Modeling Every Hill, Bus, Traffic Signal, and Car: How San Francisco Collaboratively Built a Citywide Dynamic Traffic Assignment Model

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Daniel Tischler, San Francisco County Transportation Authority
Renee Alsup, Parsons Brinckerhoff, et al.

Available at: https://works.bepress.com/gregory-erhardt/21/
Modeling Every Hill, Bus, Traffic Signal, and Car

How San Francisco Collaboratively Built a Citywide Dynamic Traffic Assignment Model

Elizabeth Sall, Greg Erhardt, Lisa Zorn, Daniel Tischler, Renee Alsup, & Neema Nassir

SAN FRANCISCO COUNTY TRANSPORTATION AUTHORITY
TRB Planning Applications Conference
May 5th, 2013
Why DTA? (recap)

Better representation of the real world

- $v \leq c$
- Queues spill back to adjacent links
- Signals & intersection design matter
- Transit and cars interact

Less messy spreadsheet work

- Less subjectivity
- Fewer typos/errors
An additional tool in the toolbox - DTA

SF-CHAMP

Regional static user equilibrium within an activity-based model

Dynamic Traffic Assignment

Time-dependent user equilibrium with realistic, but simplified vehicle simulation

Traffic Microsimulation

Highly realistic simulation of vehicle behavior and interactions
Why Collaboration?

Why not just ask for a “product”?

We have to own it in the end

“This code is inscrutable!”

“How do I do Validation or actually run a scenario?”

Shared ownership / credit makes more people care and understand situation

“We just don’t have the budget to get to that calibration target”

“I don’t care, that’s what’s in the scope”

We work with planners on real projects in SF every day.

“Shoot, Well what I really hoped DTA would be able to capture was…”

“These results don’t make any sense. I thought DTA was supposed to be useful!”

Cool Project – Let lots of interested and smart people take part and learn!

See Lisa Zorn present “The Codebase IS the Deliverable” Monday 10:30
DTA Model Development Objectives (for now)

- Have a working DTA model with results that make sense for the **PM Peak** period in **San Francisco**
- Have seamless process from SF-CHAMP to DTA results:
  - Little human intervention
  - Reduce human error
  - Use SF-CHAMP demand directly
    - Behaviorally consistent
  - Allow SF-CHAMP to take advantage of all fixes
DTA Model Development Approach

- Write code when possible for repeated human tasks
  - Don’t re-write code that exists in our DTA package
  - Develop in an open source environment
- Use as much ‘real’ data as possible
- Fix all issues “at the source” if possible
Where we were starting from in SF-CHAMP

Every transit stop
Every transit line
Every street
Every Hill

981 Zones in SF
DTA ANYWAY CODEBASE & INPUT DEVELOPMENT

Input

Codebase

Calibration
DTA Anyway for Automation

- Static Network
- Static Network + Projects
- Python Scripts
- DTA Anyway Python Module
- DTA Network
- DTA Network + Projects
## DTA Anyway Capabilities

<table>
<thead>
<tr>
<th>DTA Anyway <strong>Can</strong></th>
<th>DTA Anyway <strong>Cannot</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Read Cube Networks / text-based static networks</td>
<td>• Visualize anything directly</td>
</tr>
<tr>
<td>• Read/Write Dynameq ASCII files</td>
<td>• Read/Write DTA networks for other DTA software (but designed to make this easily implementable)</td>
</tr>
<tr>
<td>• Write GIS shapefiles</td>
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<tr>
<td>• typical network edits</td>
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</tbody>
</table>
DTA Inputs

http:// dta. googlecode. com
Input Development (alongside codebase development)

Signals
- 1,100 signals
- Actuated signals approximated to fixed
- Source: SFMTA-defined Excel files

Transit
- 236 Lines
- Source: SF-CHAMP Cube Files

Demand
- CHAMP Demand
- 620k vehicles 2:30-7:30 PM
- 976 zones + 22 Exts
- Time profile f(counts)

Stops
- 1,845 AWSC
- 919 TWSC
- Source: SFMTA GIS
CALIBRATION AND VALIDATION
“Model Calibration involves the identification of a set of DTA model inputs and parameters that results in model outputs that are reasonably close to those field observations.”

- DTA Primer
Model Calibration Approach

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Source: DTA Primer

VS

Downstream

Upstream
Model Calibration Approach

1. Ensure quality inputs
2. Measure anything that can be measured
3. Evaluate the results qualitatively
4. Evaluate the results quantitatively
5. Make defensible adjustments

What factors that affect driver behavior are missing from the model?

For detailed “Adventures in Calibration”: Dta.googlecode.com Webinar Presentation Slides 25-29
### Data sources for parameter estimation

<table>
<thead>
<tr>
<th>Param.</th>
<th>Free-flow Speed</th>
<th>Saturation Flow</th>
<th>Response Time</th>
<th>Jam Density</th>
</tr>
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<tbody>
<tr>
<td>FT</td>
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<tr>
<td>PeMS</td>
<td>PeMS</td>
<td>PeMS</td>
<td></td>
<td>Inferred from CBD arterials</td>
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<tr>
<td>Arterials</td>
<td>SFMTA speed</td>
<td>CBD saturation headway observations</td>
<td>CBD queue dissipation observations</td>
<td>CBD arterial queue length observations</td>
</tr>
<tr>
<td>Locals &amp; Collectors</td>
<td>Limited SFMTA speed surveys &amp; supplemental observations</td>
<td>Mostly inferred from CBD arterials</td>
<td>Mostly inferred from CBD arterials</td>
<td>Mostly inferred from CBD arterials</td>
</tr>
</tbody>
</table>

*Red text = data limitations*
Final Calibration Parameters

- Final generalized cost expression
  - Travel Time, Tolls, Turn Penalties
  - Distance tried, didn’t work well
- Response times
  - Function of uphill and downhill slopes
- Signalized turning movement capacity:
  - Function of asserted pedestrian densities
- Read all about the details:
  
  http://www.sfcta.org/dta

Additional reading material!
Validation Data - Counts

- Count Dracula is SFCTA’s traffic counts database
- Recent (2009-2011) midweek (Tue/Wed/Thu) counts queried from Count Dracula API for DTA Validation

For more CountDracula
Lisa Zorn presents: “Sharing Is Caring” Wednesday, 1:30 PM

<p>| | |</p>
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>97</td>
<td>15-minute link counts</td>
</tr>
<tr>
<td>22</td>
<td>60-minute link counts</td>
</tr>
<tr>
<td>864</td>
<td>15-minute movement counts</td>
</tr>
<tr>
<td>160</td>
<td>5-minute movement counts</td>
</tr>
</tbody>
</table>

https://github.com/sfcta/CountDracula
Validation Data – Travel Times

- Spring 2011 Level of Service Monitoring
- 272 Summary Segments
Validation Results
Convergence & Performance

- DTA shows stable convergence for ~20 iterations
- Mean Relative Gap: 2.7%
- ~109 50ish hours computing
- Max waiting vehicles ~ 350 (1%)
- Demand clears in reasonable time
- No observed gridlock
Validation Results
Link Volumes

- Total volume ~13% low.
- What are some good standards? We couldn’t find any and neither could our peer review panel.
- 55% total RMSE, 40% RMSE for links >500 vph.
- 75% of arterials within Caltrans maximum desirable deviation guidelines.

[Graphs showing 60-Minute Link Volume and Average Link Volume]
Travel times are reasonable on average.

A few outliers drive differences.
Validation Results
Citywide Flow Patterns

- Overall flow pattern logical, and similar to static model
SENSITIVITY & SCENARIO TESTING

Random Number Seeds
Small Network Change
Future Demand
Congestion Pricing
Bus Rapid Transit
Added a $3 fee to anyone crossing the cordon to manage congestion in downtown San Francisco
Congestion Pricing Application Test – Static vs. DTA Flow Maps

- DTA Model shows a much clearer diversion to paths outside the cordon
- Static model shows some odd shifts that in the Northern region including increases in EB traffic going toward the CBD

Map of Flow Change from Static Pricing Test (Red links – flow loss of at least 250 vehicles, Blue links – flow gain of at least 250 vehicles)

Map of Flow Change from DTA Pricing Test (Red links – flow loss of at least 250 vehicles, Blue links – flow gain of at least 250 vehicles)
Congestion Pricing Application Test – Static vs. DTA Speed Maps

- DTA Model shows more widespread impacts on speed with faster speeds in most of the CBD.
- Using the static model results could greatly underestimate the potential travel time impacts in the CBD.

Map of Speed Change from Static Pricing Test (Red links – speed loss of at least 5 mph, Blue links – speed increase of at least 5 mph)

Map of Speed Change from DTA Pricing Test (Red links – speed loss of at least 5 mph, Blue links – speed increase of at least 5 mph)
Credit where it is due...

**SFCTA**
- Elizabeth Sall – Conductor
- Lisa Zorn – Code Cowgirl
- Daniel Tischler – Calibration Hero
- Neema Nassir – Traffic Model Data Collection Dynamo
- John Urgo – Willing data collector
- Annie Chung & Matthew Chan – Courageous count coders

**Parsons Brinckerhoff**
- Gregory Erhardt – Consultant PM
- Renee Alsup – Calibration Hero
- [Michalis Xynatarakis] – the one who had done this before
- Jim Hicks & Joel Freedman – Parental Supervision

**Peer Review Team**
- Joe Castiglione
- Bruce Griesenbeck
- Vassilis Papayannoulis
- David Stanek
- Xuesong Zhou

**Keeping Us Sane**
- Michael Mahut – INRO
- Brian Gardner – FHWA

www.sfcta.org/dta  dta.googlecode.com
Credit where it’s due....

Greg Erhardt (PB) – Consultant PM
Lisa Zorn (SFCTA) – Codebase Lead + CountDracula
Daniel Tischler (SFCTA) – Traffic Flow Calibration Lead
Renee Alsup (PB) – Calibration + Sensitivity Testing
Neema Nassir (SFCTA/U of Arizona) – Traffic Flow Model
Michalis Xyntarakis – Early codebase development

www.sfcta.org/dta       dta.googlecode.com
FUTURE WORK
&
ONGOING RESEARCH
Future Work: Deployment

- Examine stochasticity
  - Useful tool for finding ranges
- Work with local consultants and agencies
- Use with real projects!
Future Work: Development

- Improve pedestrian/bike interaction representation
- Represent actual parking locations
- Improve demand in SF-CHAMP
Research: Person-based Transit Assignment
FAST-TrIPs

Simulate individual riders, individual buses based on DTA trajectories (or GTFS)

Why?

- Bus Bunching
- Transit reliability
- Capacities
- Actual schedules

See: Khani, Zorn and Sall, 2013 TRB Annual Meeting

Update transit vehicles’ dwell time f(FAST-TrIPs boarding and alightings)
Research: Person-based Transit Assignment
FAST-TrIPs

Route 38 - Geary Blvd, Vehicle Trip Starting at 5:47PM

See: Khani, Zorn and Sall, 2013 TRB Annual Meeting
Research: Transit Reliability / FAST-TrIPs Development

- More FAST-TrIPs/DTA Integration
  - Convergence methodologies
- FAST-TrIPs/CHAMP Integration
  - Use static assignment
  - Skimming
  - Sensitivity tests
- Develop Reliability Metrics in FAST-TrIPs
  - As function of demand profiles
  - As function of network and service characteristics
Convert Static Network → Dynamic

1. Define Scenario: vehicle types and classes, generalized cost
2. Import Cube network data, defining DTA attributes in terms of Cube attributes
3. Add all movements, prohibiting most U-Turns, explicitly naming some where geometry is confusing
4. Read GIS shapefile for road curvature
5. Add virtual nodes/links between centroids and road nodes
6. Move centroid connectors from intersections to midblock

| 15,000 | Nodes |
| 37,000 | Links |
| 109,000 | Movements |
Import Transit Routes

1. Reads Cube-formatted transit line files and converts into DTA transit lines
2. Use shortest-path to connect links that may have been split
3. Where LRT lines go off the DTA network (underground or on separated ROW), they are split into segments (discarding those not on the DTA network)
4. Movements are explicitly allowed for transit if previously prohibited
Import Signals

- Reads signal card data from Excel files in a SFMTA-defined format
- We search for the section specifying the weekday PM peak plan
- For errors and unique circumstances encountered (and there were many), responses could be:
  - Update signal card itself
  - Update signal-card reading code
  - Update static network

1,100 Signal Time Plans

- We approximate the few actuated signals with their fixed time version
- Signal-reading code is not very reusable
Import Stop Signs

- Stop signs are coded as (GIS point, street name, cross street name, and direction the stop sign is facing)
- Signal data takes precedence
- Mark as all-way stops when # of stop signs for a node matches the # of incoming links
- Otherwise, mark as two-way

1,845 All-way stop nodes
919 Two-way stop nodes
1,020 Custom priority stop nodes

Custom priorities for two-way stops where facility types tie
Auto and truck tables are imported from SF-CHAMP MD, PM, EV demand tables

535.2k auto trips, 84.2k truck trips loaded

2:30-7:30p

The DTA network uses same TAZ structure is used as SF-CHAMP because the zones are small (976 within SF, plus 22 external stations)

The PM (3:30p-6:30p) demand is peaked slightly towards 5-6p based on traffic counts
Future Work - Development

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Level of Effort

Low Effort
Near Term

- 3.1 Investigate Stability
- 2.1 Transit Representation (Transit Lanes)
- 2.2 Non-Motorized Representation
- 2.3 Robust Parking Model
- 2.5 Truck / Commercial Vehicle Model

Level of Effort

Level of Effort

High Effort
Long Term

- 2.1 Transit Representation (FAST-TriPs)
- 2.4 External Geographic Representation
- 4.3 Dynamic Skims
- 4.3 Temporal Robustness

Level of Effort

Integrated SF-CHAMP / SF-DTA Model

Level of Effort

Level of Effort

3.2 Computing Efficiency

Level of Effort

4.2 24-Hour DTA

Level of Effort

4.1 Reliability Variables