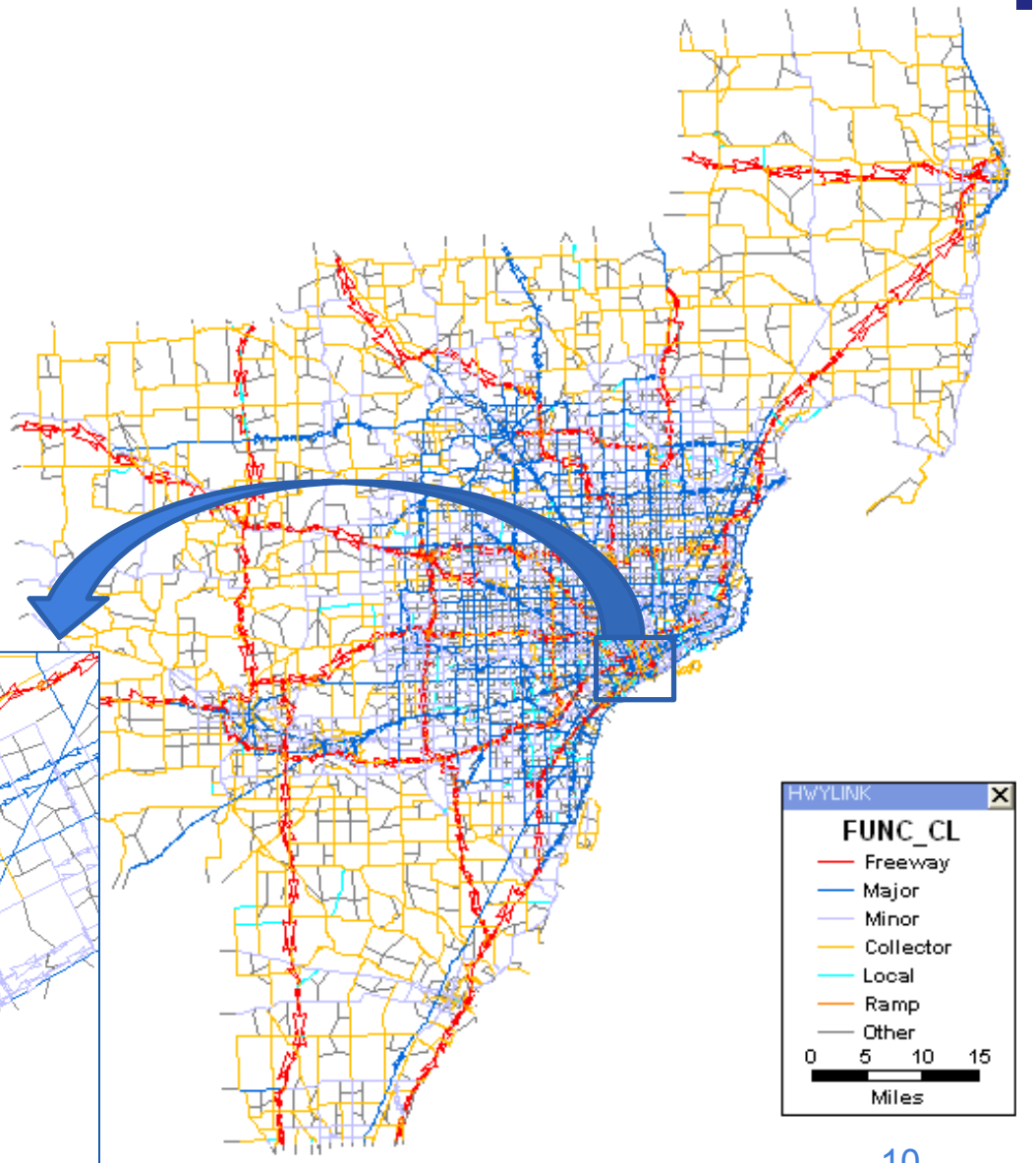
Highway Facility Type

1, 2, 11: Freeway
3, 4: Major
5: Minor
6: Collector
7: Local
8: Ramp
90: External





Data Conversion

- Approach
  - Develop a conversion tool using GISDK in TransCAD (TransCAD2NET)
  - Convert data from TransCAD to TRANSIMS
- Utility Modules in TRANSIMS
  - TransimsNet – network data processing
  - IntControl – control data processing
  - ConvertTrips – trip data processing
  - ArcNet – ArcGIS shapefile processing

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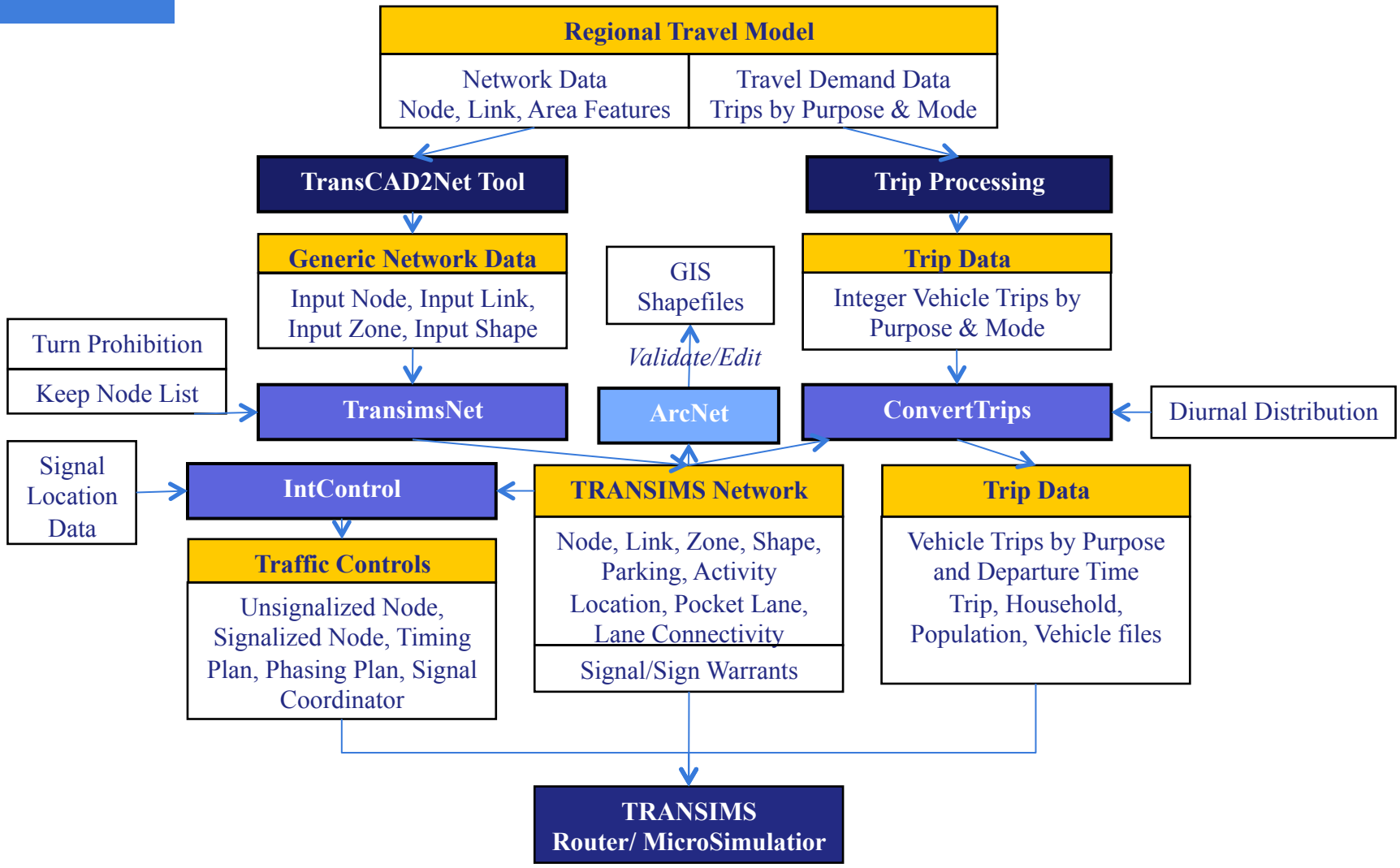
Data Conversion Process



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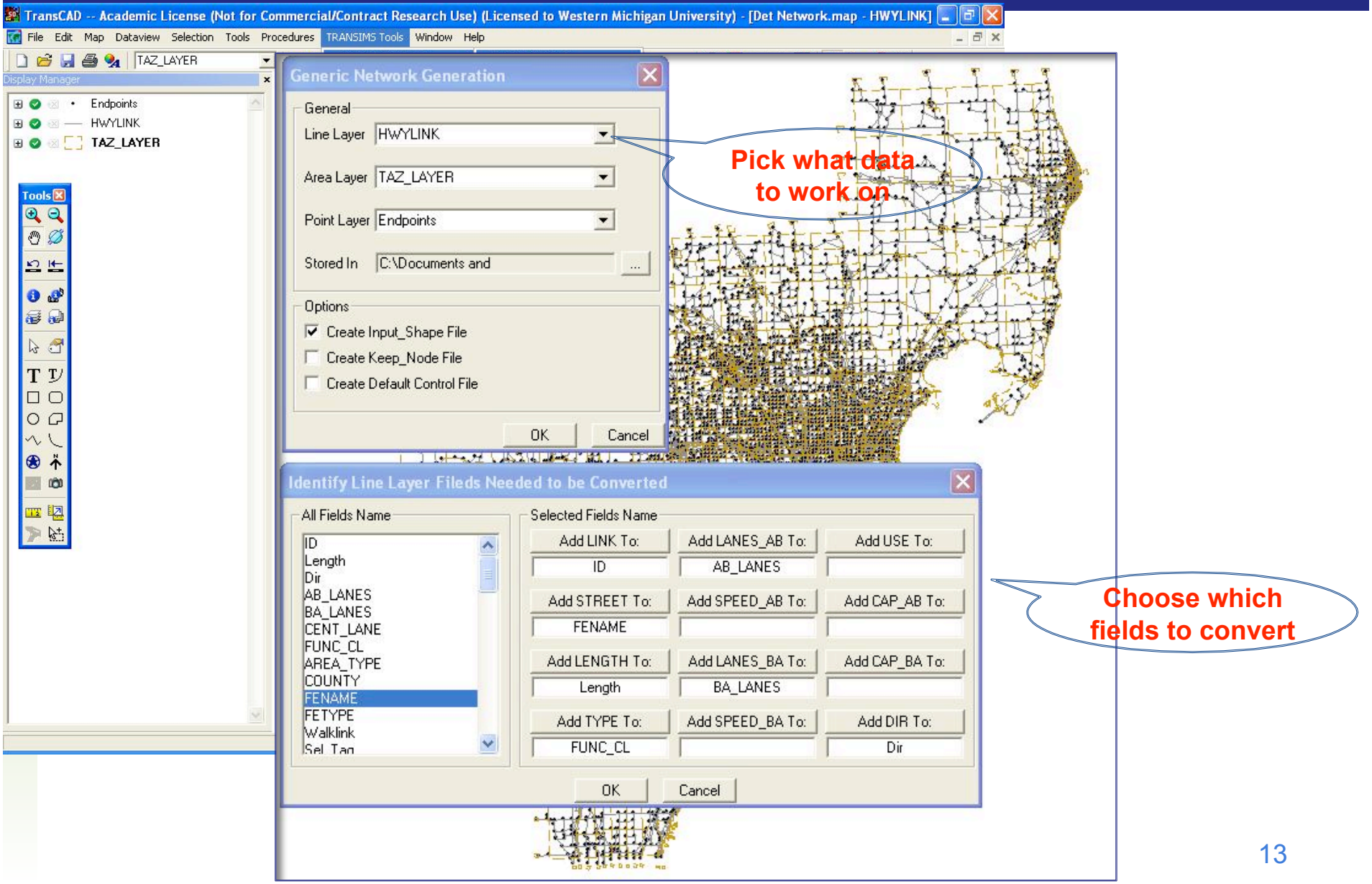
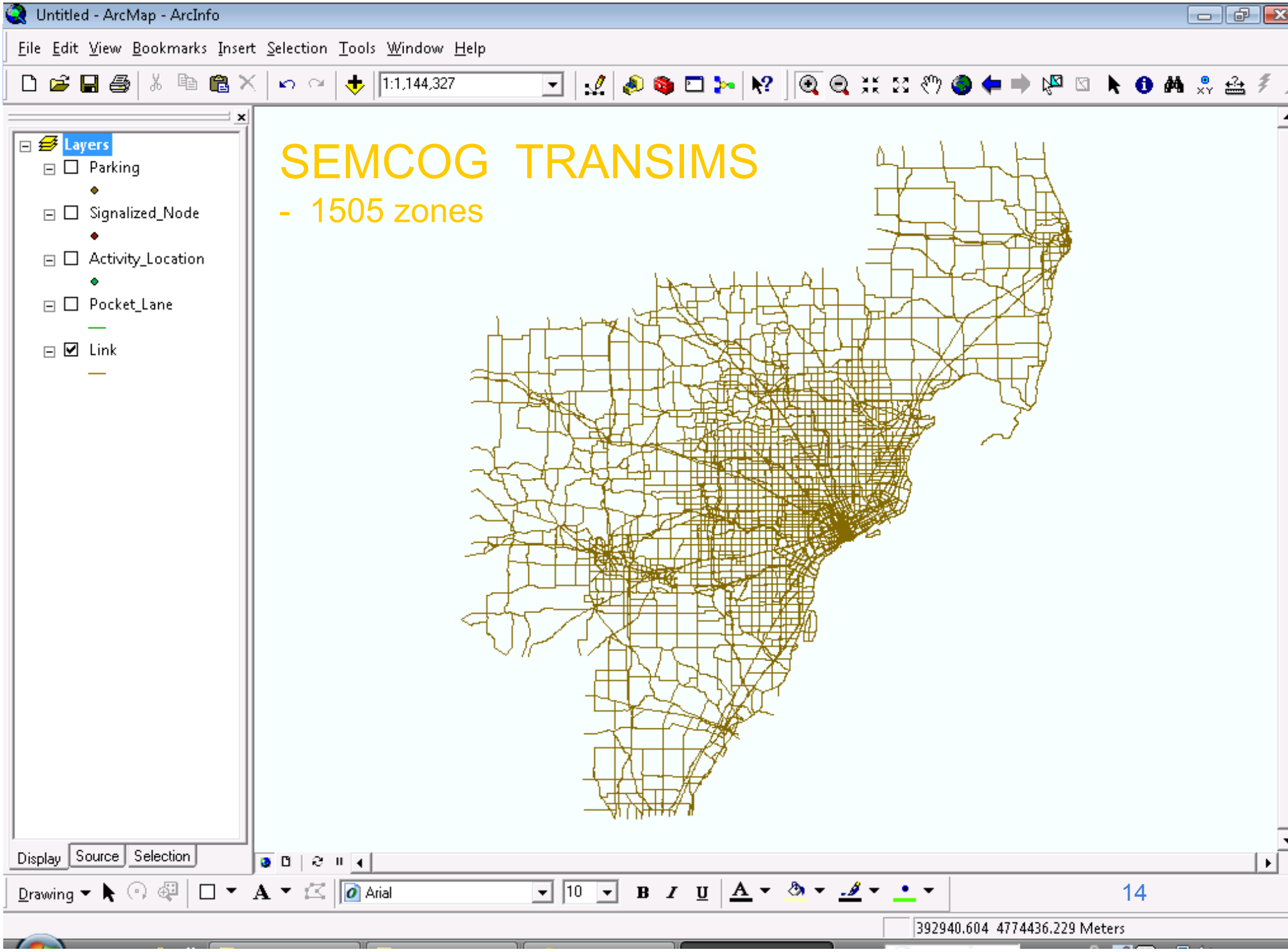
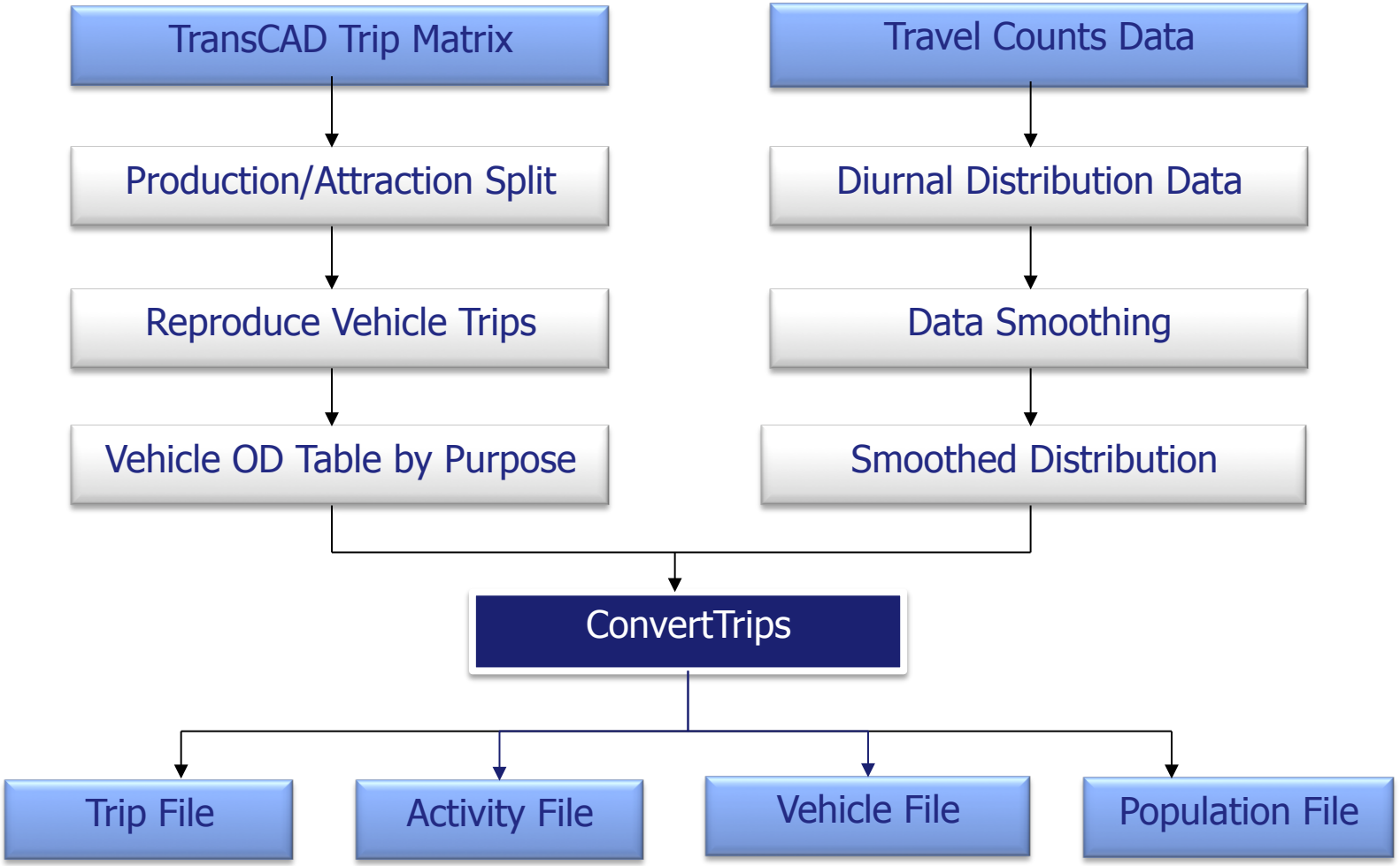
Network Conversion Tool
(TransCAD2Net)




Untitled - ArcMap - ArcInfo
File Edit View Bookmarks Insert Selection Tools Window Help
1:1,144,327
Layers
Parking
Signalized_Node
Activity_Location
Pocket_Lane
Link
SEMCOG TRANSIMS
- 1505 zones
Display Source Selection
Drawing
Arial
10
14
392940.604 4774436.229 Meters

Overview of Trip Conversion



Trip Data Preparation

- Current Data Format
  - SEMCOG model processed vehicle trips in four time periods (AM, MD, PM, OP)
  - Passenger Vehicle Types: SOV, HOV2, HOV3
  - Truck Vehicle Types: LT, MT, HT
- Need to split production/attraction by trip purpose to apply diurnal distribution
- Reprocessed trip data from TransCAD

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Total Vehicle Trips

Period	SOV	HOV2	HOV3+	Light Truck	Med Truck	Heavy Truck	Total
AM	1,221,381	216,925	82,141	65,938	22,044	34,766	1,643,195
(%)	74.33%	13.20%	5.00%	4.01%	1.34%	2.12%	100.0%
MD	3,401,870	833,952	240,690	414,465	110,559	159,966	5,161,502
(%)	65.91%	16.16%	4.66%	8.03%	2.14%	3.10%	100.0%
PM	2,274,118	522,805	218,772	99,221	25,096	39,401	3,179,413
(%)	71.53%	16.44%	6.88%	3.12%	0.79%	1.24%	100.0%
OP	3,125,121	874,184	323,210	48,354	11,870	30,545	4,413,284
(%)	70.81%	19.81%	7.32%	1.10%	0.27%	0.69%	100.0%
All Day	10,022,490	2,447,866	864,813	627,978	169,569	264,678	14,397,394
(%)	69.61%	17.00%	6.01%	4.36%	1.18%	1.84%	100.0%

Trip Files

- Total 42 Trip Tables
  - Passenger Production / Attraction (2 x 6 x 3 = 36)
    - 6 trip purposes (HBW, HBSH, HBSC, HBO, NHBW, NHBO)
    - 3 modes (SOV, HOV2, HOV3)
  - External trip in three modes (SOV, HOV2, HOV3)
  - Truck trip (3 truck types – LT, MT, HT)
- Integer Trip Values
  - Round values to the nearest integer
  - The total number of trips: 12,900,743 trips (excluding intra-zonal trips)

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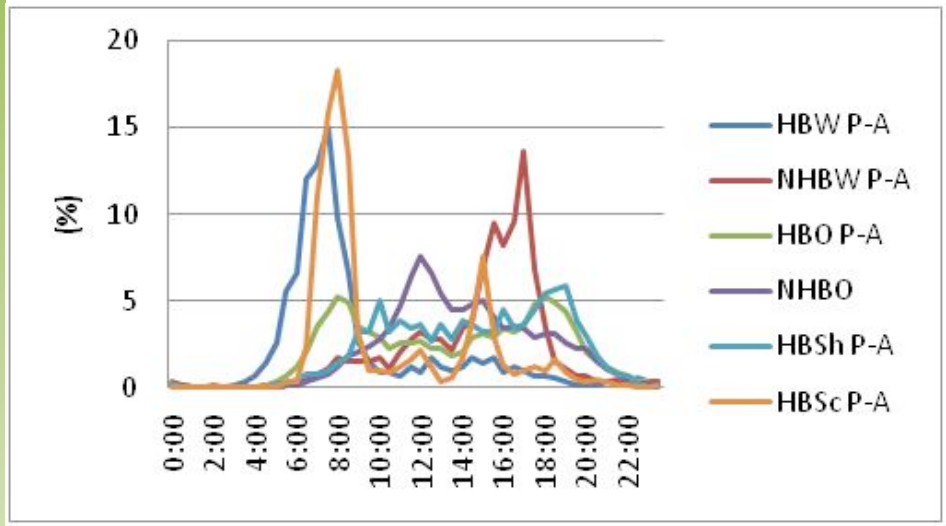
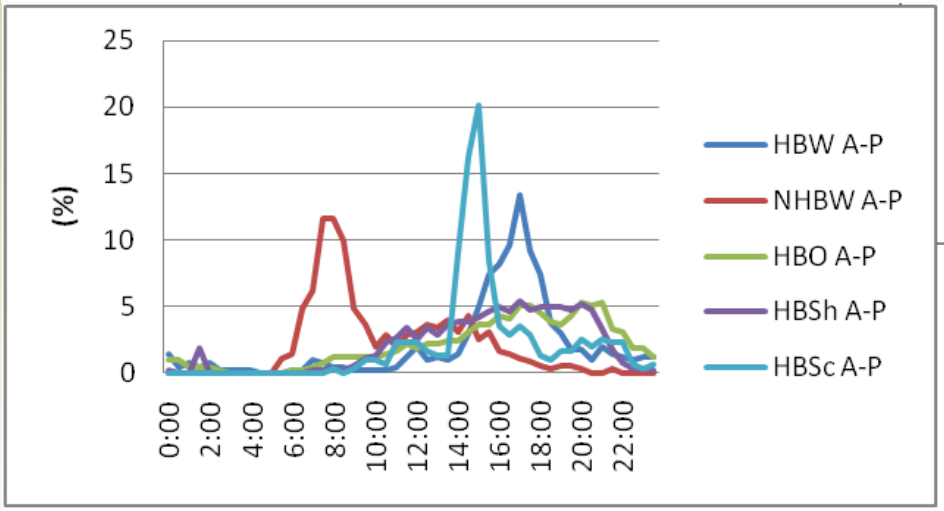
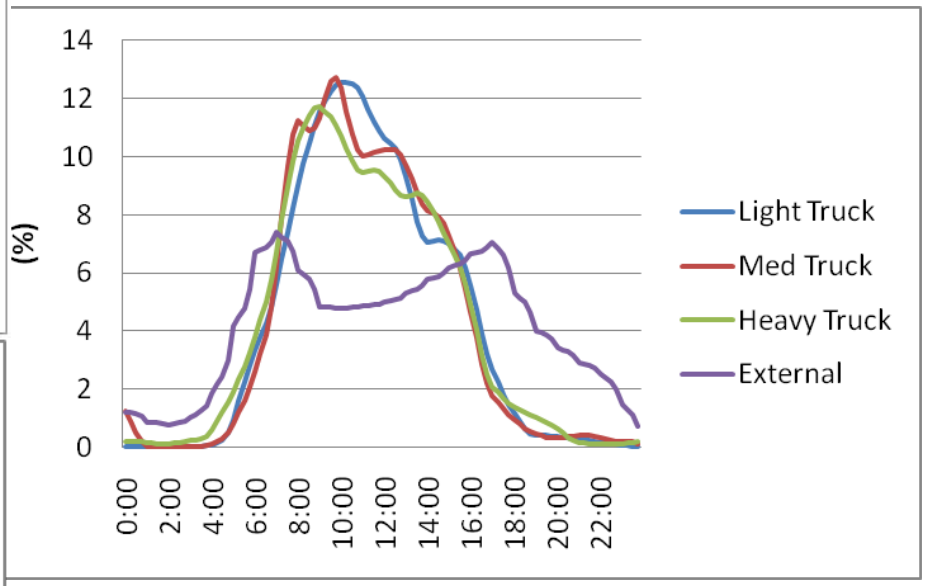
Diurnal Distribution by Trip Purpose







Challenge in Activity Location

- **Problem**
  - Some zones contain no activity location or only one activity location ➔ causes errors in ConvertTrips
- **Reason**
  - By default, the TransimsNet program assigns each activity location to the closest zone centroid.
  - However, when the zone boundaries are irregular, this can frequently assign activity locations to the wrong zone number
- **Solution**
  - Develop a module to correct each activity location's zone based on zone polygon
  - Identify zones with no or only one activity location

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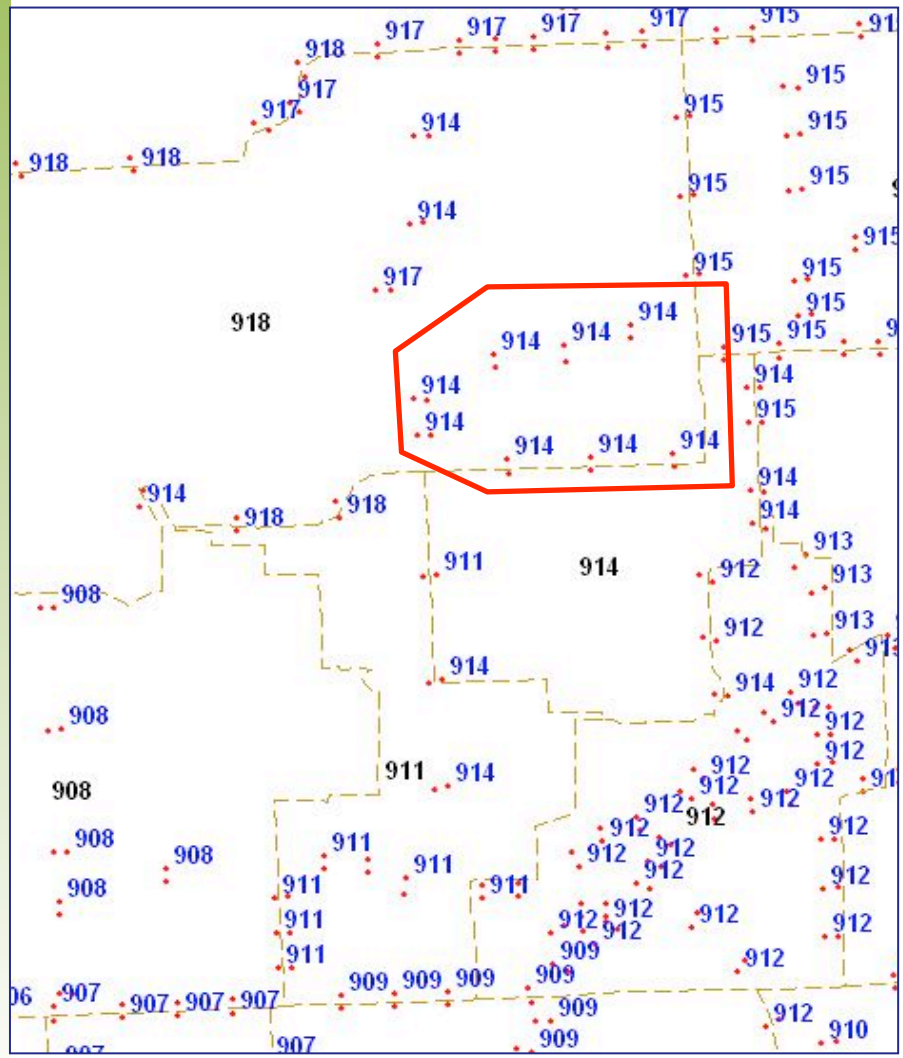
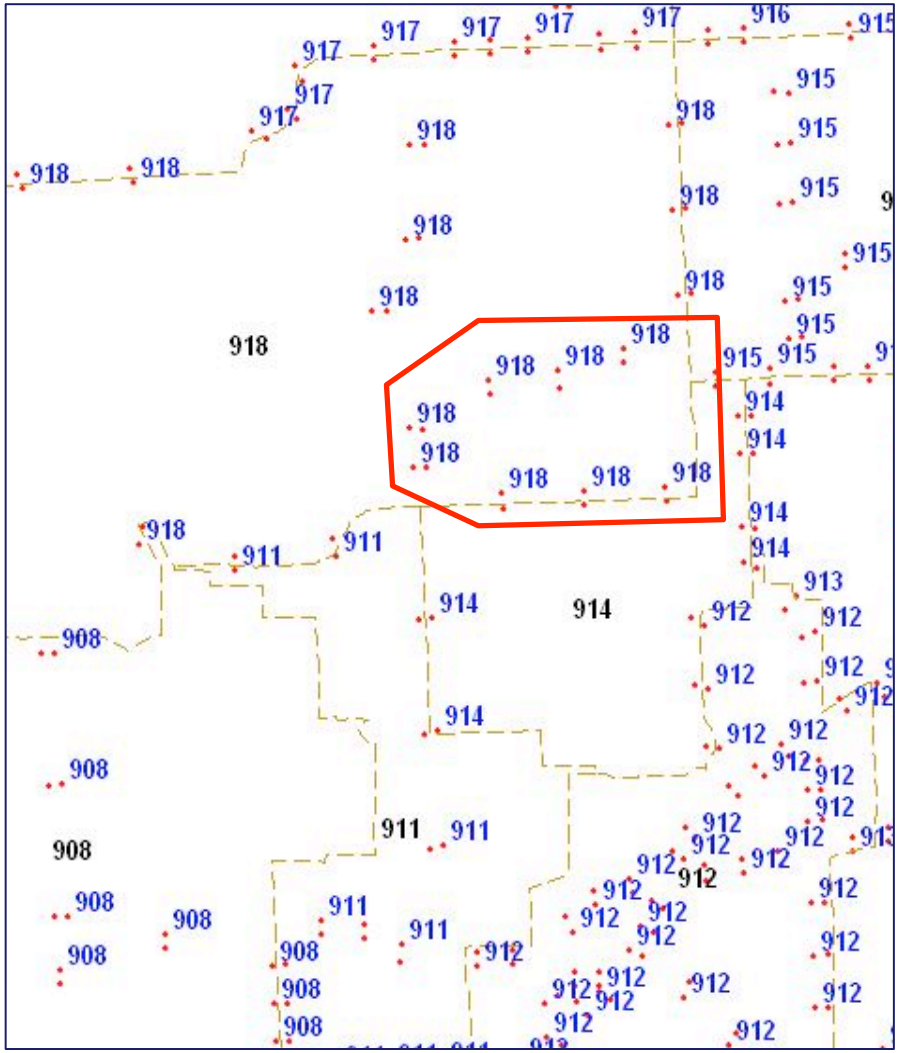
Correcting activity location data





Lesson Learned

- Network conversion process is relatively straightforward, but there are some challenges.
- Need precise GIS shape data for network conversion
  - Activity locations
  - Lane connectivity
- Regional Demand Model Data are insufficient
  - Comprehensive data inventory is necessary for advanced models - network, lane configuration, intersection control data

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Hybrid Network Structure

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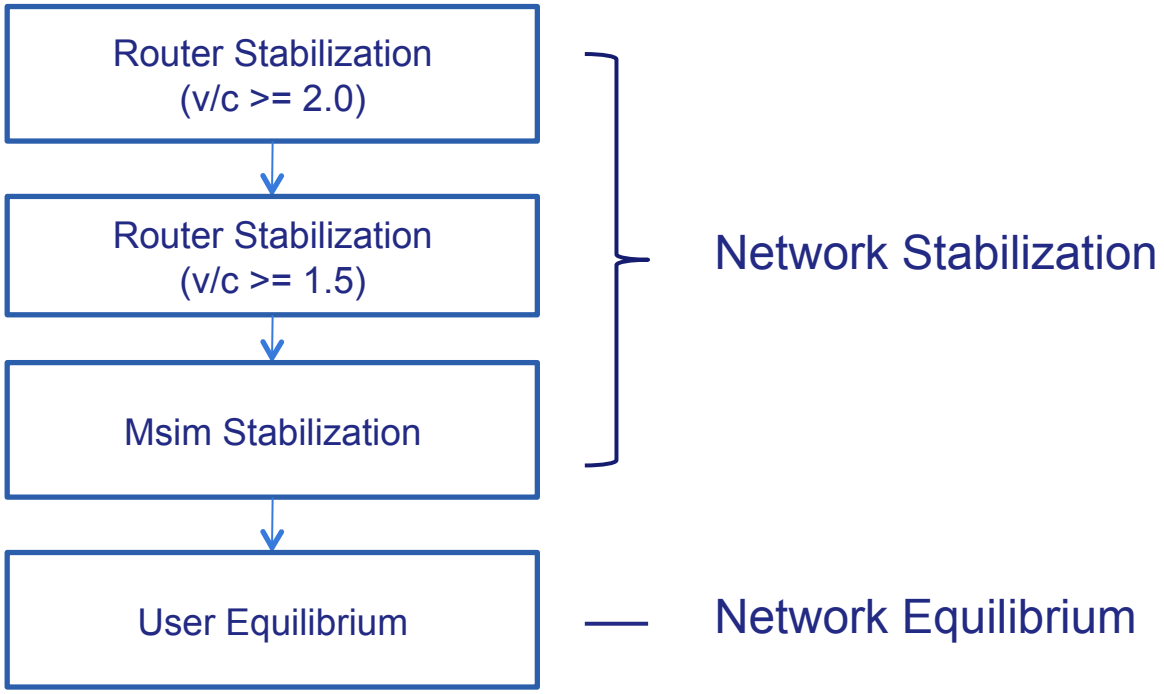
Model Equilibrium Process



- Hybrid network approach
  - Whole network - Router
  - Subarea network - Microsimulator

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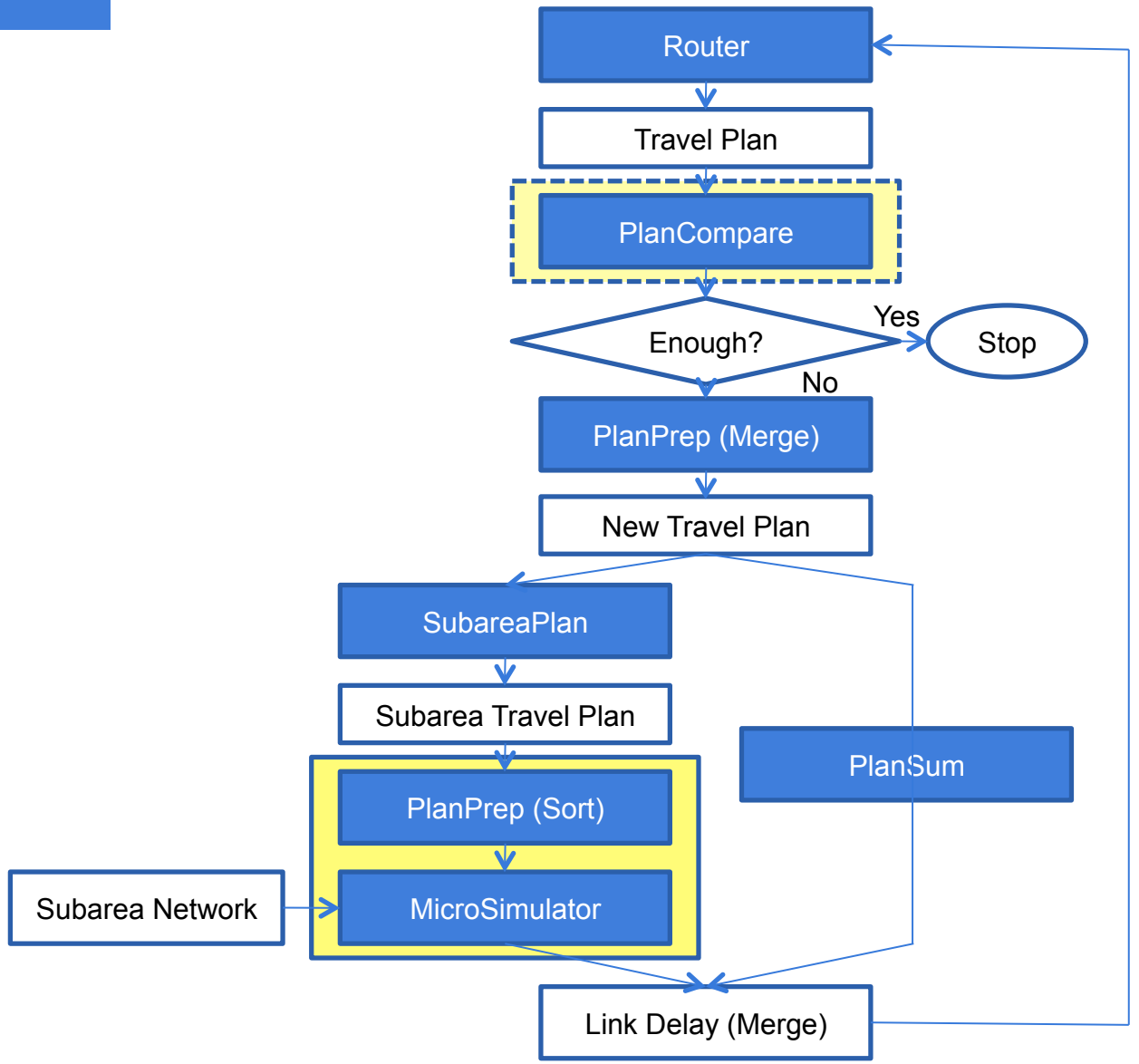
User Equilibrium Process



User Equilibrium

- User Equilibrium
  - A condition where no traveler can reduce their trip travel time by changing paths
  - User Equilibrium
    - Percentage of Travelers Selected
    - Relative Gap

$$\textit{Relative Gap} = \textit{Average Absolute Travel Time Difference} = \frac{1}{N}\sum_{n=1}^{N}\left|\frac{TT_n - BT_n}{BT_n}\right|$$

- TT_n = *New Travel Time for Traveler n*
- BT_n = *Base Travel Time for Traveler n*
- *N = the number of travelers compared*

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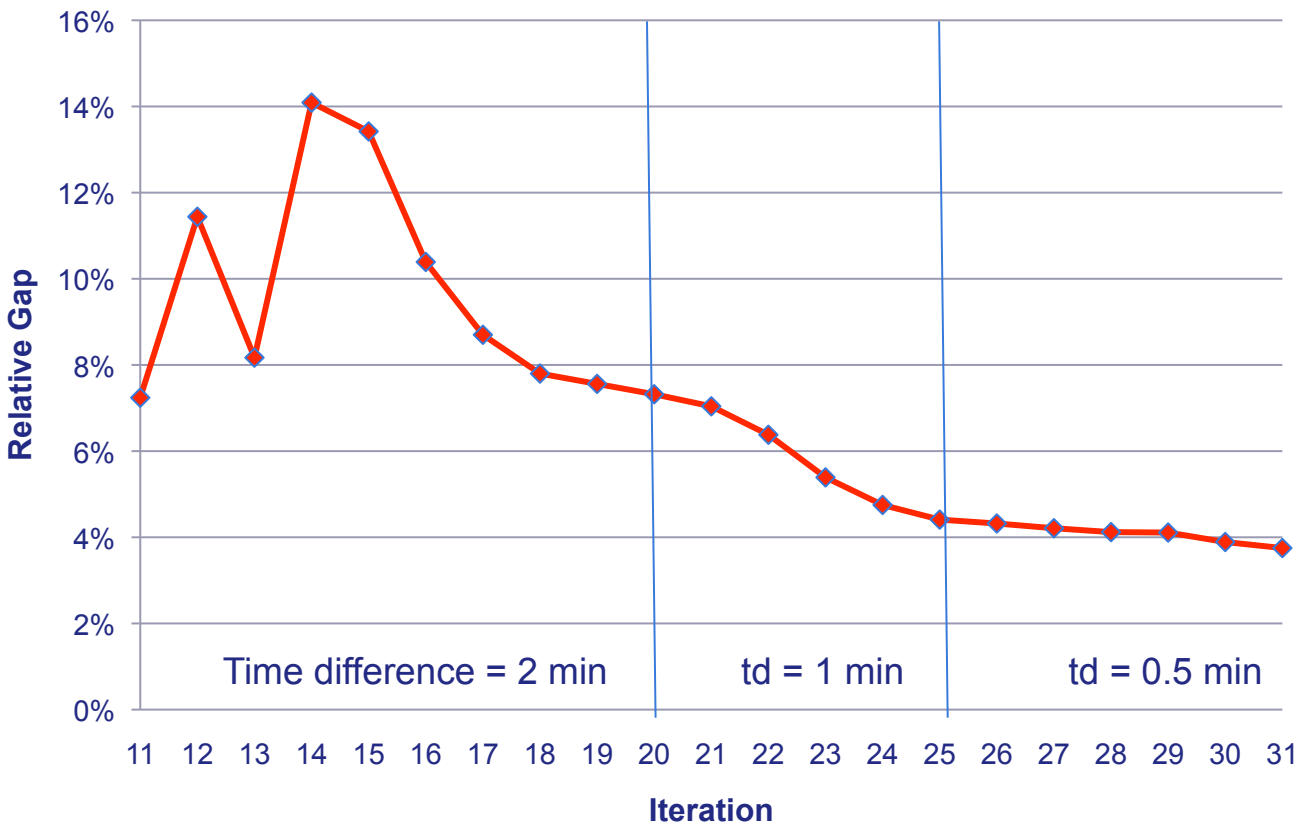
UE Model Convergence (RG)



Total Computational Time: 88 hours

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Output Visualization in TransCAD

- Purpose
  - To display/visualize TRANSIMS output in TransCAD
  - To compare with traffic data from other sources
- Methodology
  - Import TRANSIMS output to TransCAD
  - Using TransCAD GISDK and MS Access Database

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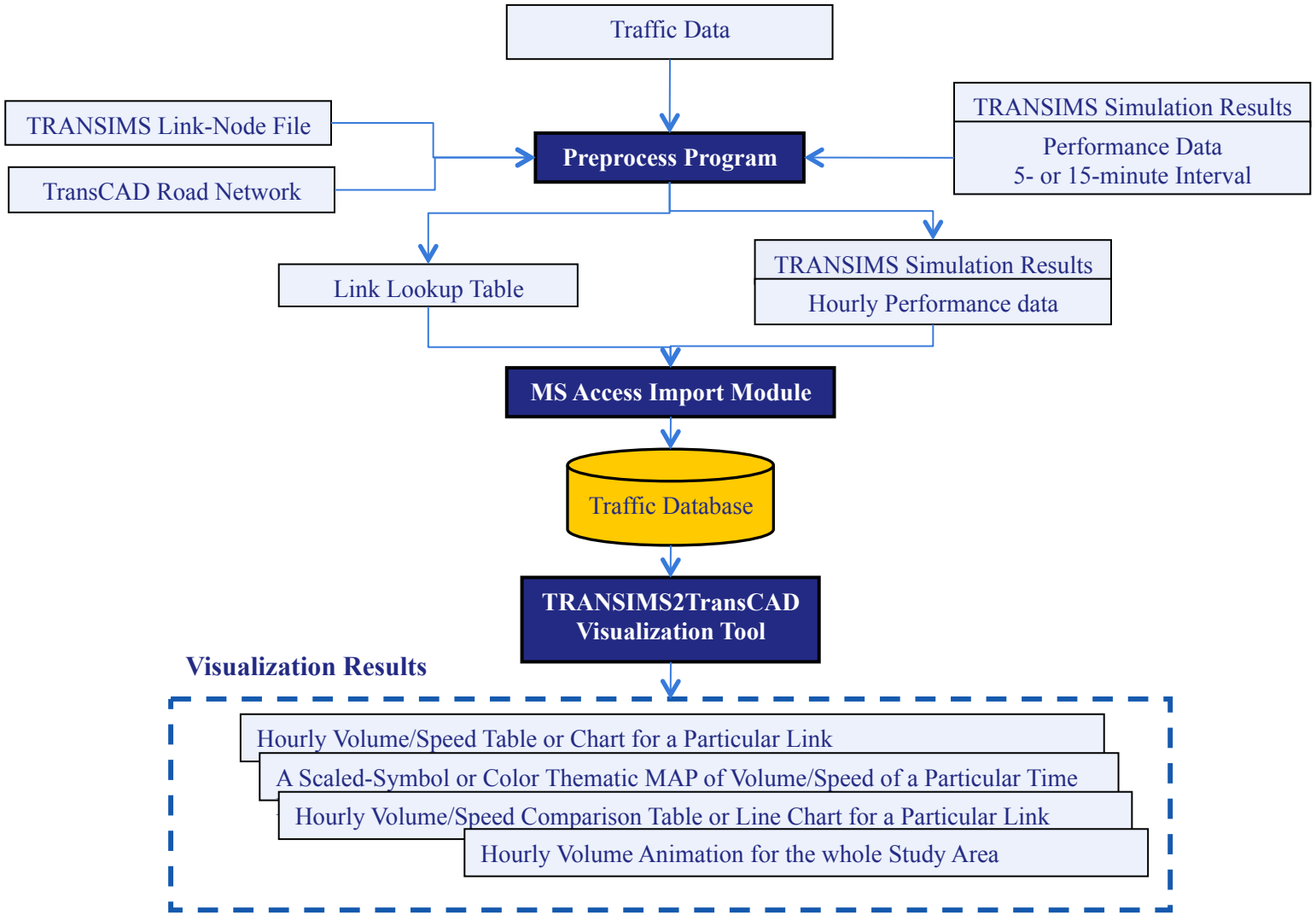
Visualization Process



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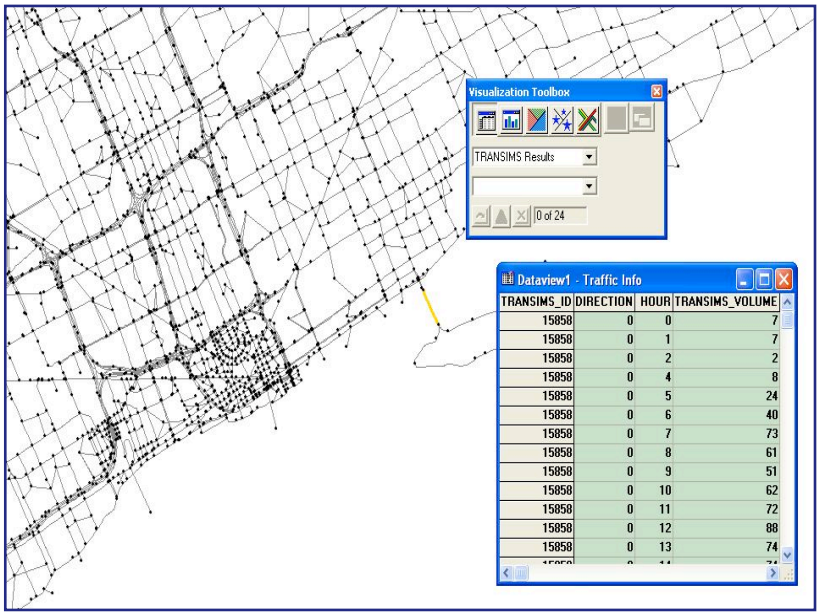
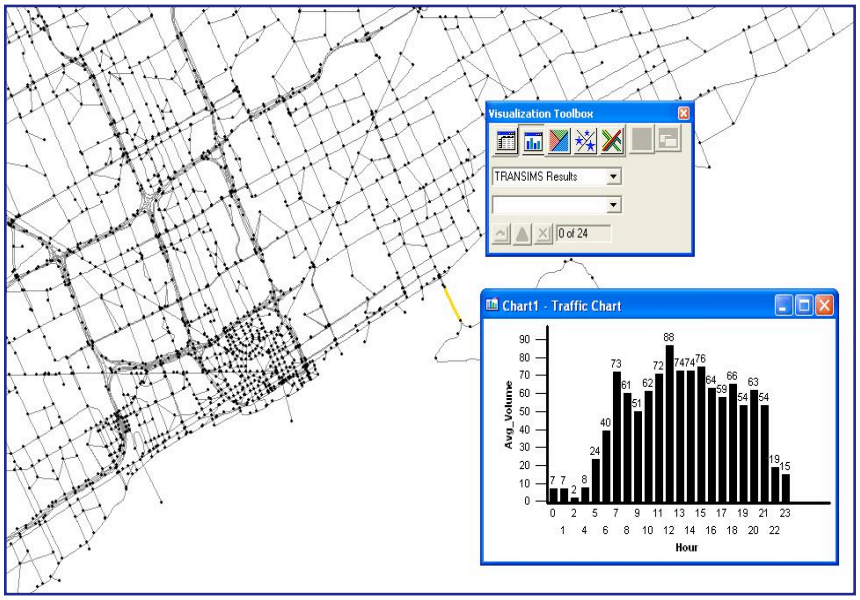
Output Display – Hourly Volume



TRANSIMS_ID	DIRECTION	HOUR	TRANSIMS_VOLUME
15858	0	0	7
15858	0	1	7
15858	0	2	2
15858	0	4	8
15858	0	5	24
15858	0	6	40
15858	0	7	73
15858	0	8	61
15858	0	9	51
15858	0	10	62
15858	0	11	72
15858	0	12	88
15858	0	13	74

Volume Data View



Volume Bar Chart

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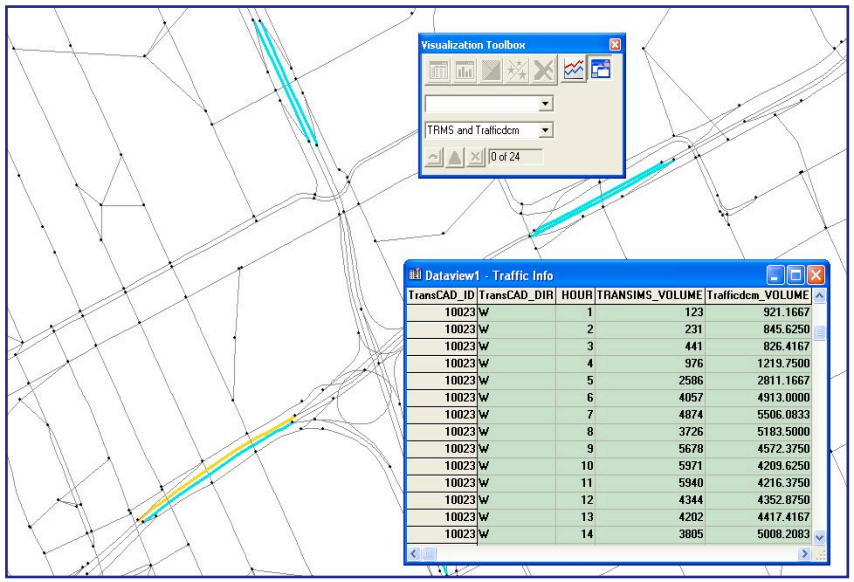
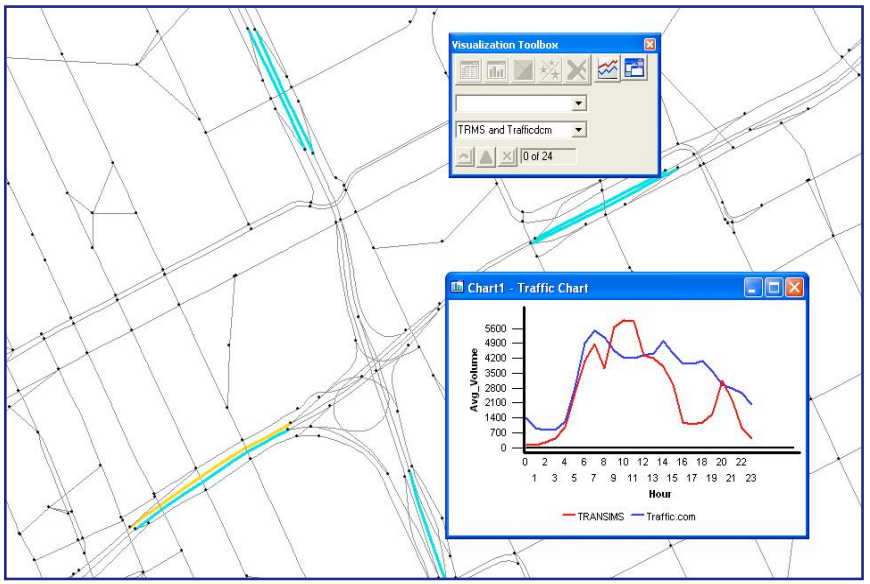
Output Display - Comparison



TransCAD_ID	TransCAD_DIR	HOUR	TRANSIMS_VOLUME	Trafficdcm_VOLUME
10023	W	1	123	921.1667
10023	W	2	231	845.6250
10023	W	3	441	826.4167
10023	W	4	976	1219.7500
10023	W	5	2586	2811.1667
10023	W	6	4057	4913.0000
10023	W	7	4874	5506.0833
10023	W	8	3726	5183.5000
10023	W	9	5678	4572.3750
10023	W	10	5971	4209.6250
10023	W	11	5940	4216.3750
10023	W	12	4344	4352.8750
10023	W	13	4202	4417.4167
10023	W	14	3805	5008.2083

Volume Data Comparison



Volume Comparison with Line Chart

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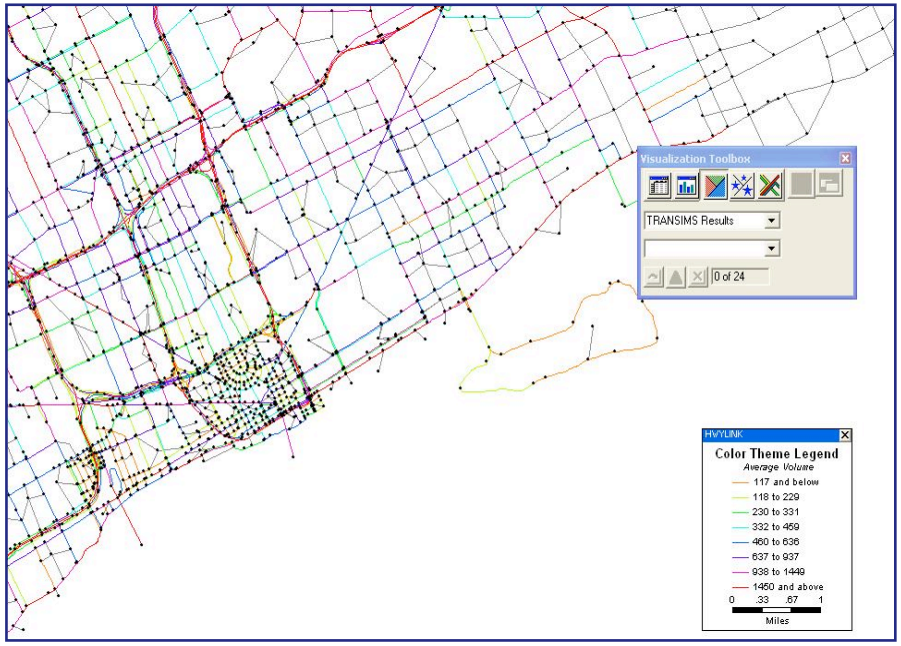
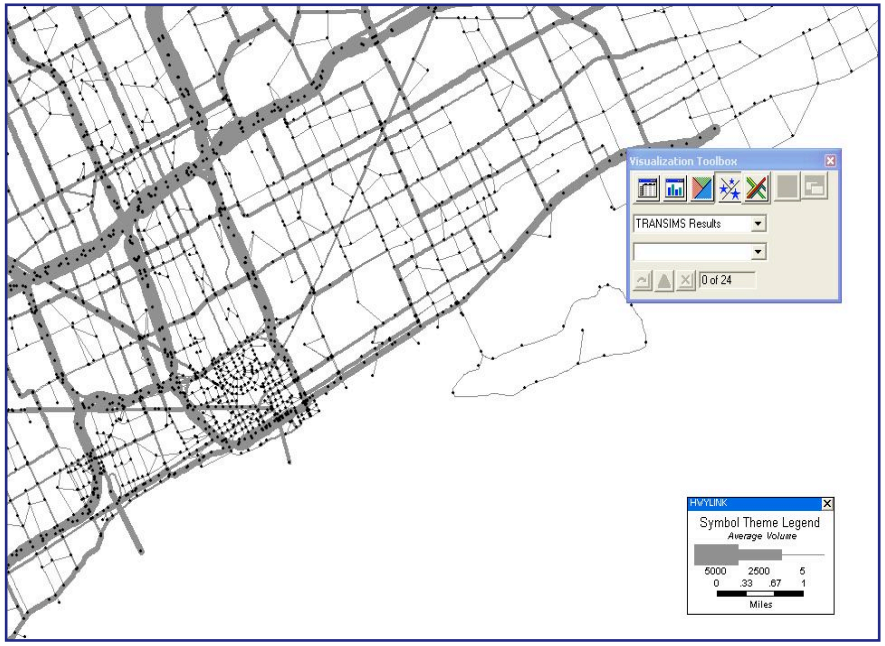
Output Display – Color / Scale



Color Thematic Map



Scaled-symbol Thematic Map

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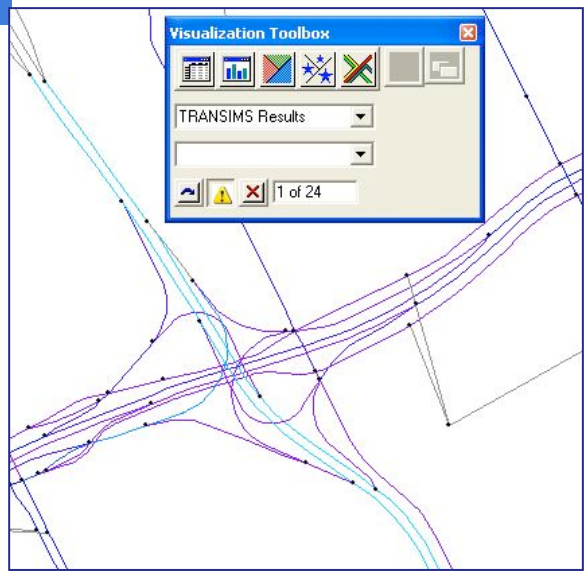
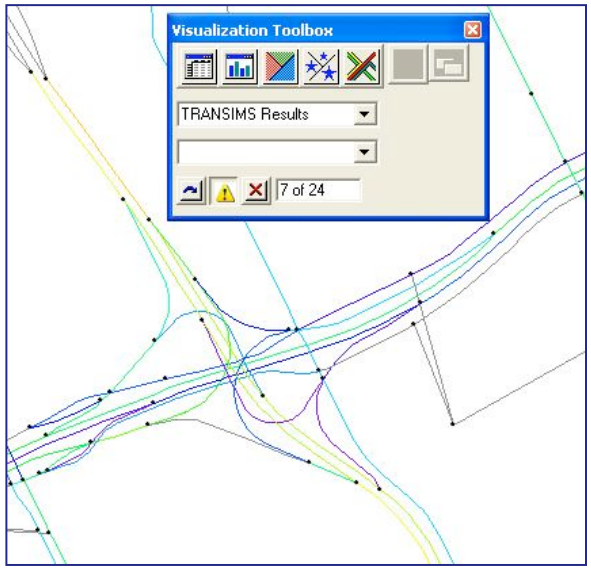
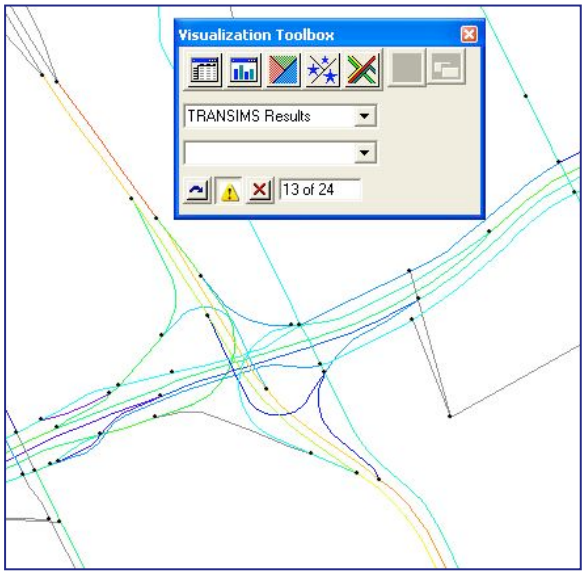
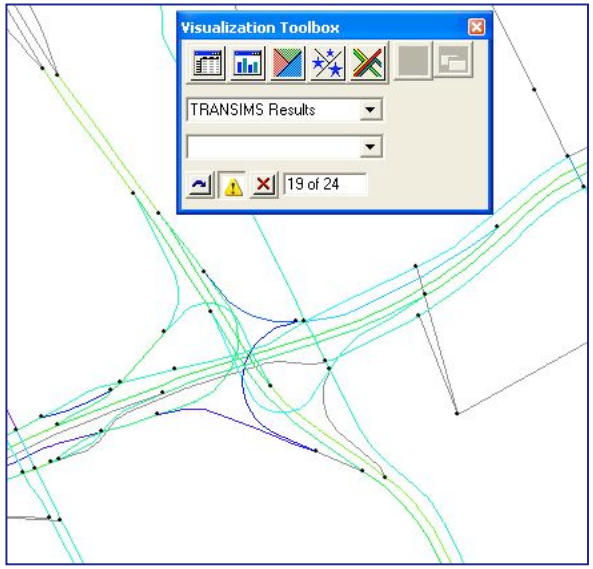
Animation: Hourly Volume Changes









Lessons Learned

- Large scale simulation requires heavy computation, especially for the UE process
- Need to further investigate on UE process and develop a formalized UE process
- Visualization tools are important for model implementation and validation

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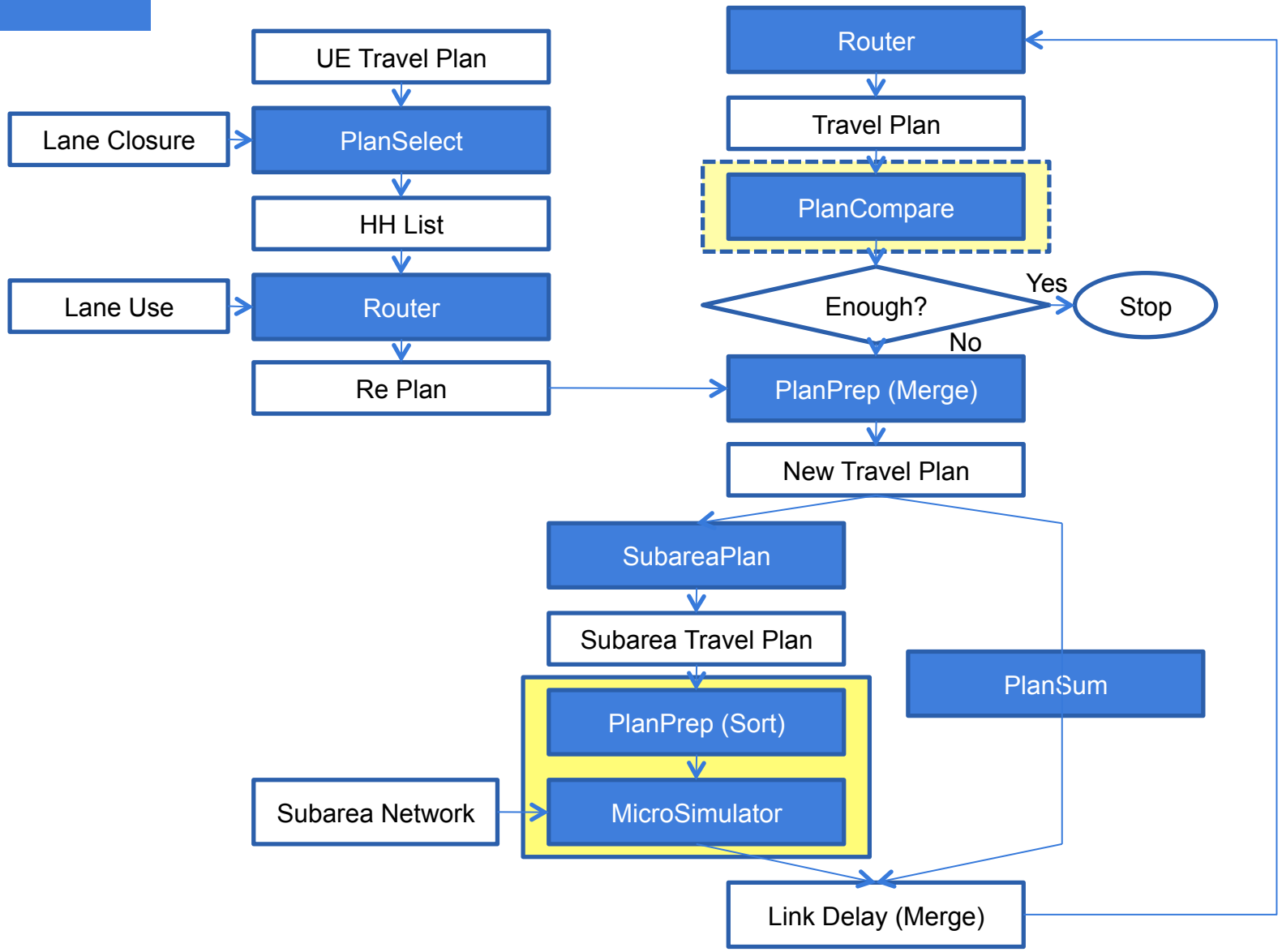
Work Zone Implementation Process



Expected Outputs

- Drivers who traveled through the highways to be closed
- Alternative routes for the traffic and their changes over time (day-to-day evolution)
- Identification of problem links and corridors
- Changes in network conditions
  - New UE pattern during construction
  - Impact of short-term & long-term work zone

Case Example

- Assumed I-96 southbound is closed

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Traffic on Link to be Closed♪

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Route Changes after the Closure♪

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Route Changes after the Closure♪

Day 0

Day 1

Day 5

Day 10

Day 15

Day 20

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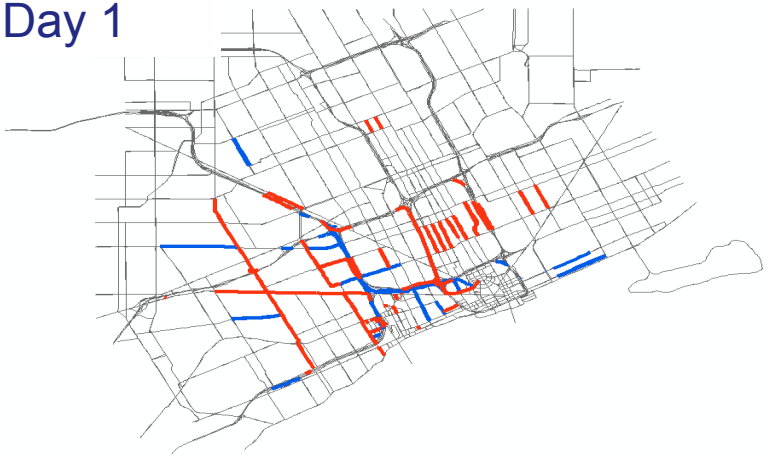
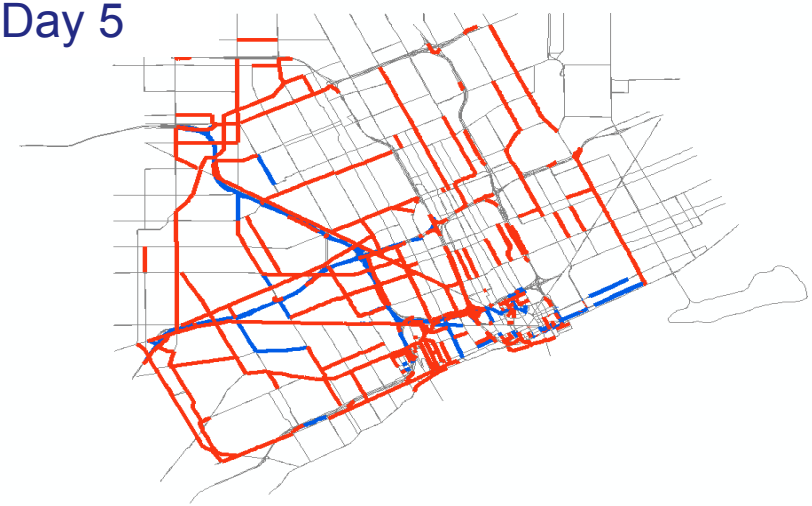
Changes in Volume

Day 1

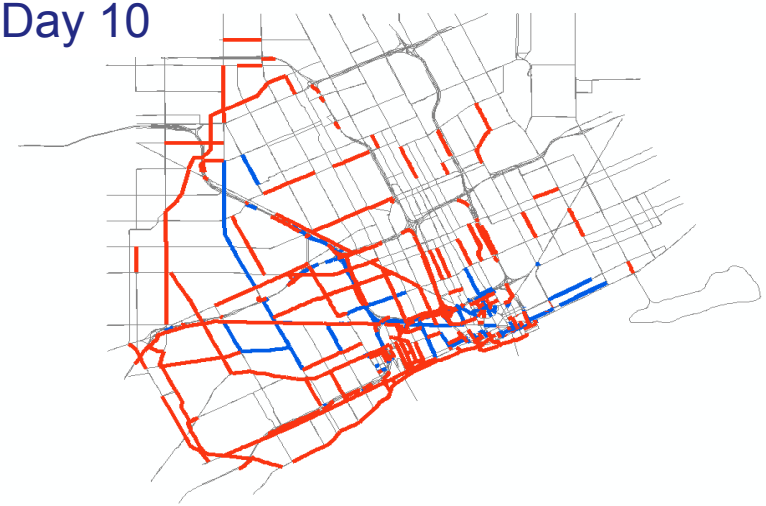


Day 20

Day 5



Day 10



Volume difference > 30% or < -30%♪

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Changes in Speed

Day 1

Day 20

Day 5

Day 10

Speed difference > 30% or < -30%♪

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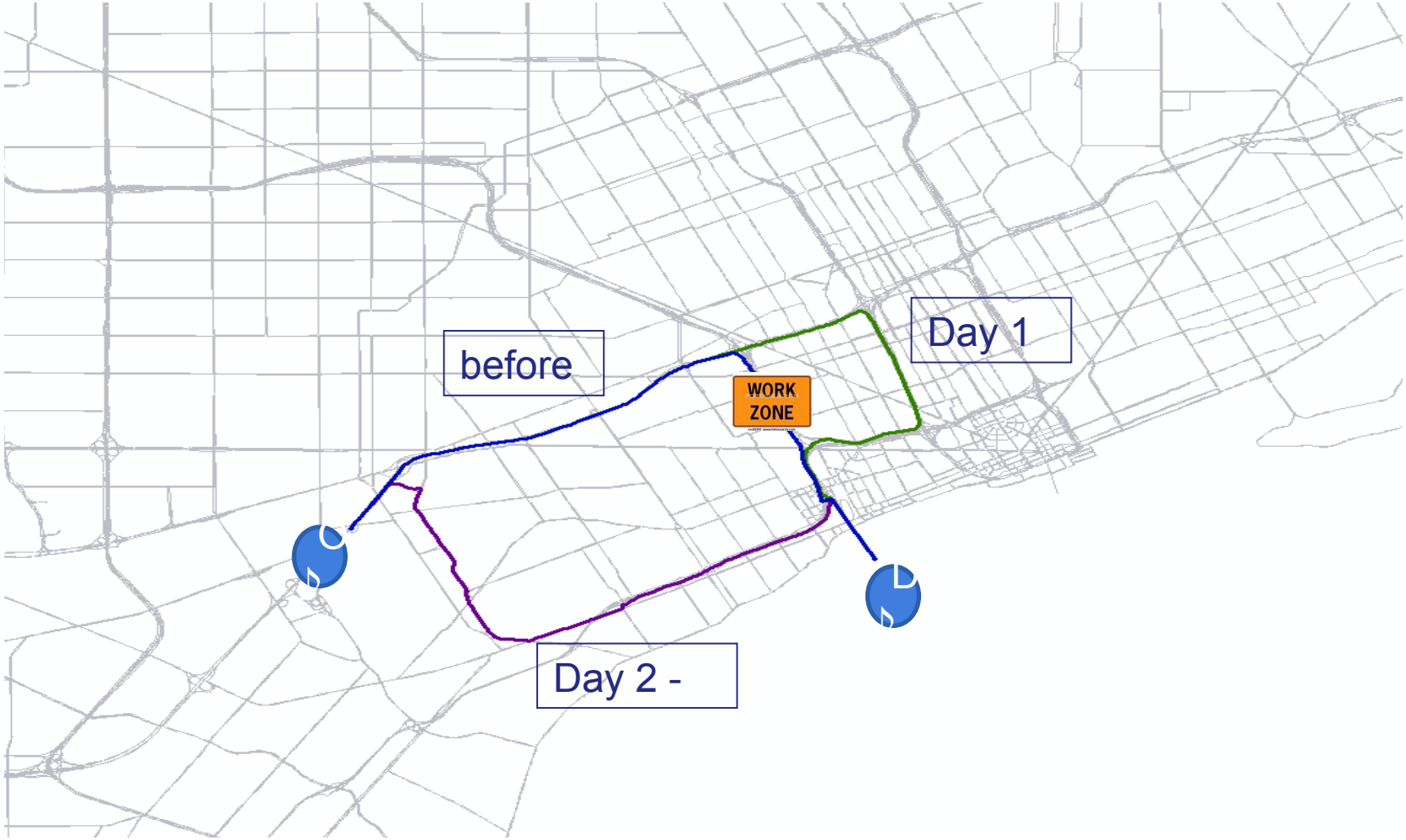
HHold_11347816♪



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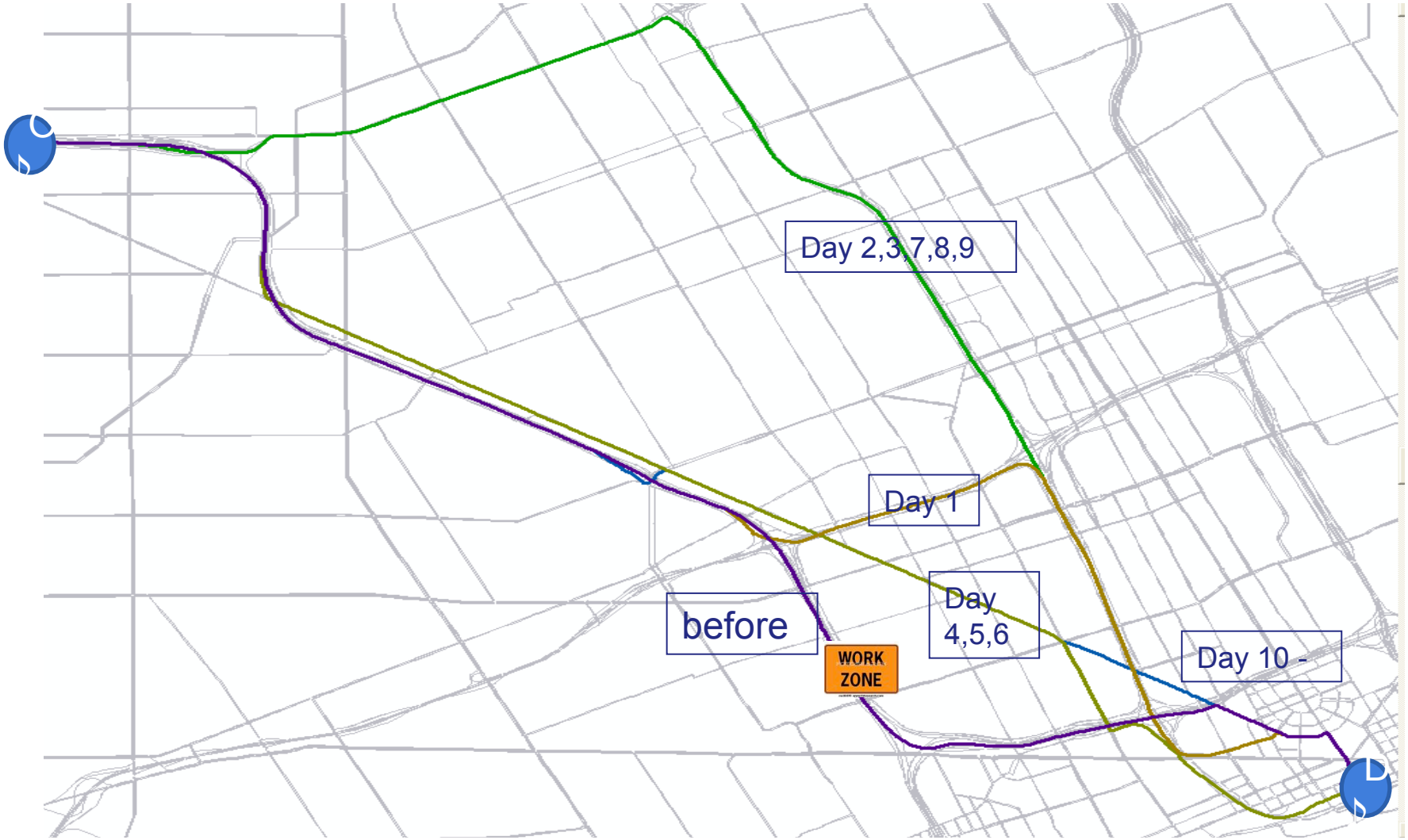
HHold_89196♪



Conclusion

- There is still a question if the day-to-day approach represent actual drivers' behavior.
- TRANSIMS is able to analyzes travel pattern changes due to highway work zones
- Some challenges and future research
  - Real time rerouting via VMS
  - Incorporation of departure time choice problem

Questions ?