Dynamic Traffic Assignment for SCAG Region

Present to: Modeling Task Force for SCAG

Cooperate | Reduce Traffic | Plant a Tree | Arrive on Time

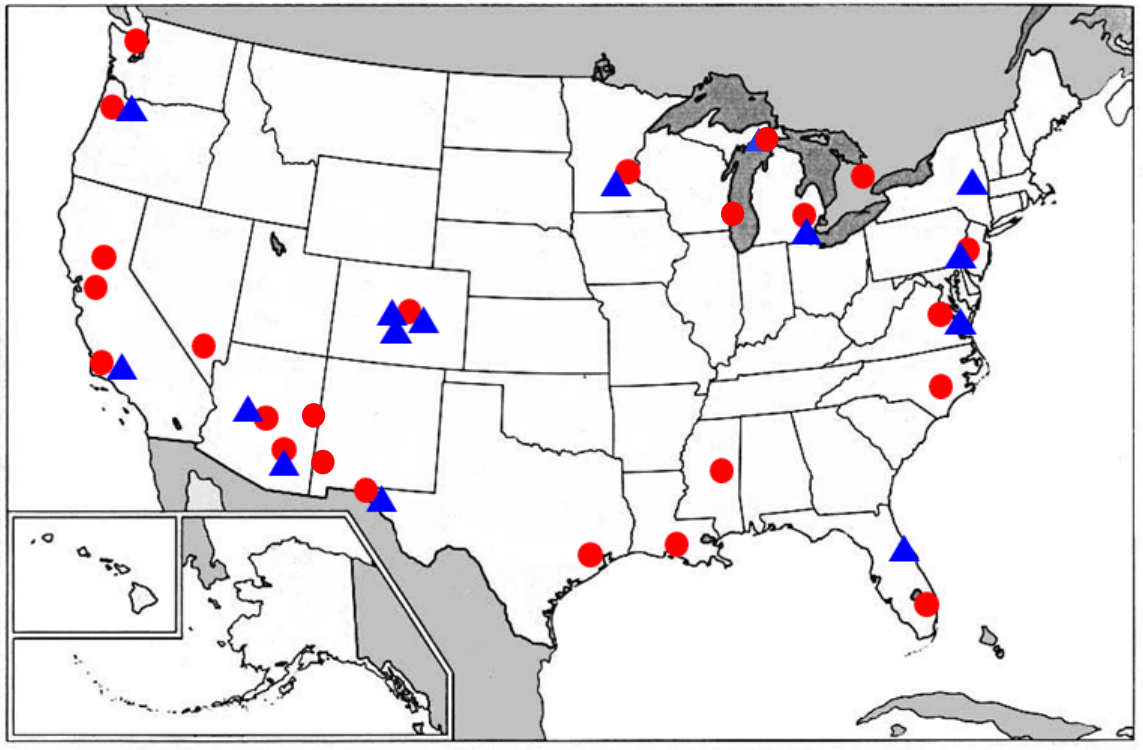
January 28, 2014

Project Goals

- General Dynamic Traffic Assignment training for SCAG staff
- Latest development/deployment status of Dynamic Traffic Assignment.
- Demonstrate how DynusT can be used for the SCAG region.

DynusT (Dynamic Urban Systems for Transportation)

- **Simple**, **lean** and easy **integration** with macro, micro models.
- Developed since 2002, applied to 50+ regions since.
- 1000+ uses world-wide since 2011.



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DynusT Professional Developments

- Metropia Inc.
  - Established in 2011
  - 12 full-time staff (3 PhDs)
  - Clients – SCAG, LADOT, NYCDOT, FHWA, ELPMPO, H-GAC
  - DynusT Modeling, software development, consulting
- University of Arizona
  - DynusT Laboratory
  - Research and Development

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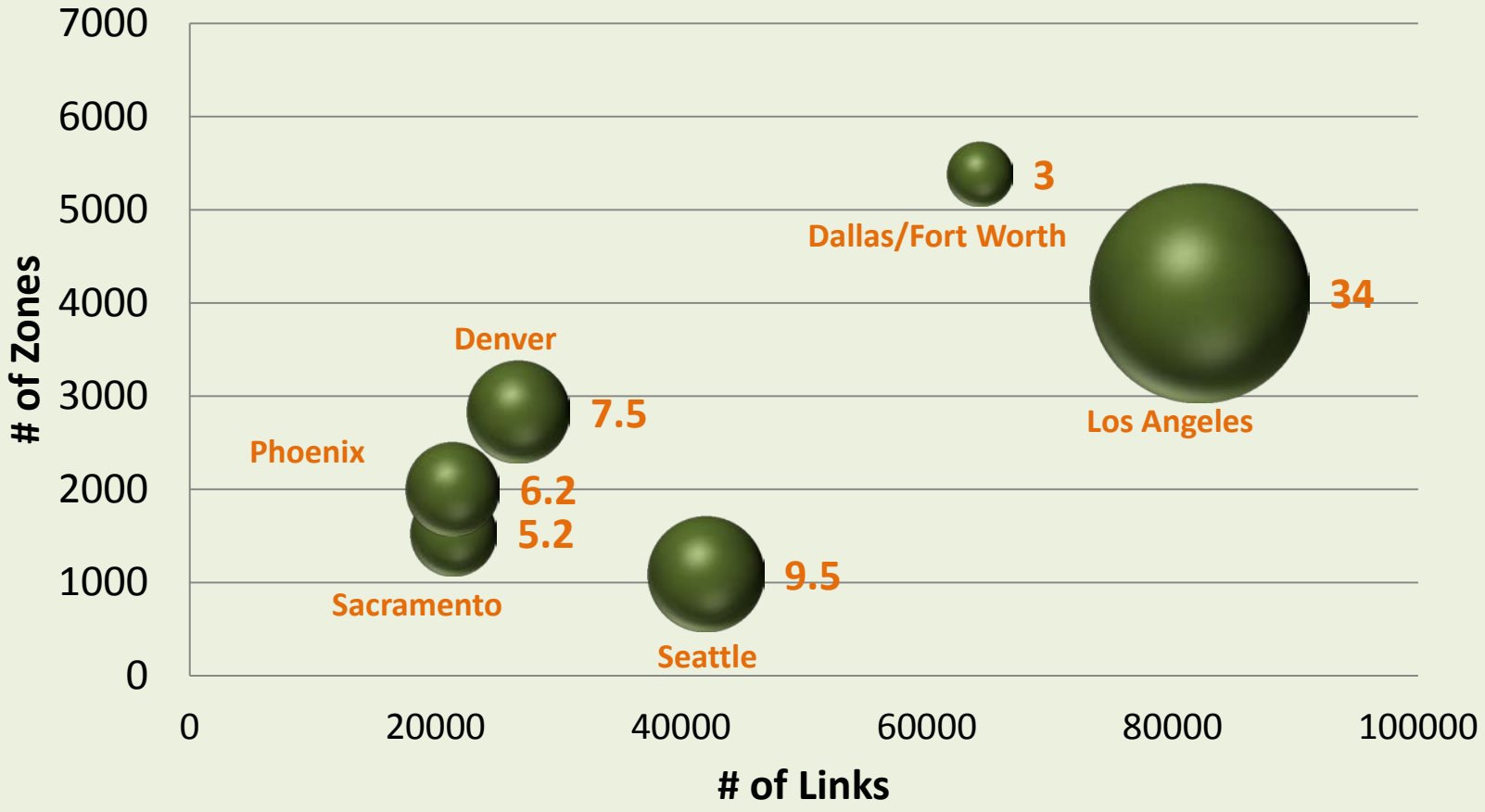
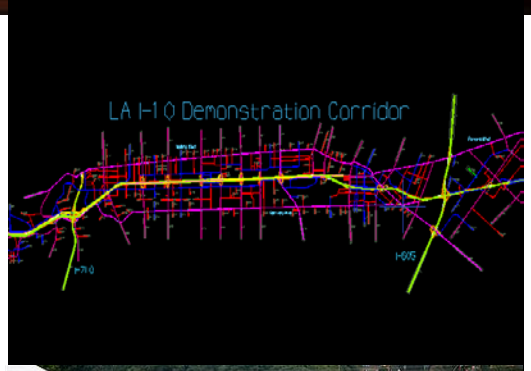
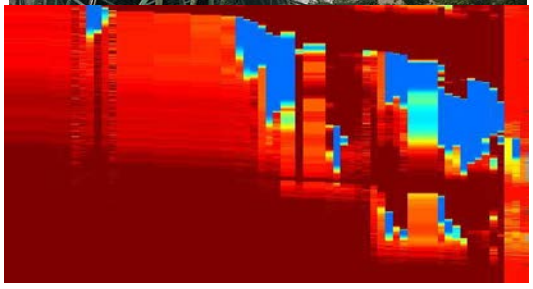
DynusT Daily Regional Models



DynusT Applications





- **Interstate highway corridor improvement** (TTI, **TxDOT**, **ELPMPO,** Kittelson**, ADOT, CDOT**)
- **Value pricing** (ORNL, **FHWA**; SRF, **Mn/DOT**, TTI, **TxDOT**, UA, **CDOT/DRCOG, Atkins/CDOT, RST/WSDOT)**
- **Evacuation operational planning** (TTI, **TxDOT**, UA, **ADOT**; LSU, **LDOT**; Noblis, **FHWA**; Univ. of Toronto, Cornell Univ. Jackson State Univ., **MDOT**, Univ. of Missouri, **MDOT**)
- **Integrated Corridor Management modeling** (CS, **FHWA**, **MAG**, NCSU, **NCDOT, MAG**)
- **Four-step model integration** (**Portland Metro, RST/FHWA, H-GAC**)
- **Activity-based model integration** (**SHRP2 C10**, **FHWA EARP**)
- **Work zone impact management** (**SHRP2 R11**)

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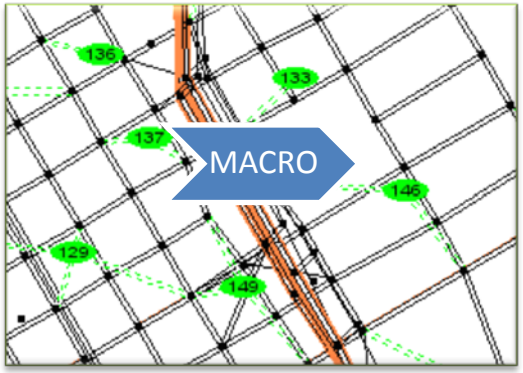
Modeling Capabilities

- Capacity Improvement/restrictions
- Congestion pricing (fixed pricing, time-of-day pricing, congestion responsive pricing, truck-only, truck restriction)
  - Dynamic user equilibrium
  - Generalized cost with heterogeneous individual attributes (e.g. value of time)

Modeling Capabilities

- ITS Strategies
- Active Traffic/Demand Linking with activity-based models.
- TDM (travel demand management)
  - Peak spreading
  - Ridesharing/TNC (ongoing)
- Linking with air quality models.

Multi-resolution Modeling
(MRM)



- Static/Instantaneous Paths
- Region Wide
- Centroid based zonal Trips
- Analytical Equilibrium
- Demand Driven
- Planning/Forecasting

Vehicle OD

DTA

Vehicle Trajectory

- Dynamic/Time Varying Paths
- Subarea / Corridor
- Vehicle Platoons

- Static Paths
- Corridor/Intersection
- Individual Vehicles
- Simulation One-Shot
- Supply Driven
- Operational

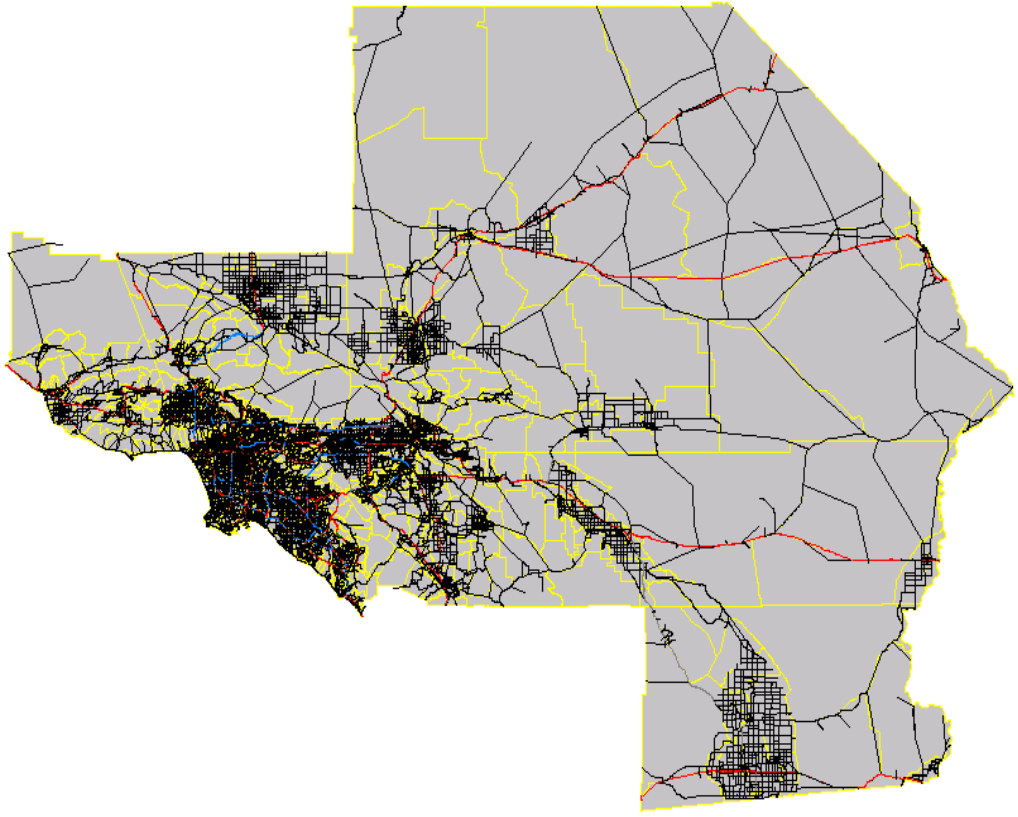
- Simulation Equilibrium
- Supply Driven
- Planning/Operational

SCAG Regional DynusT Model

Cooperate | Reduce Traffic | Plant a Tree | Arrive on Time

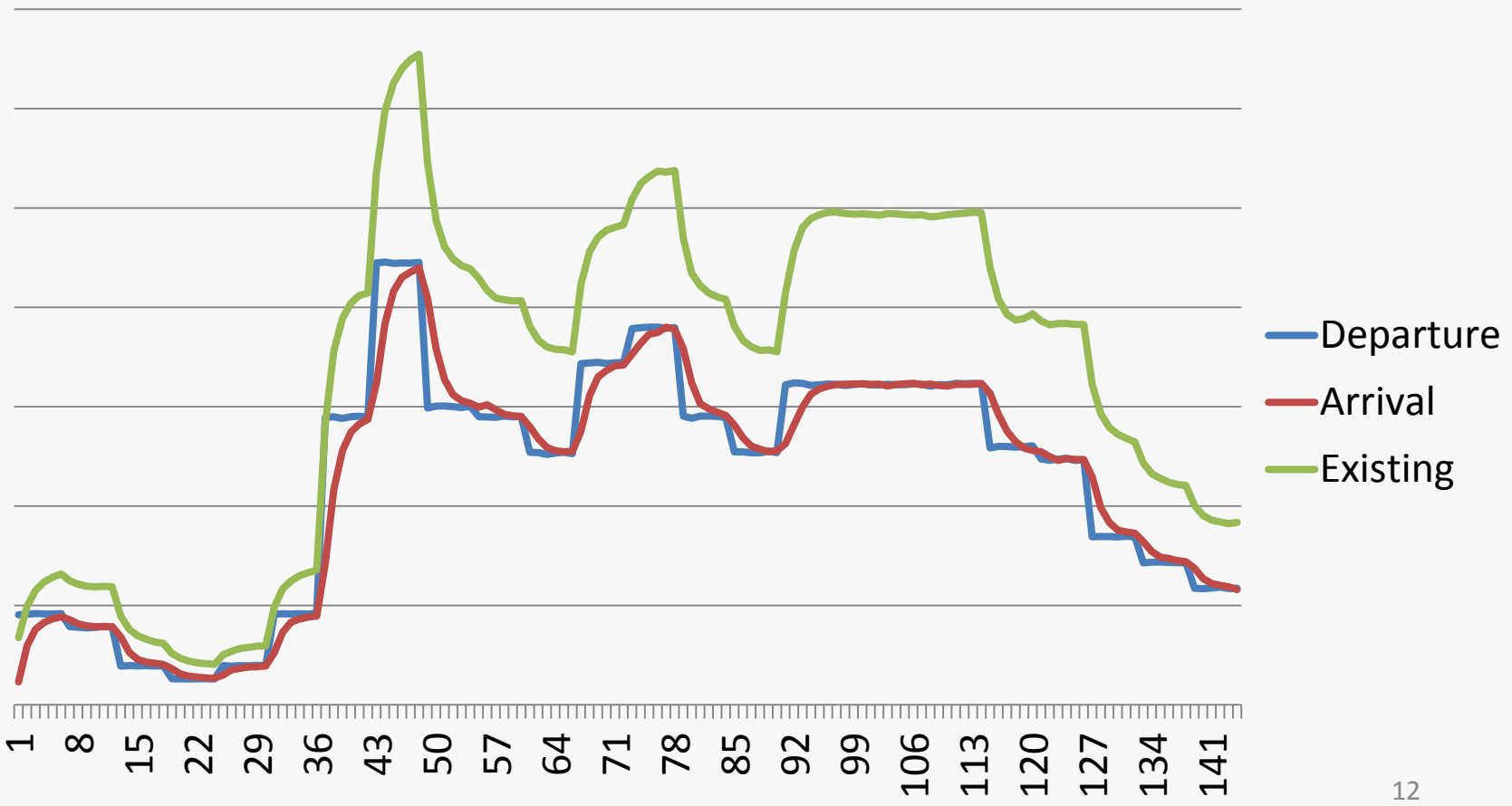
SCAG Regional Model

- 20K center line miles
- 31k nodes
- 82k links
- 4k/11k zones



24-hr Loading

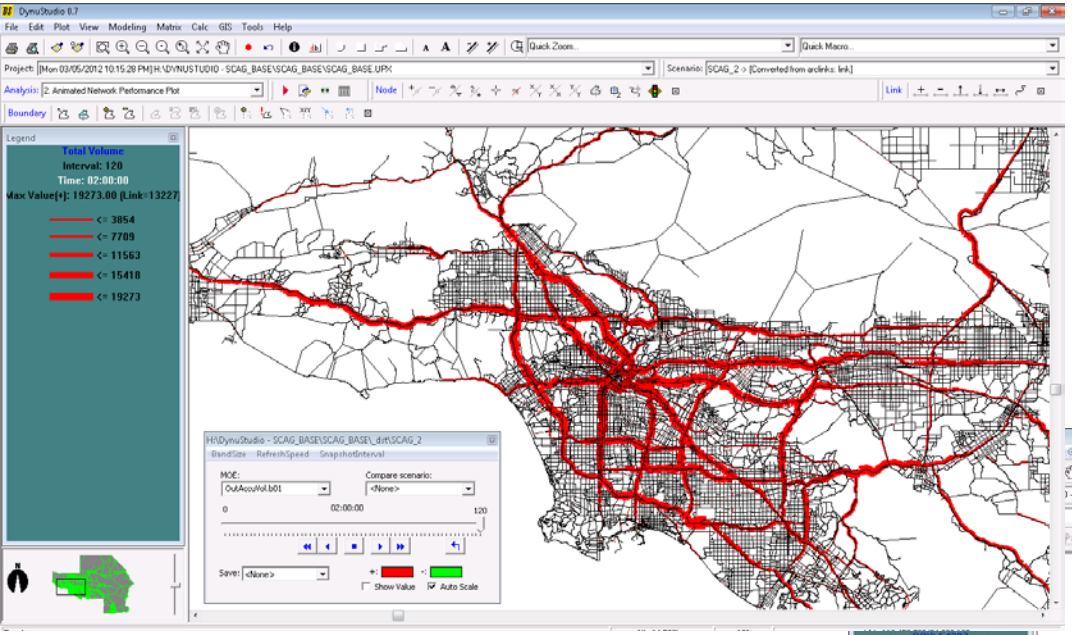
- Loading – 33 M

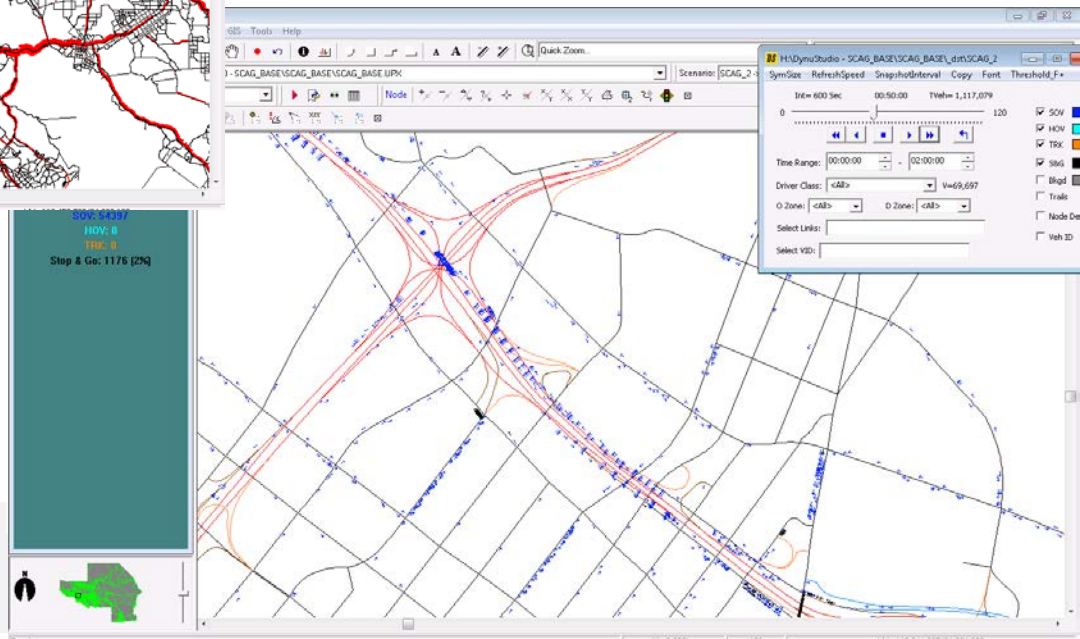


Computational Characteristics

- Peak Memory – 50GB
- Per iteration (hr)
  - Simulation – 1.5
  - Assignment – 2.0
- Improvement Opportunities
  - Run time
    - Solid-State Drive (SSD)
    - 64 GB 48 Core server
    - Reduce locking/critical regions
    - Use of static stacks v.s. dynamic allocate

Video Demo





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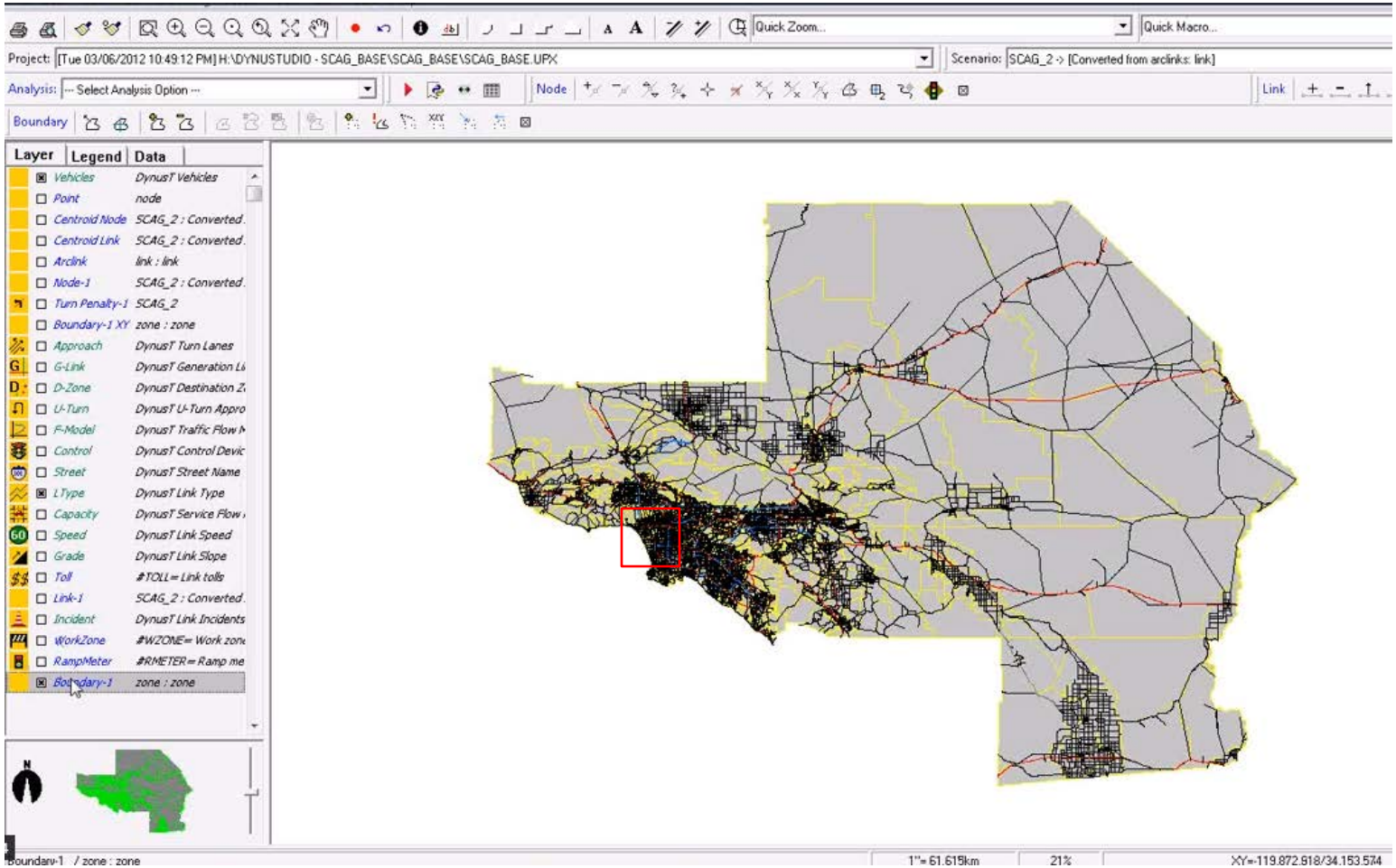
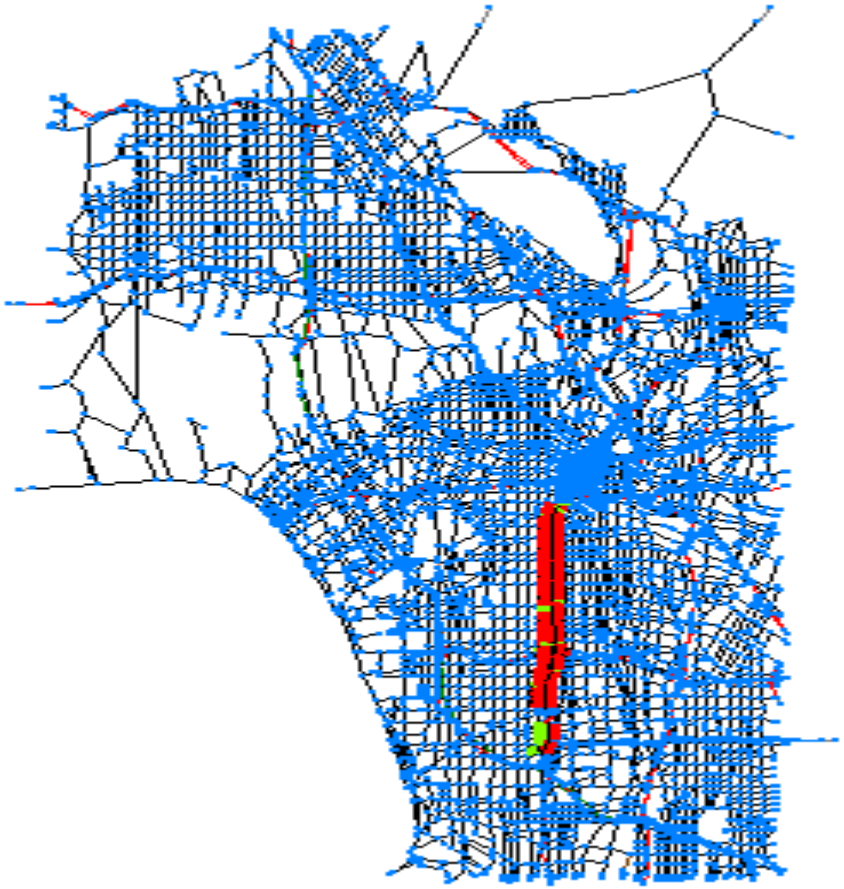
SCAG Model Applications – Congestion Pricing

Cooperate | Reduce Traffic | Plant a Tree | Arrive on Time

Regional DynusT Model

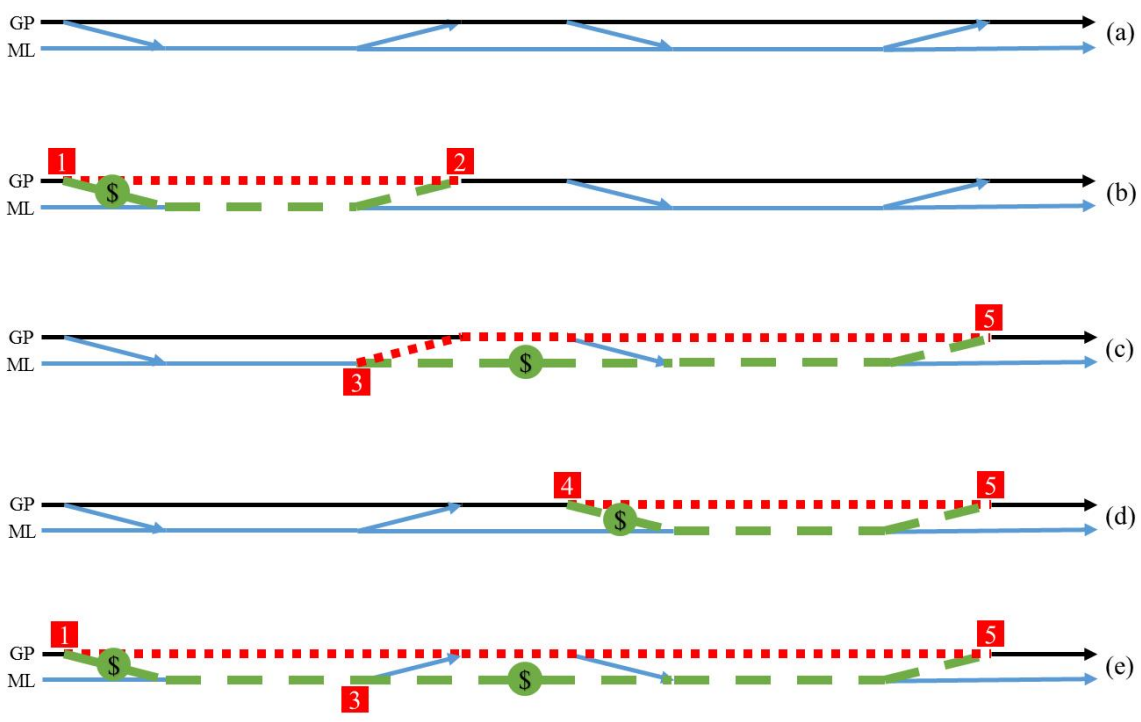


Sub-Area and HOT Scenario



Pricing Segments

- Paired HOT-GP Segment defined by ingress-egress points.
- Each segment operates independent pricing scheme



Route Choice Model

- Dynamic User Equilibrium

$$G_{l,n}^{t} = h_{l,n}^{t} + \frac{S_l^t}{\theta_n}, \qquad \forall\, l \in L, t \in T, n \in N$$

Where,

N : set of vehicle types; $N = [SOV, HOV, truck]$

n : vehicle type in set N

T : set of time intervals

t : time unit in set T

L : set of links

l : link in set L

$G_{l,n}^{t}$: generalized cost for link l at time t

$h_{l,n}^{t}$: travel time on link

Pricing Model

- Throughput Optimization

$$\max Z = \sum_{l \in L} \sum_{t \in T} k_l^t v(k_l^t)$$

Subject to,

$$v(k_l^t) \geq v_l^0, \qquad \forall\, l \in L, t \in T$$

$$\frac{d_l}{\theta_n}\left(\frac{1}{\bar{v}_l^t} - \frac{1}{v(k_l^t)}\right) \leq \pi_l^t, \qquad \forall\, l \in L, t \in T, n \in N$$

$$\frac{d_l}{\theta_n}\left(\frac{1}{\bar{v}_l^t} - \frac{1}{v(k_l^t)}\right) \geq \pi_l^t - \varepsilon, \qquad \forall\, l \in L, t \in T, n \in N$$

$$Other\ DUE\ Conditions$$

Where,

Z : managed lane flow

N : set of vehicle types; $N = [SOV, HOV, truck]$

n : vehicle type in set N

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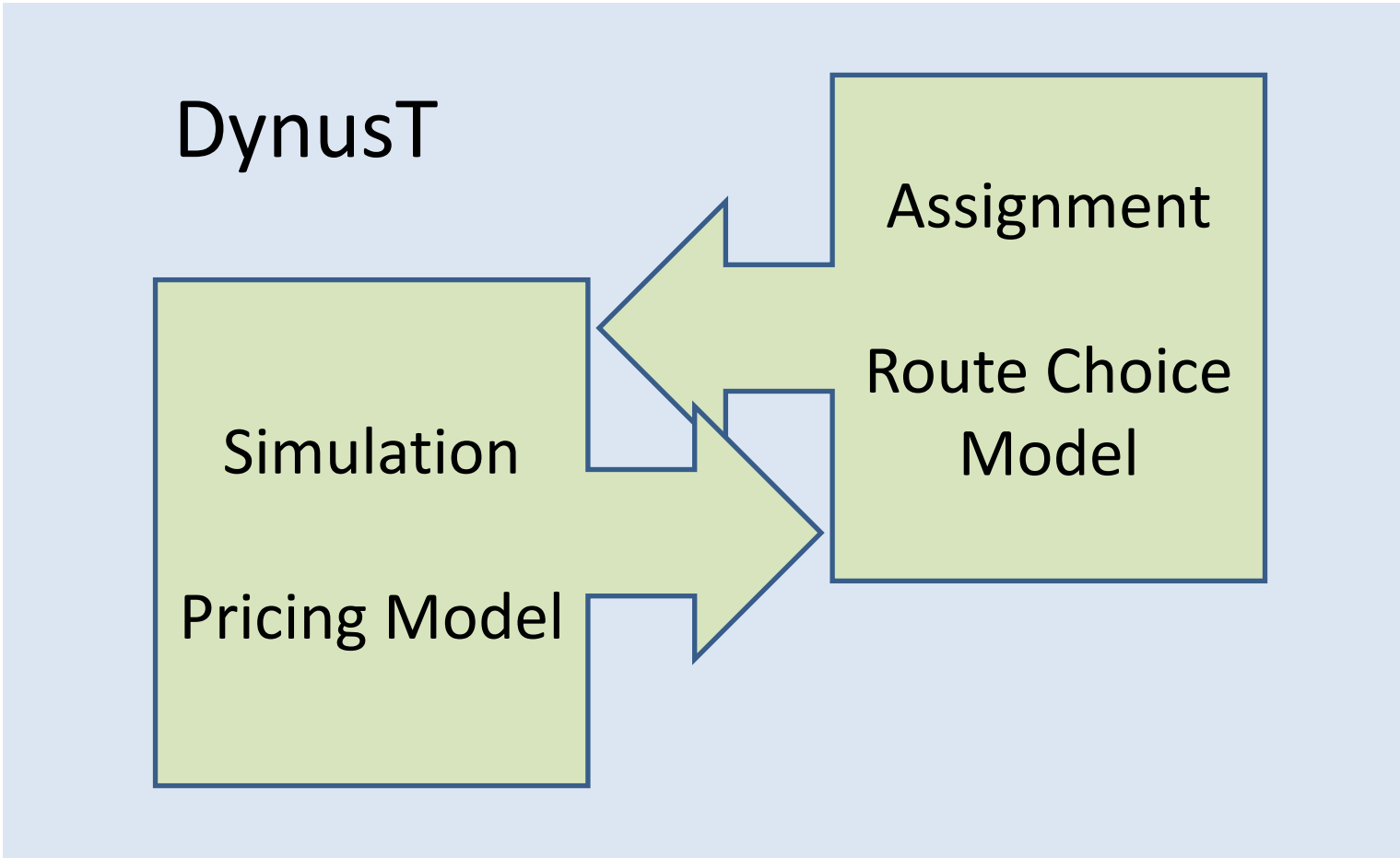
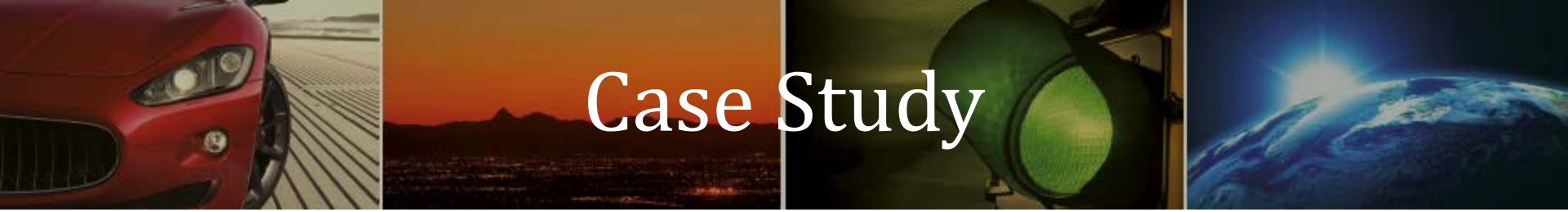
Solution Algorithm



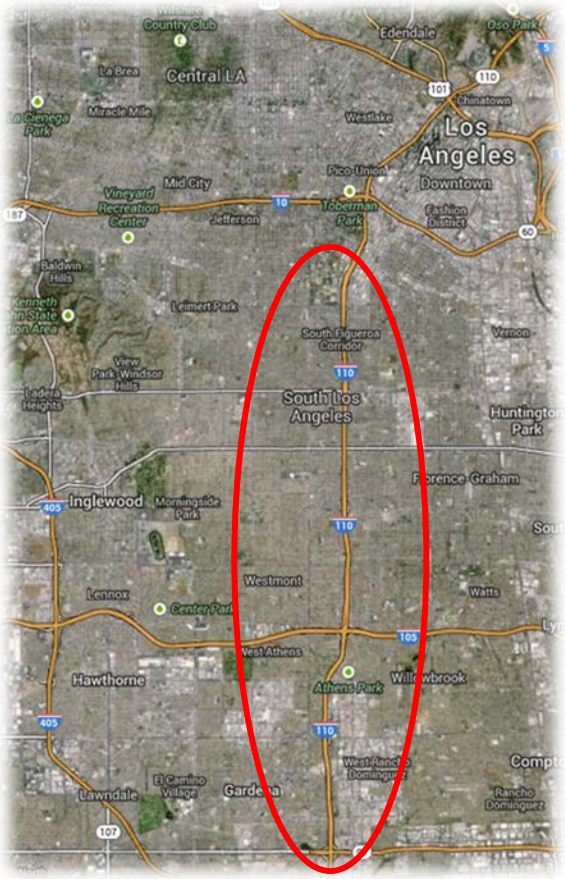


Case Study

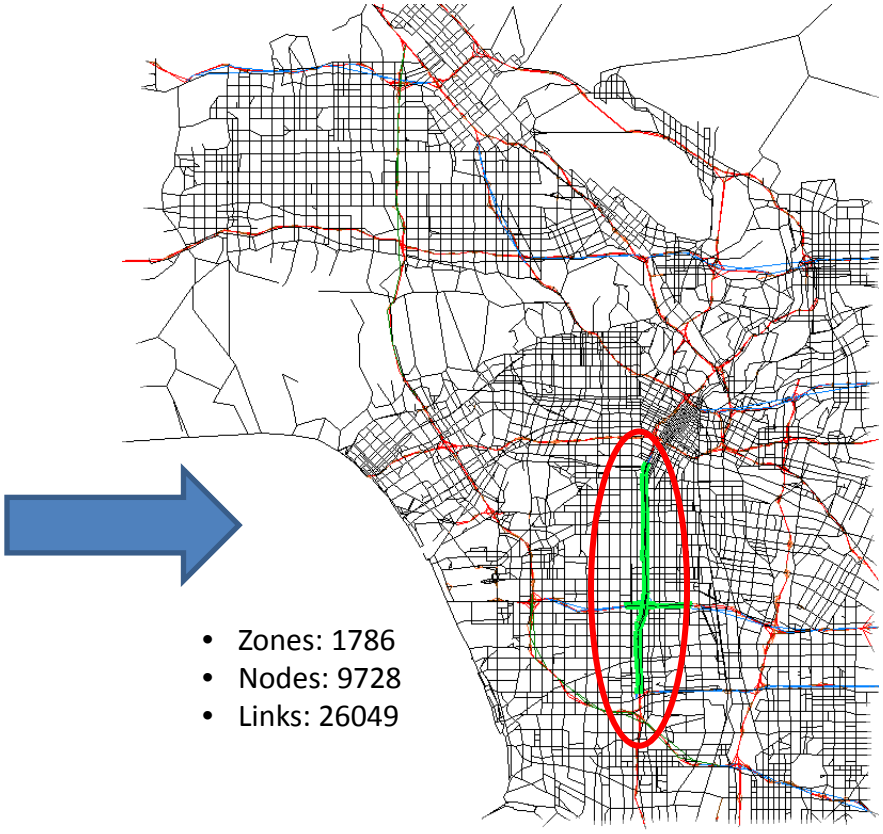
- Demonstrate use of DynusT regional model through congestion pricing modeling.
- Congestion pricing modeled as a joint throughput maximization and DUE route choice problem.
- Considering Value-of-Time.
  - SOV = $20
  - HOV = $35
  - Trucks = $60

Case Study Network

I-110 Corridor



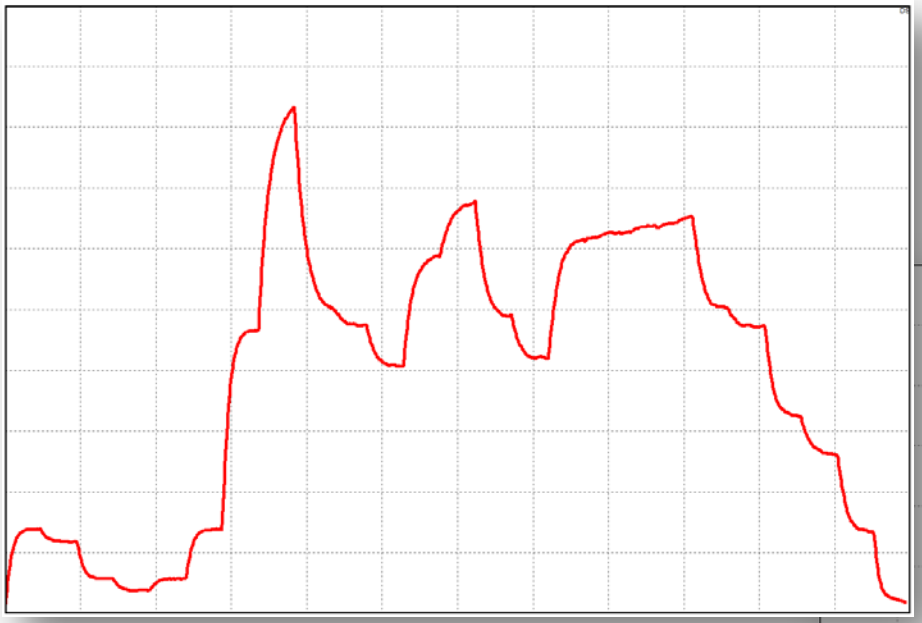
DynuStudio Sub-Area Cut



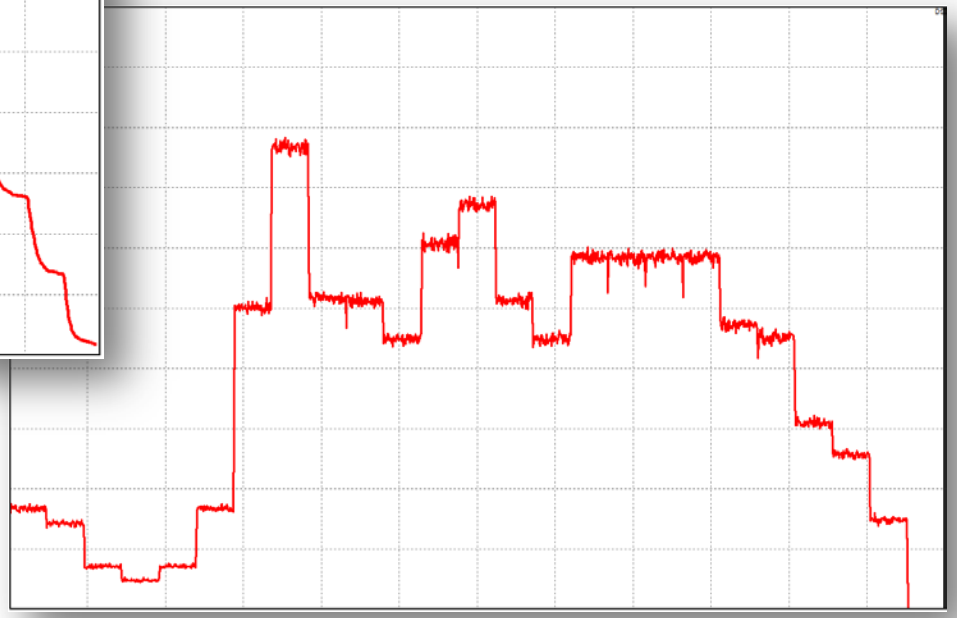
- Zones: 1786
- Nodes: 9728
- Links: 26049

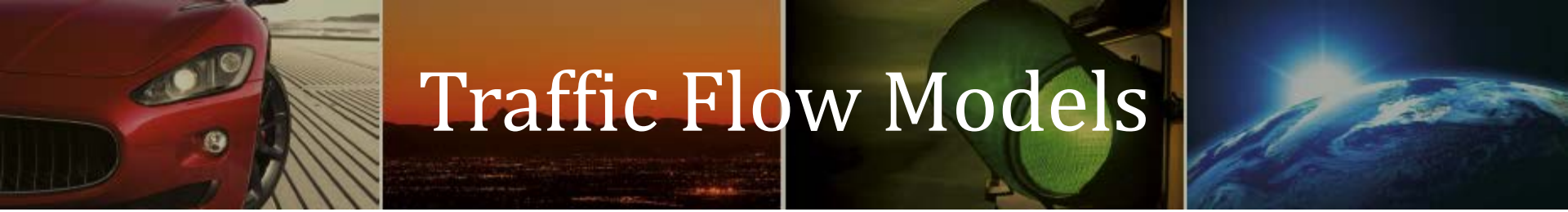
System-Wide Conditions

System Volume Profile



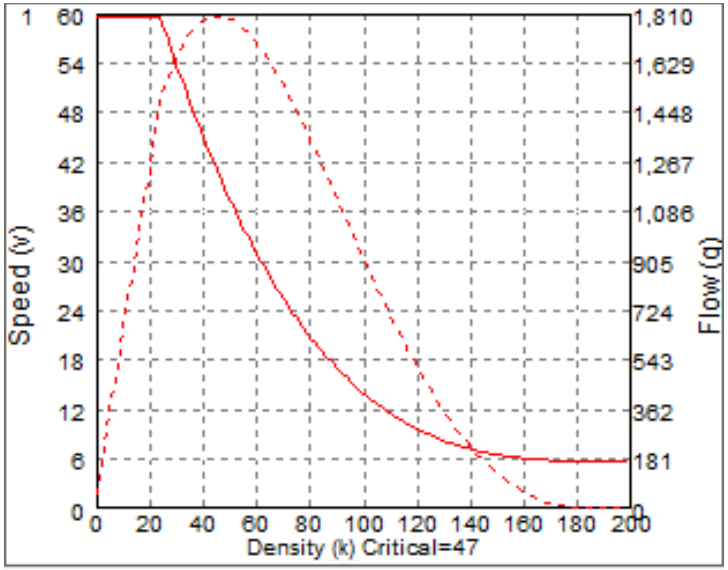
System Departure Profile



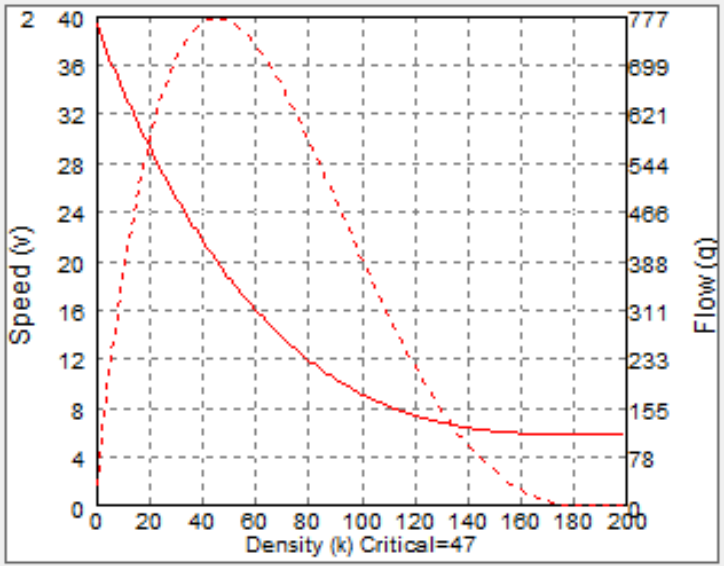


Traffic Flow Models

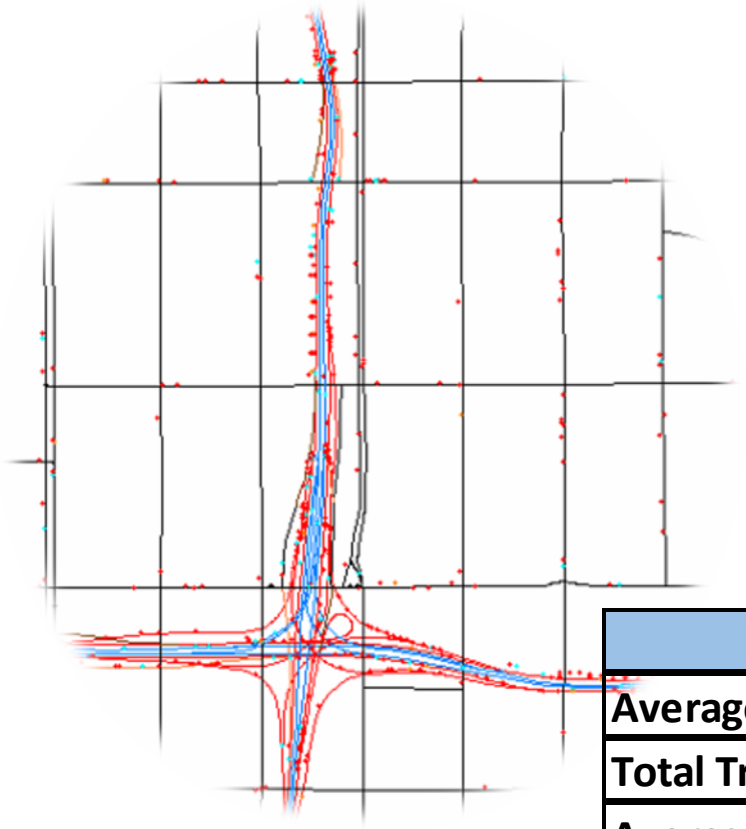
Uninterrupted Flow



Interrupted Flow



Overall Statistics



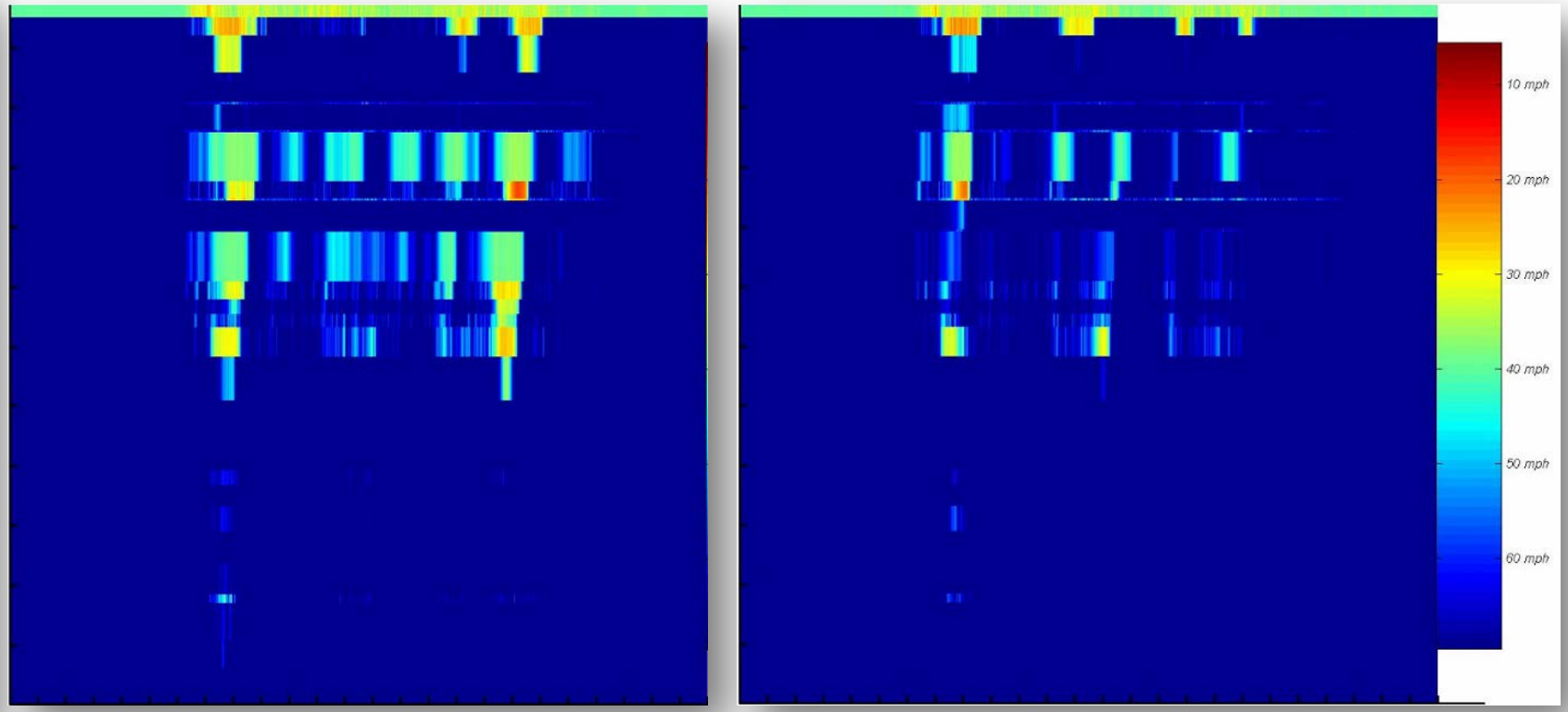
	Base	HOT
Average Travel Time	15.1887	15.1676
Total Travel Time (Minutes)	2,010,098	2,002,110
Average Trip Time	15.2281	15.2069
Average Trip Distance	9.8854	9.8532
Total Trip Distance (Miles)	78,292,408	78,036,952
Toll Revenue ($)	$0.00	$6,024.10

Case Study Network

I-110 Northbound

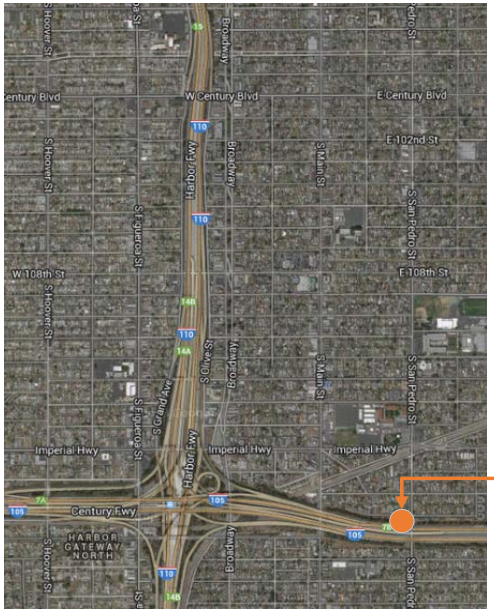
Base Scenario

HOT Scenario

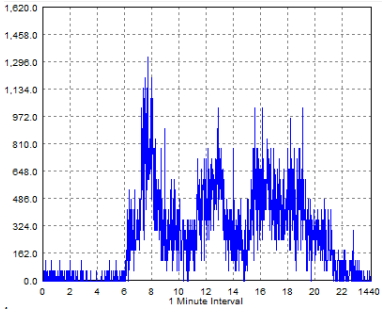


Time of Day

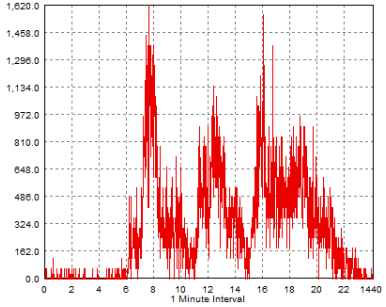
Time-Varying Pricing Scheme



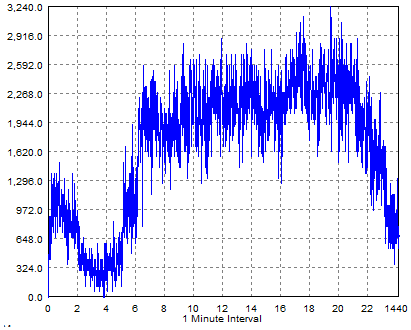
Base – HOV Segment Volume



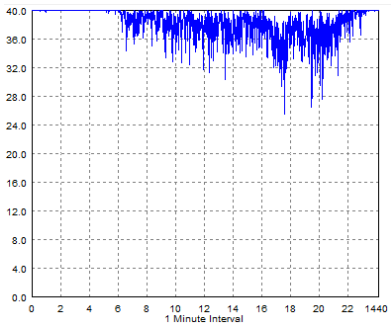
HOT – HOT Segment Volume



Base – GP Segment Volume



Base – GP Segment Speed



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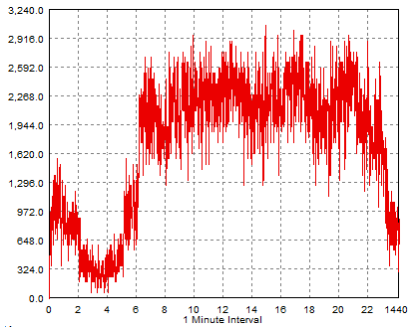

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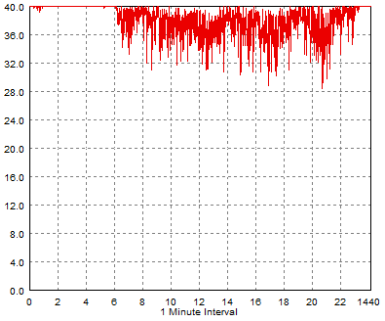
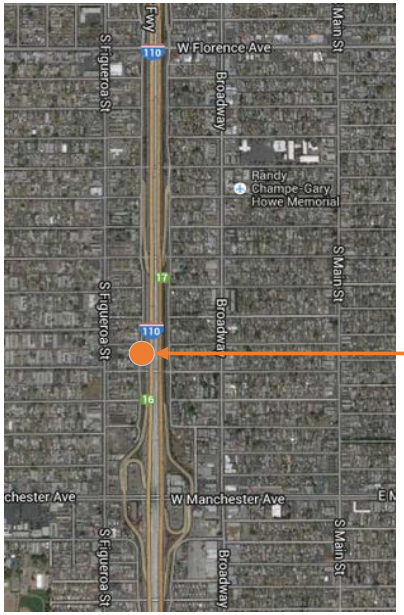
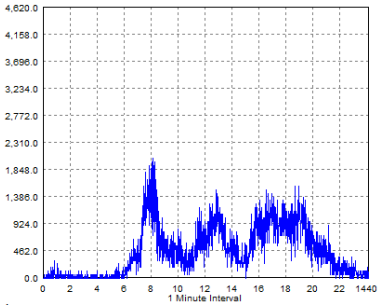


Time-Varying Pricing Scheme



Base – HOV Segment Volume



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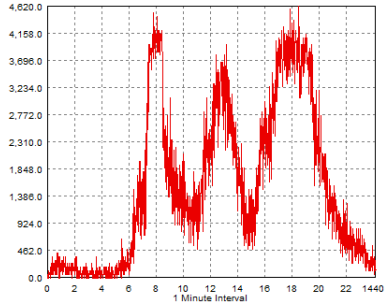

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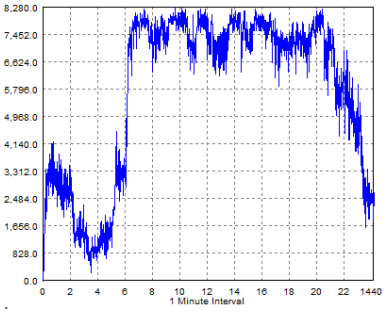

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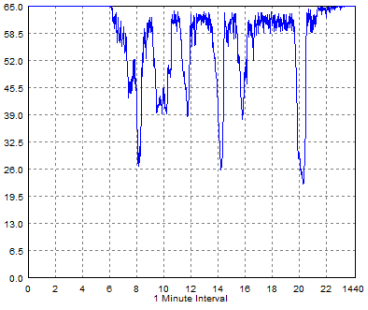

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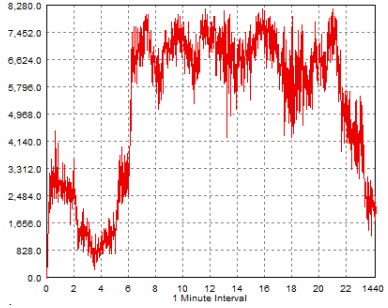

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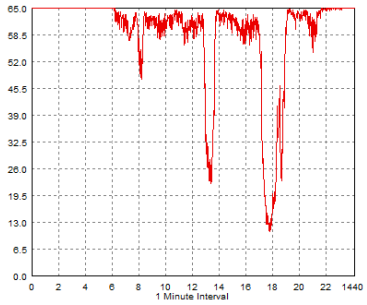

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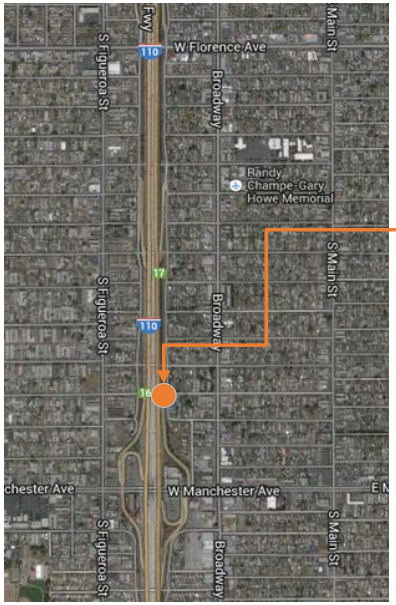
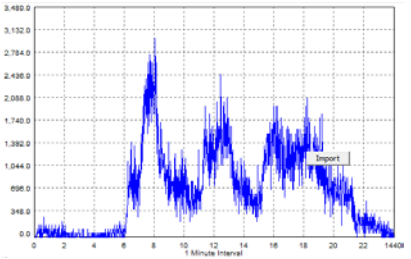


Base – HOV Segment Volume



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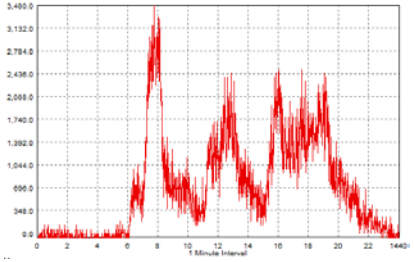

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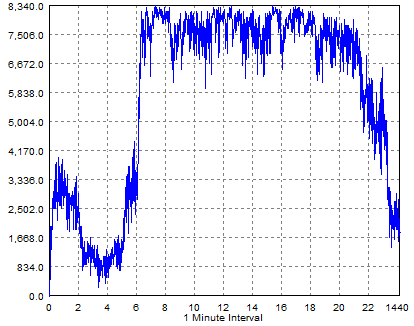

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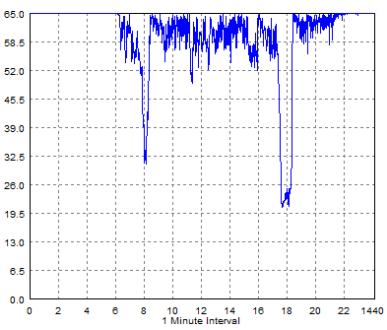

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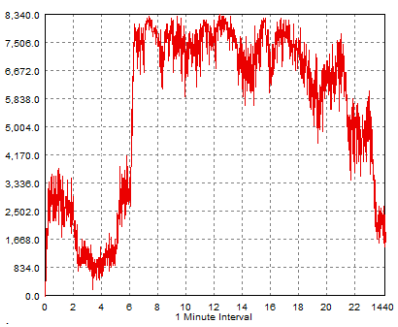

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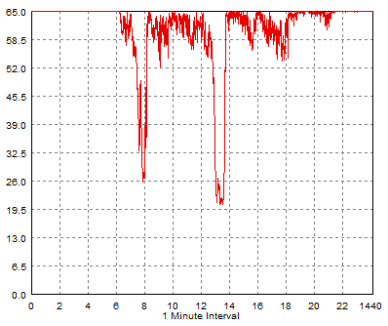

Thank You