Dynamic Traffic Assignment for SCAG Region

Present to: Modeling Task Force for SCAG

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.
- Metropia Inc.
  - Established in 2011
  - 12 full-time staff (3 PhDs)
  - Clients – SCAG, LADOT, NYCDOT, FHWA, ELPMP, H-GAC
  - DynusT Modeling, software development, consulting

- University of Arizona
  - DynusT Laboratory
  - Research and Development
DynusT Daily Regional Models

# of Zones vs. # of Links

- Los Angeles: 34 zones, 9.5 links
- Dallas/Fort Worth: 7 zones, 3 links
- Sacramento: 5.2 zones, 6.2 links
- Seattle: 5.2 zones, 7.5 links
- Denver: 6.2 zones, 7.5 links
- Phoenix: 7.5 zones, 5.2 links
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)
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)

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

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

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

Vehicle Trajectory
- DTA
- Vehicle OD
SCAG Regional DynusT Model
SCAG Regional Model

- 20K center line miles
- 31k nodes
- 82k links
- 4k/11k zones
• 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
SCAG Model Applications – Congestion Pricing
Regional DynusT Model
• Paired HOT-GP Segment defined by ingress-egress points.
• Each segment operates independent pricing scheme
• Dynamic User Equilibrium

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

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
• **Throughput Optimization**

\[
\max Z = \sum_{l \in L} \sum_{t \in T} k^t_l v(k^t_l)
\]

Subject to,
\[
v(k^t_l) \geq v^0_l, \quad \forall \ l \in L, t \in T
\]
\[
\frac{d_l}{\theta_n} \left( \frac{1}{\bar{v}^t_l} - \frac{1}{v(k^t_l)} \right) \leq \pi^t_l, \quad \forall \ l \in L, t \in T, n \in N
\]
\[
\frac{d_l}{\theta_n} \left( \frac{1}{\bar{v}^t_l} - \frac{1}{v(k^t_l)} \right) \geq \pi^t_l - \varepsilon, \quad \forall \ l \in L, t \in T, n \in N
\]

*Other DUE Conditions*

Where,
\[
Z : \text{managed lane flow}
\]
\[
N : \text{set of vehicle types; } N = [\text{SOV}, \text{HOV}, \text{truck}]
\]
\[
n : \text{vehicle type in set } N
\]
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

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

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**

![Graph for Uninterrupted Flow](image1)

![Graph for Interrupted Flow](image2)
## Overall Statistics

### Average Travel Time
- **Base**: 15.1887
- **HOT**: 15.1676

### Total Travel Time (Minutes)
- **Base**: 2,010,098
- **HOT**: 2,002,110

### Average Trip Time
- **Base**: 15.2281
- **HOT**: 15.2069

### Average Trip Distance
- **Base**: 9.8854
- **HOT**: 9.8532

### Total Trip Distance (Miles)
- **Base**: 78,292,408
- **HOT**: 78,036,952

### Toll Revenue ($)
- **Base**: $0.00
- **HOT**: $6,024.10
Time-Varying Pricing Scheme

Base – GP Segment Volume
Base – GP Segment Speed
HOT – GP Segment Volume
HOT – GP Segment Speed
Base – HOV Segment Volume
HOT – HOT Segment Volume
Time-Varying Pricing Scheme

Base – GP Segment Volume
Base – GP Segment Speed
HOT – GP Segment Volume
HOT – GP Segment Speed

Base – HOV Segment Volume
HOT – HOT Segment Volume
Time-Varying Pricing Scheme

Base – GP Segment Volume

Base – GP Segment Speed

HOT – GP Segment Volume

HOT – GP Segment Speed

Base – HOV Segment Volume

HOT – HOT Segment Volume
Thank You