May 5, 2013

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

Elizabeth A. Sall, *San Francisco County Transportation Authority*
Gregory D. Erhardt, *Parsons Brinckerhoff*
Lisa Zorn, *San Francisco County Transportation Authority*
Daniel Tischler, *San Francisco County Transportation Authority*
Renee Alsup, *Parsons Brinckerhoff*, et al.

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

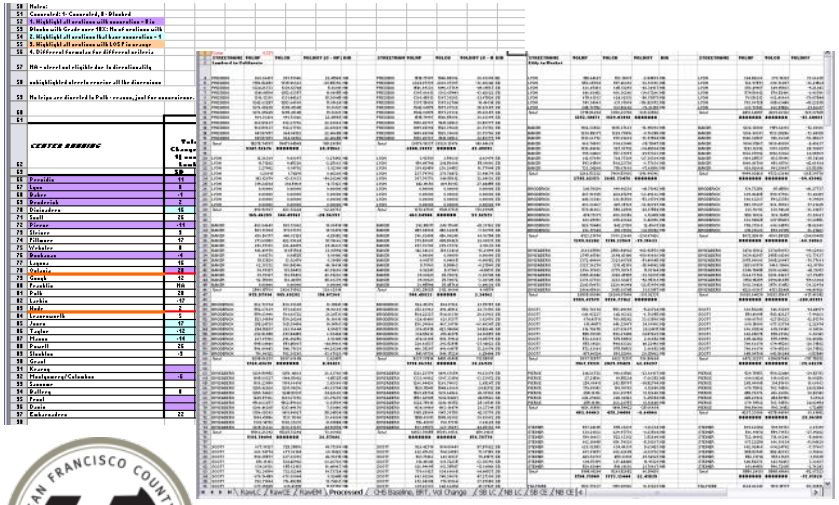
SAN FRANCISCO COUNTY TRANSPORTATION AUTHORITY

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**

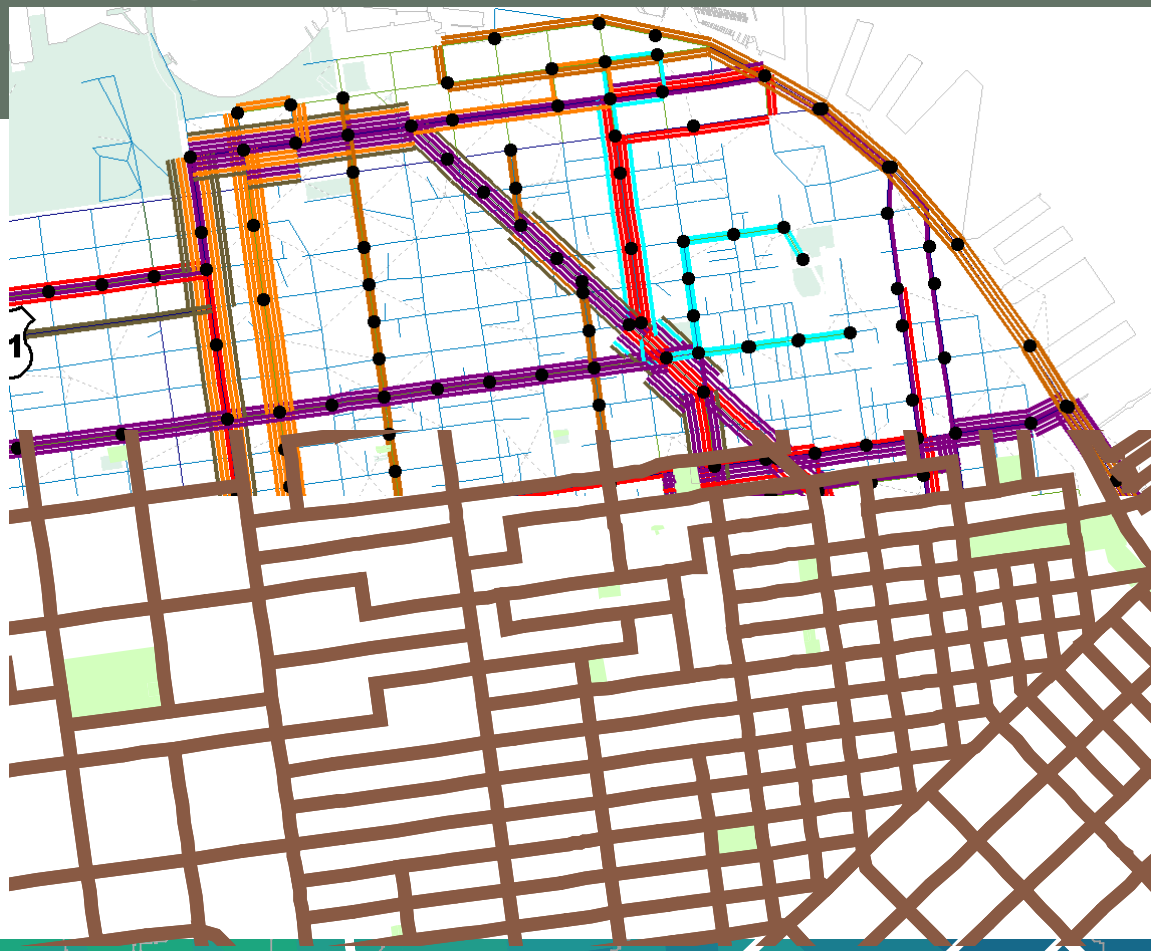
Where we were starting from in SF-CHAMP

Every transit stop

Every transit line

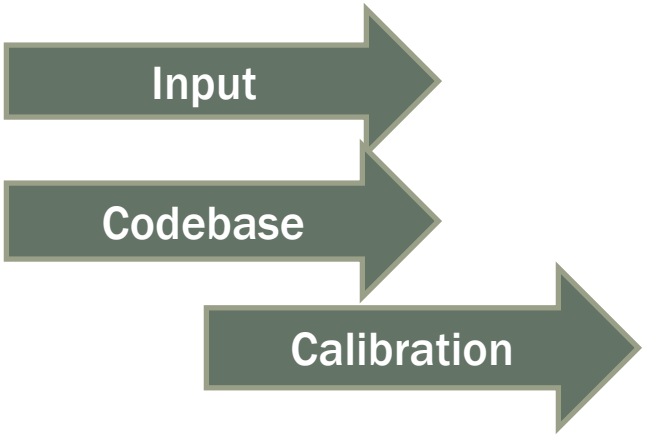
Every street

Every Hill

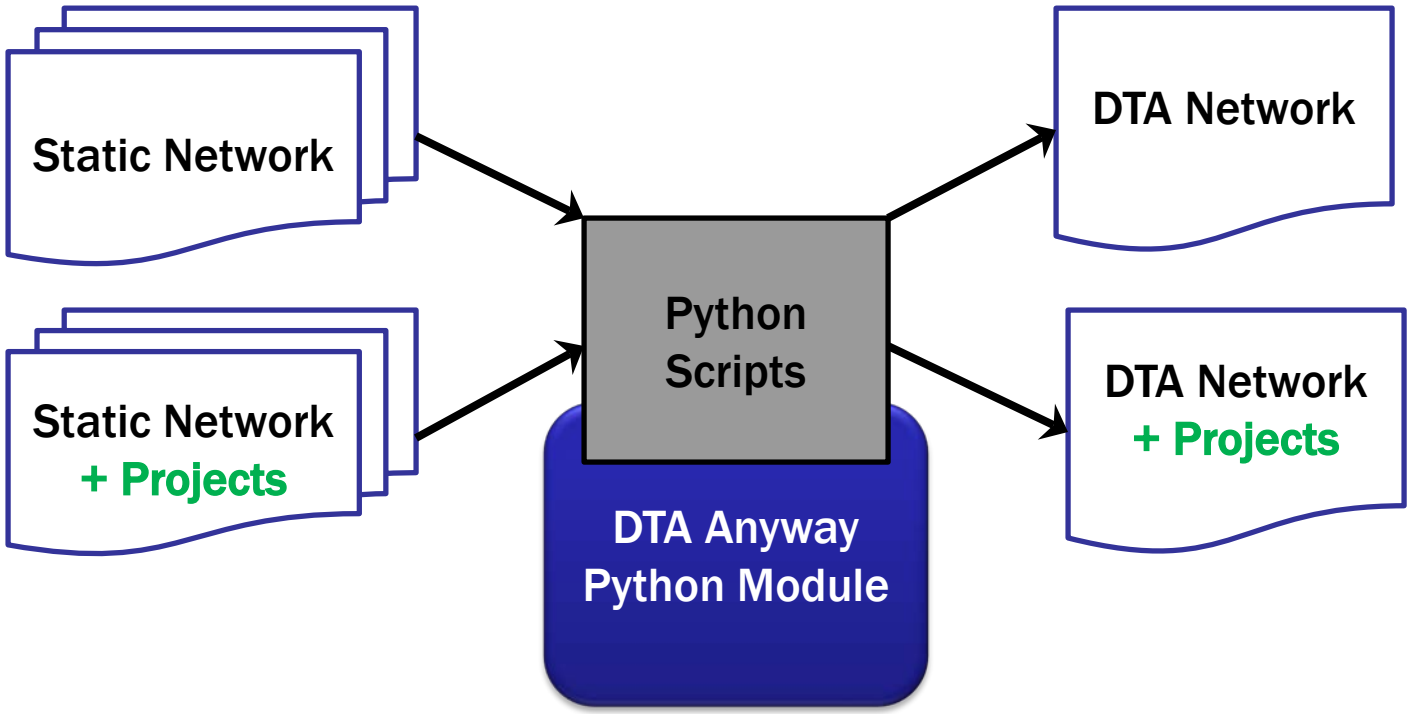


981 Zones in SF

DTA ANYWAY CODEBASE & INPUT DEVELOPMENT



DTA Anyway for Automation



DTA Anyway Capabilities

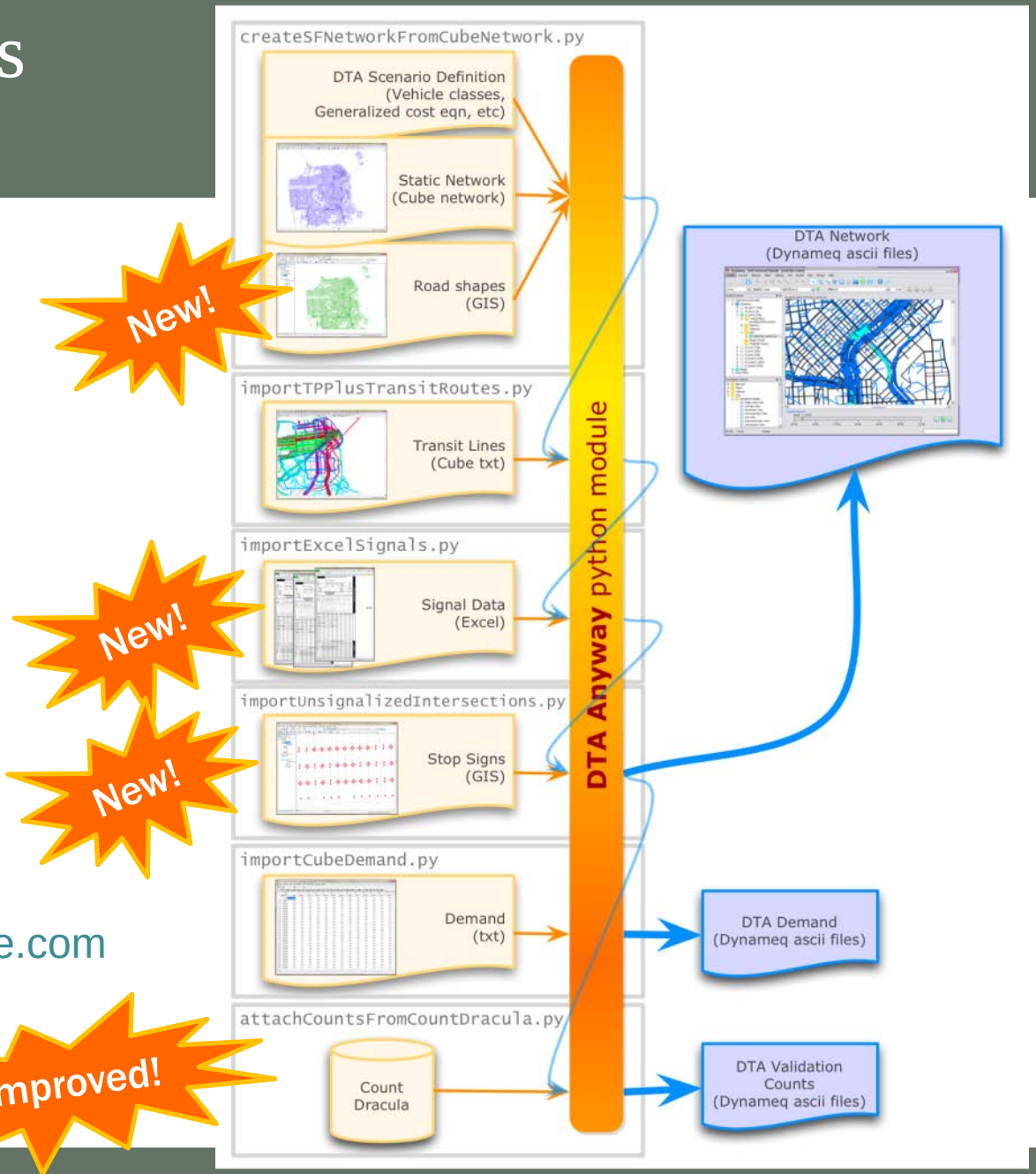
DTA Anyway *Can*

- Read Cube Networks / text-based static networks
- Read/Write Dynameq ASCII files
- Write GIS shapefiles
- typical network edits

DTA Anyway *Cannot*

- Visualize anything directly
- Read/Write DTA networks for other DTA software (but designed to make this easily implementable)

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

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

Transit

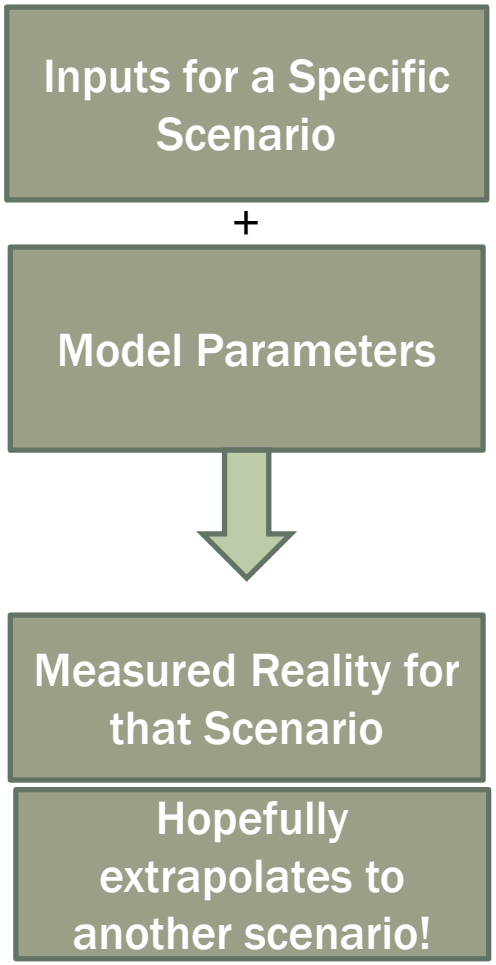
- 236 Lines
- Source: SF-CHAMP Cube Files

CALIBRATION AND VALIDATION

Model Calibration Approach

"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




Madison Campus
Trader Joe's
Geary Blvd
Cathedral Hill
Little Saigon
Metreon
Clement Street Bar & Grill
Troya
Kaiser Permanente Medical Center
Fillmore District
Turk St
Alamo Square
South of Market
The Creamery
Park Presidio Blvd
Balboa St
Lone Mountain
Redbox
Fulton St
Koret-Law Center
Panhandle
Oak St
John F Kennedy Dr
Wish
Design District
Rainbow Grocery Cooperative
Lincoln Way
Cole Valley
California Pizzeria
Milano Pizzeria
Francisco Medical Center
Woods Lot
Garden for the Environment
Forest Knolls
16th St
Anchor Brewing Company
Potrero Hill
San Francisco General Hospital
View Park
Twin Peaks
Golden Gate Heights
Laguna Honda
Twin Peaks
Twin Terrace Playground
Whole foods Market
The Roosevelt
Cesar Chavez St
Laguna Honda Hospital and Rehabilitation Center
Herbert Hoover Middle School
Forest Hill Extension
Portola Dr
Taraval St
O'Shaughnessy Blvd
Bernal Heights Park
West Portal
West of Twin Peaks
Berkeley Way
Arlington Community

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

Traffic Flow Parameter Estimation

- Data sources for parameter estimation

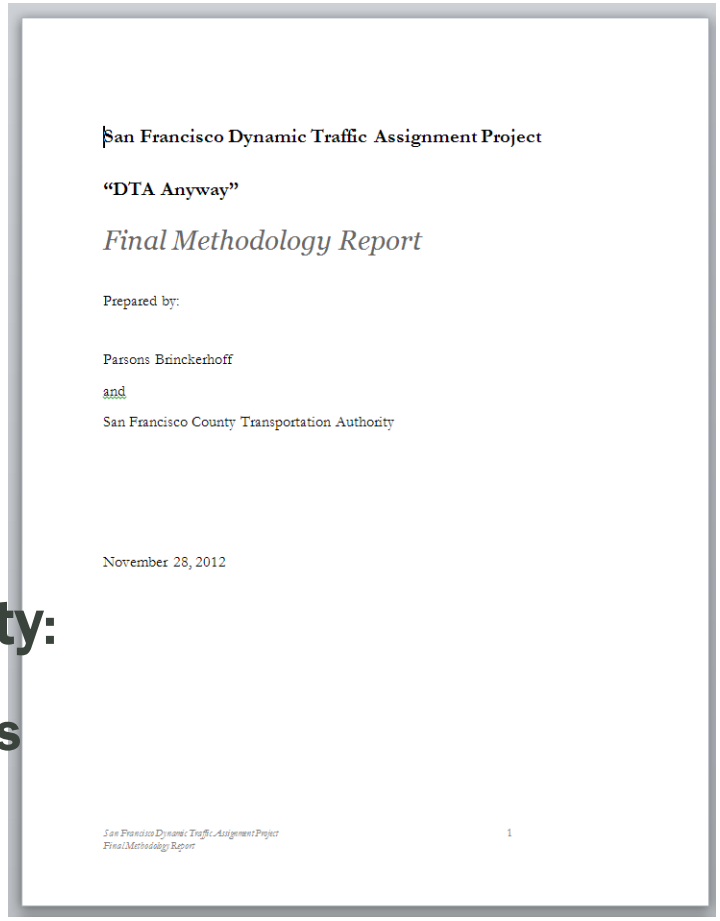
Param. / FT	Free-flow Speed	Saturation Flow	Response Time	Jam Density
	PeMS	PeMS	PeMS	Inferred from CBD arterials
Arterials	SFMTA speed surveys	CBD saturation headway observations	CBD queue dissipation observations	CBD arterial queue length observations
Locals & Collectors	Limited SFMTA speed surveys & supplemental observations	Mostly inferred from CBD arterials	Mostly inferred from CBD arterials	Mostly infer red from CBD arterials

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



San Francisco Dynamic Traffic Assignment Project

"DTA Anyway"

Final Methodology Report

Prepared by:

Parsons Brinckerhoff

and

San Francisco County Transportation Authority

November 28, 2012

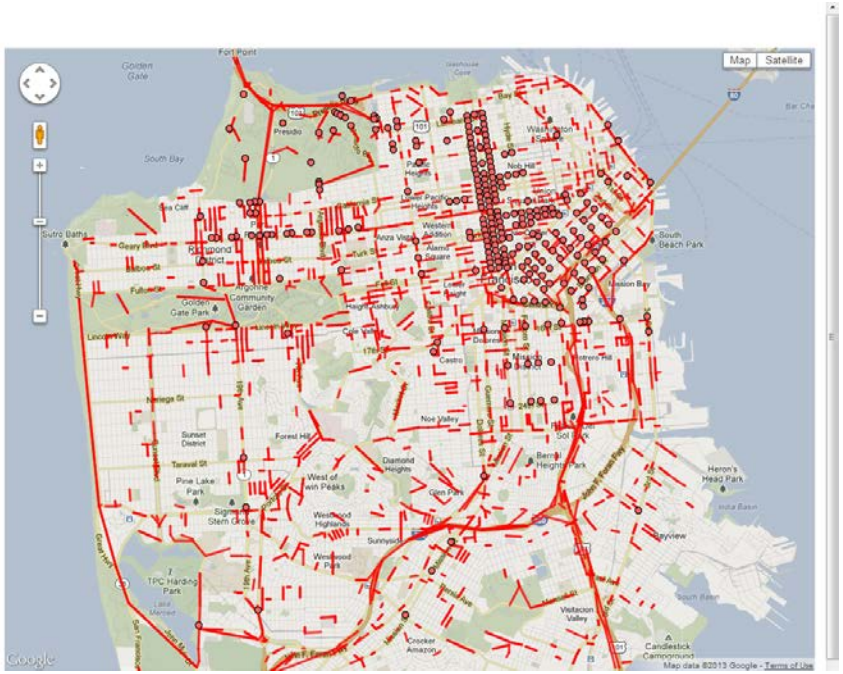
San Francisco Dynamic Traffic Assignment Project
Final Methodology Report 1

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**

97	15-minute link counts
22	60-minute link counts
864	15-minute movement counts
160	5-minute movement counts



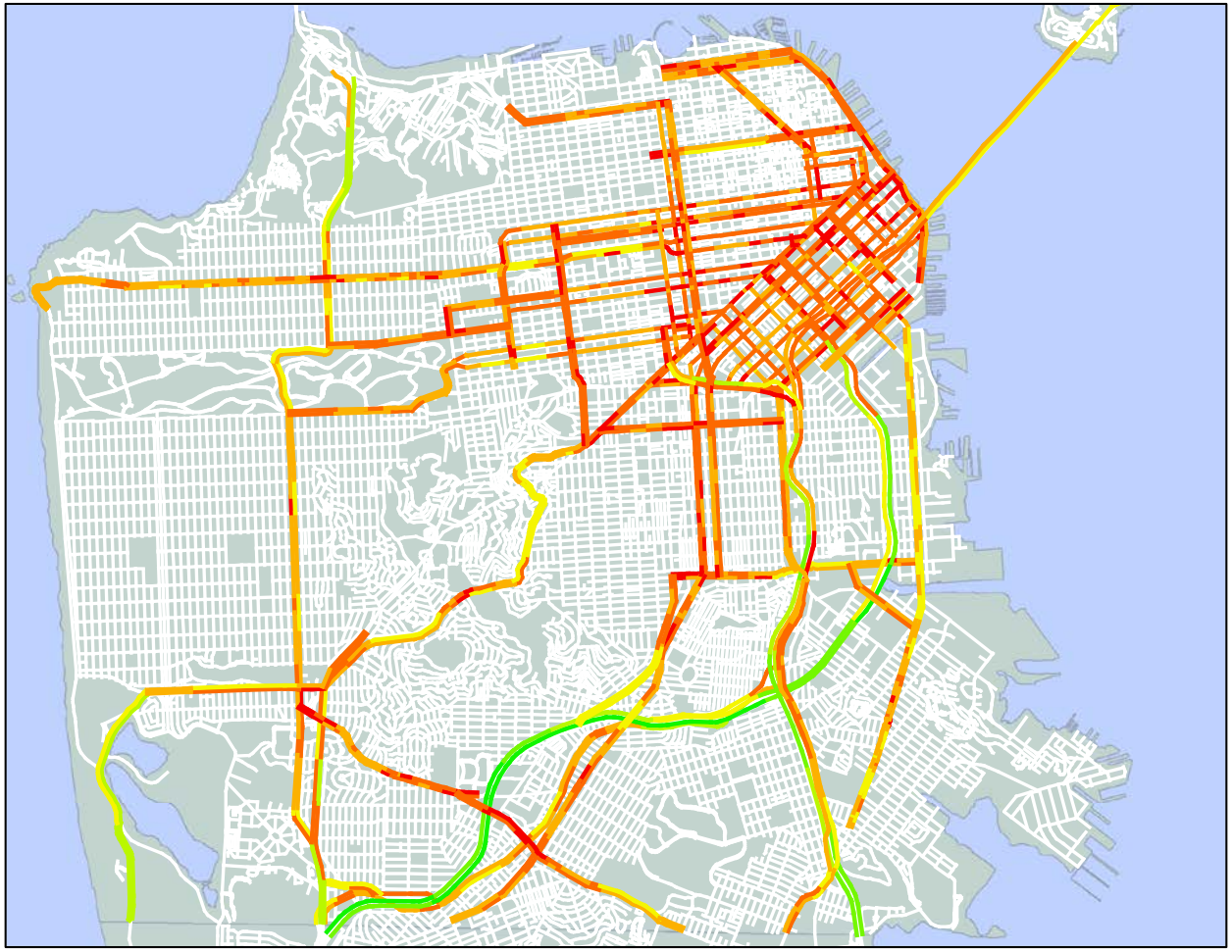
For more CountDracula

Lisa Zorn presents:
"Sharing Is Caring"
Wednesday, 1:30 PM

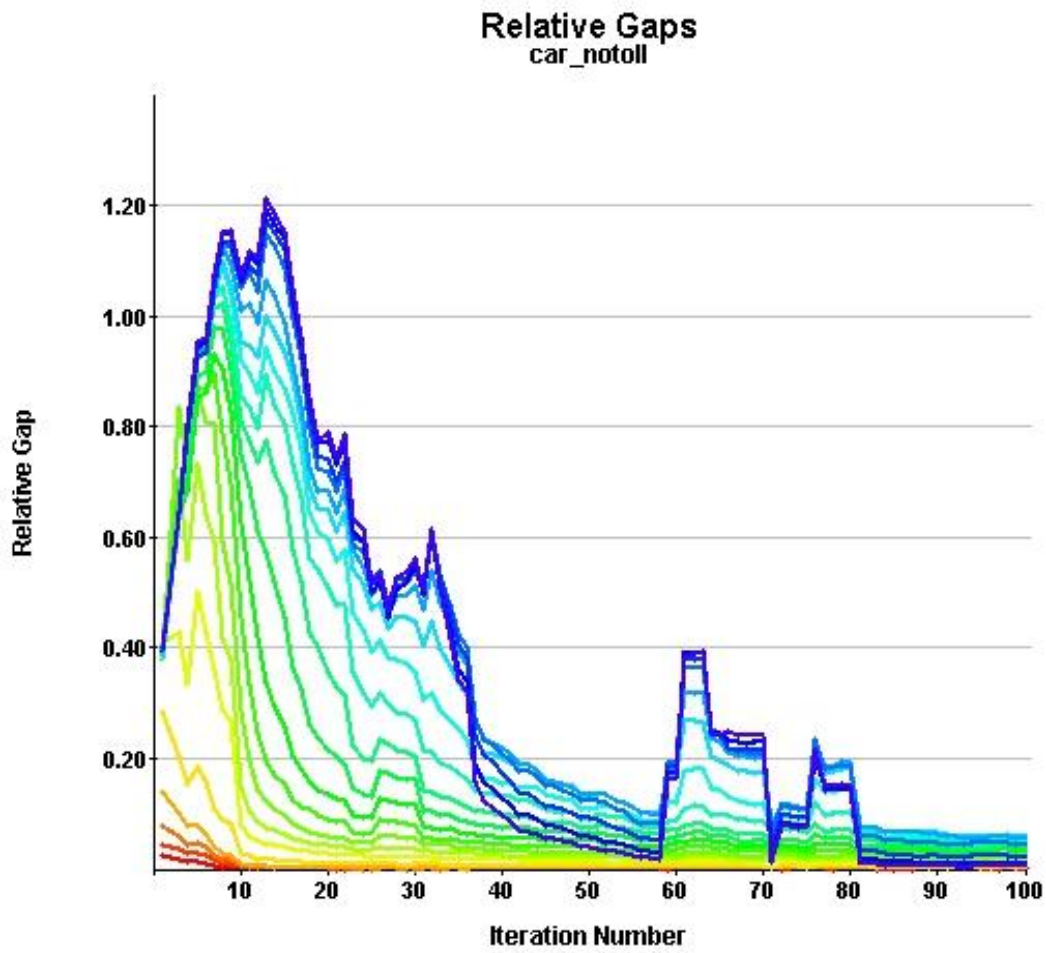
https://github.com/sfcta/CountDracula

Validation Data – Travel Times

- Spring 2011 Level of Service Monitoring
- 272 Summary Segments



Validation Results
Convergence & Performance



Convergence Plot for Final Model

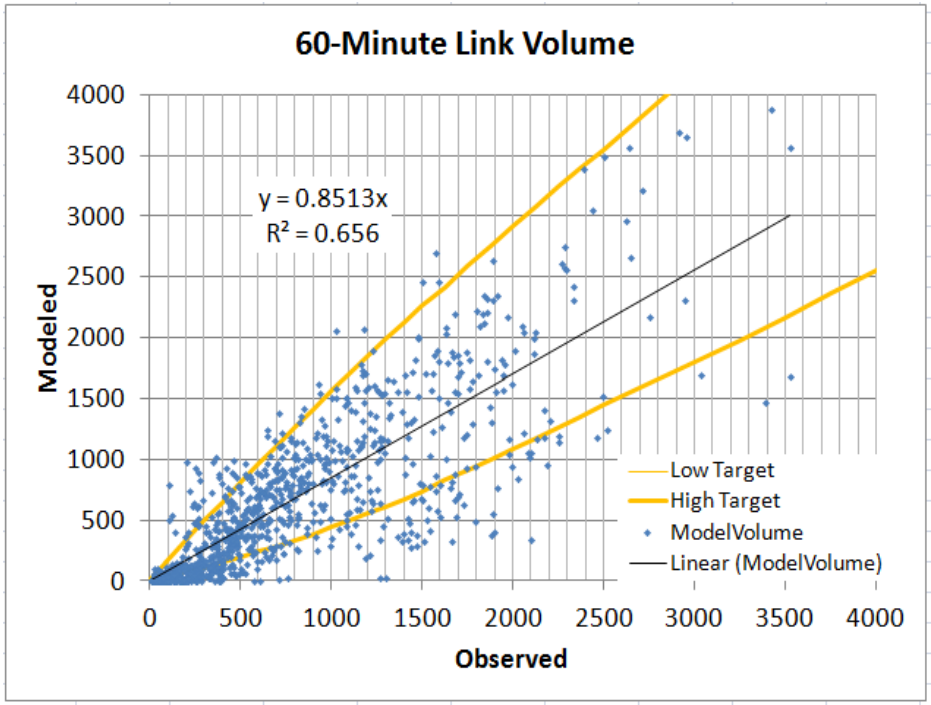
- DTA shows stable convergence for ~20 iterations
- Mean Relative Gap: 2.7%
- ~~109~~ 50ish hours computing
- Max waiting vehicles ~ 350 (1%)
- Demand clears in reasonable time
- No observed gridlock

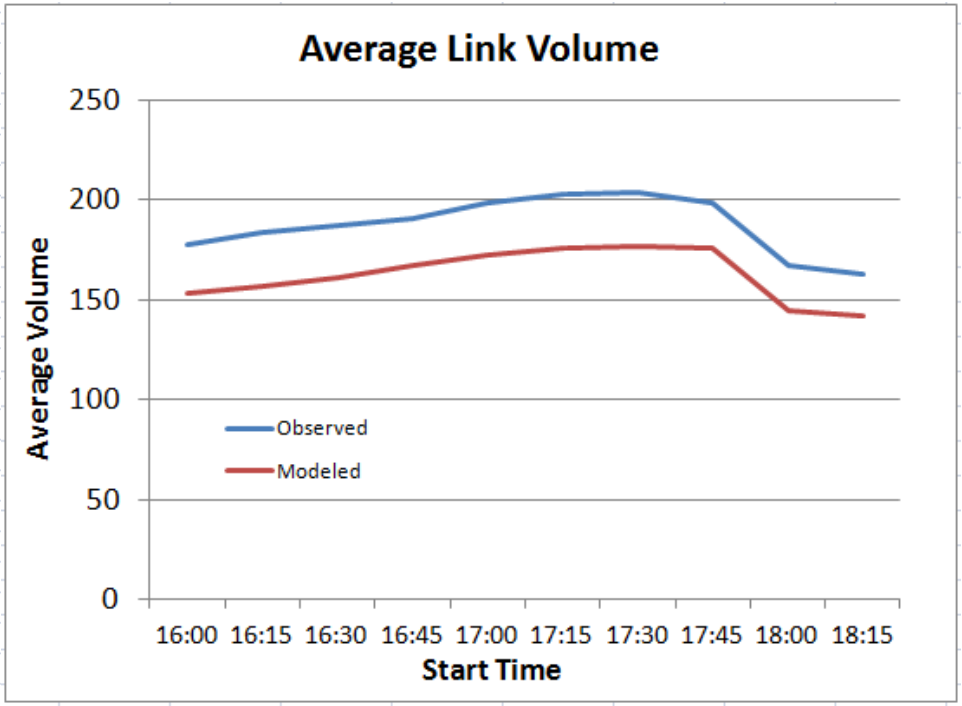
Validation Results
Link Volumes

- Total volume ~13% low.

What are some good standards? We couldn't find any and neither could our peer review panel.

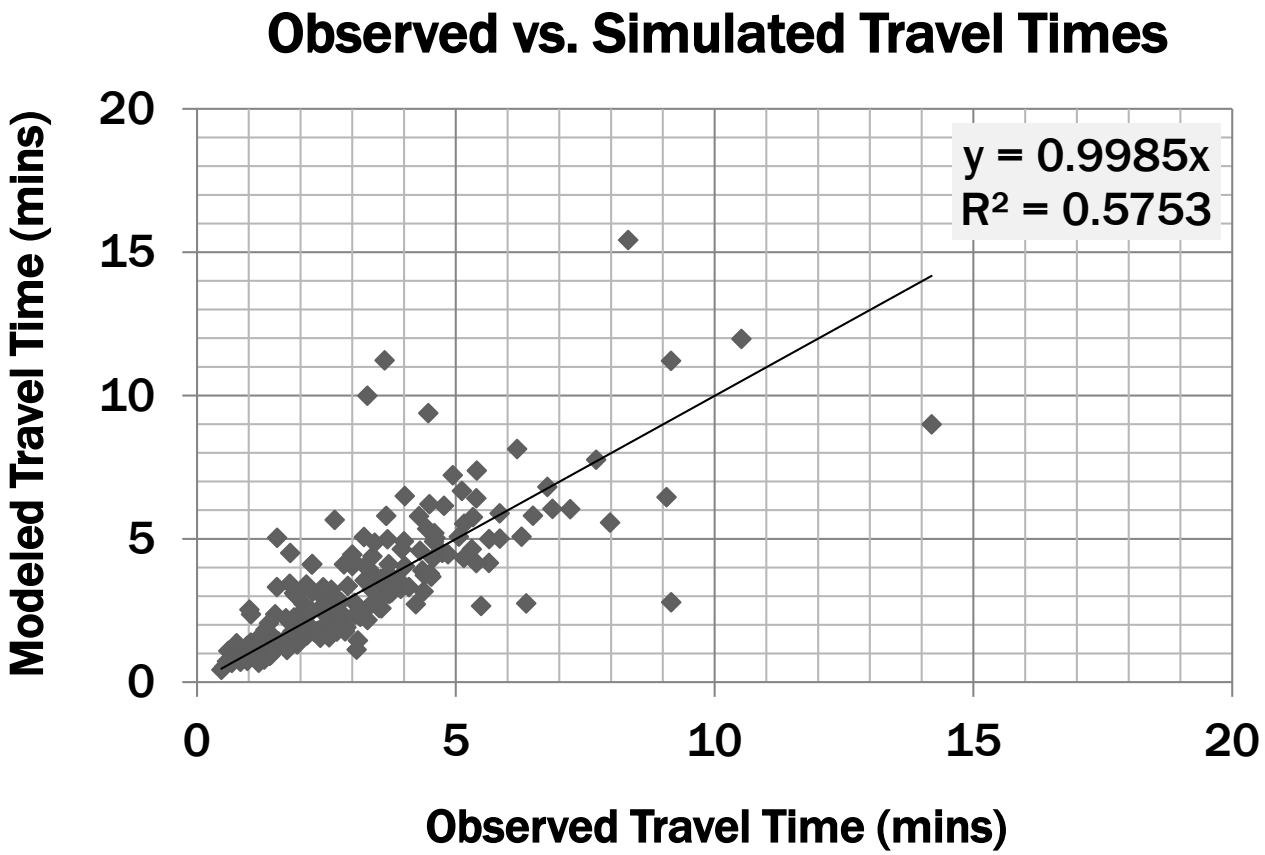
- 55% total RMSE, 40% RMSE for links >500 vph.
- 75% of arterials within Caltrans maximum desirable deviation guidelines





Validation Results
Segment Travel Times

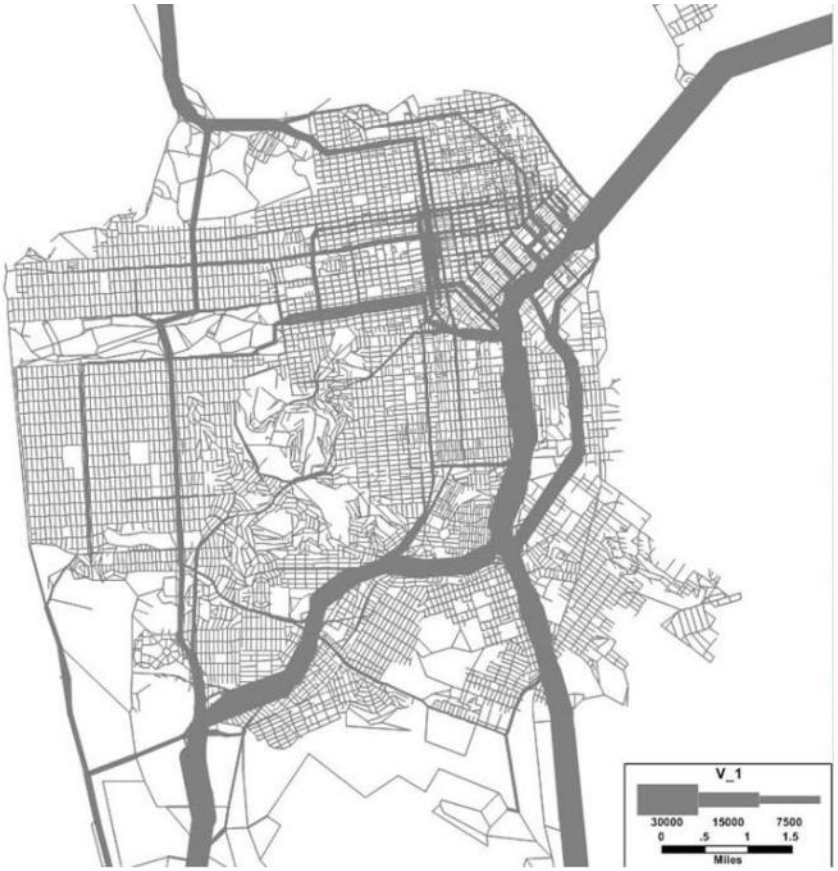
- Travel times are reasonable on average
- A few outliers drive differences



Validation Results
Citywide Flow Patterns

- Overall flow pattern logical, and similar to static model

Map of Total PM Peak Flow from DTA



Map of Total PM Peak Flow from Static Assignment

SENSITIVITY & SCENARIO TESTING

Random Number Seeds

Small Network Change

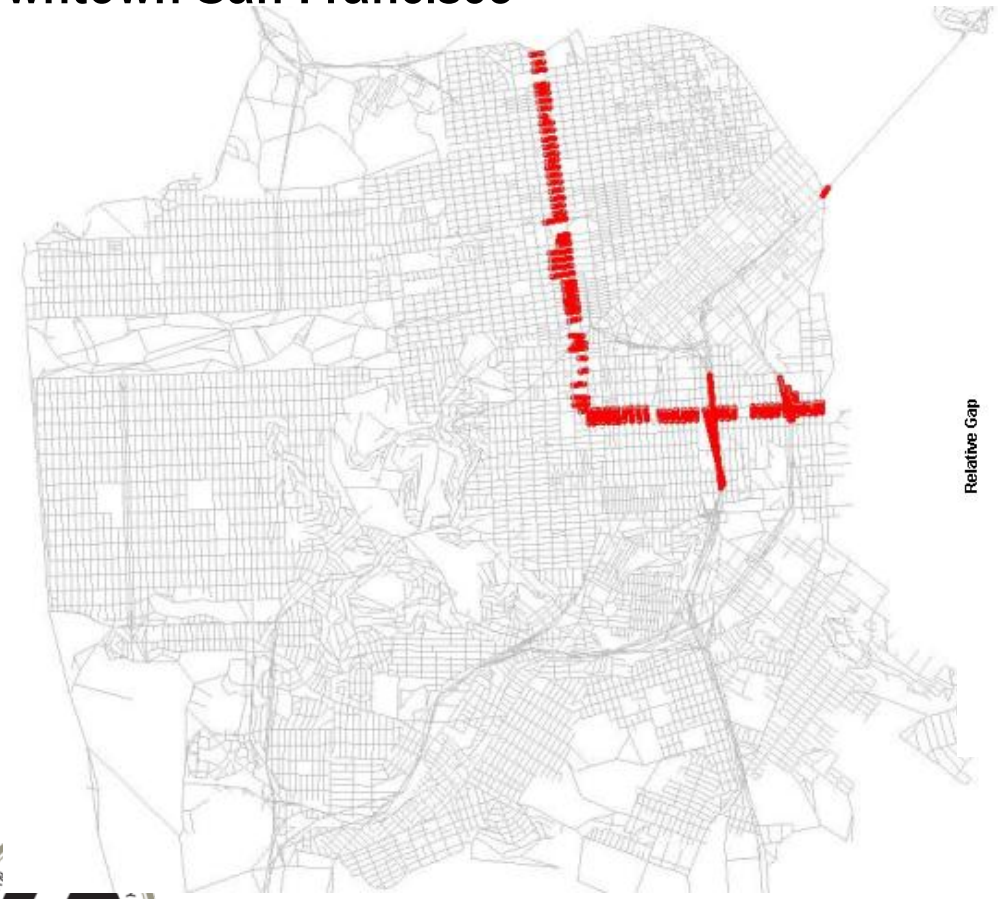
Future Demand

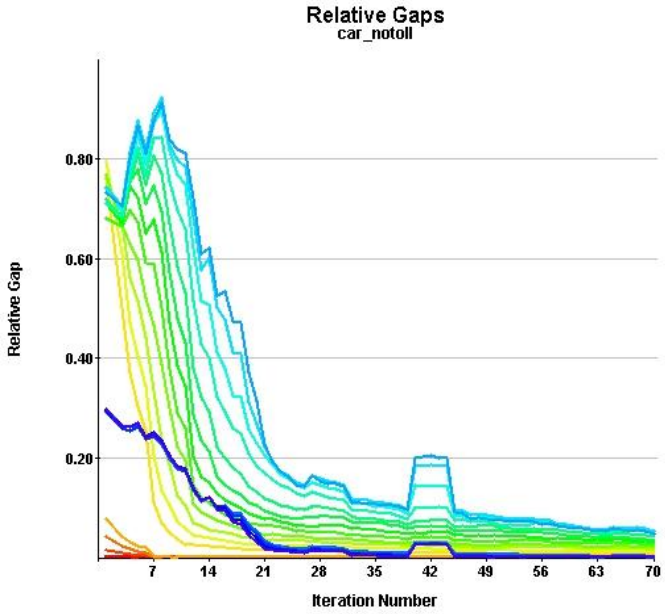
Congestion Pricing

Bus Rapid Transit

Congestion Pricing Application Test

- **Added a $3 fee to anyone crossing the cordon to manage congestion in downtown San Francisco**

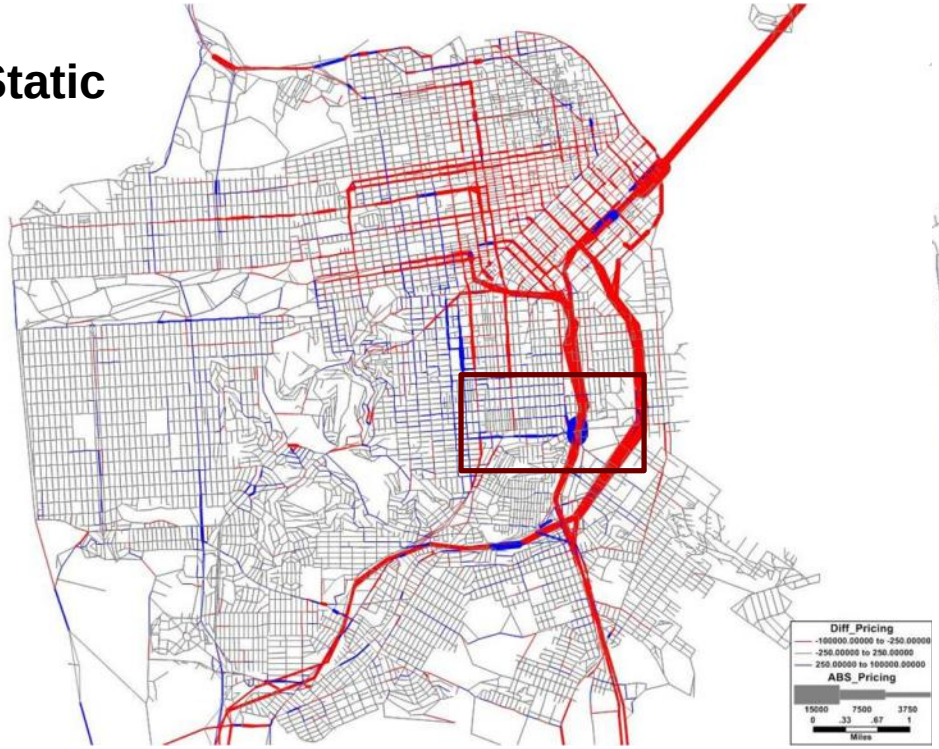




Congestion Pricing Application Test – Static vs. DTA Flow Maps

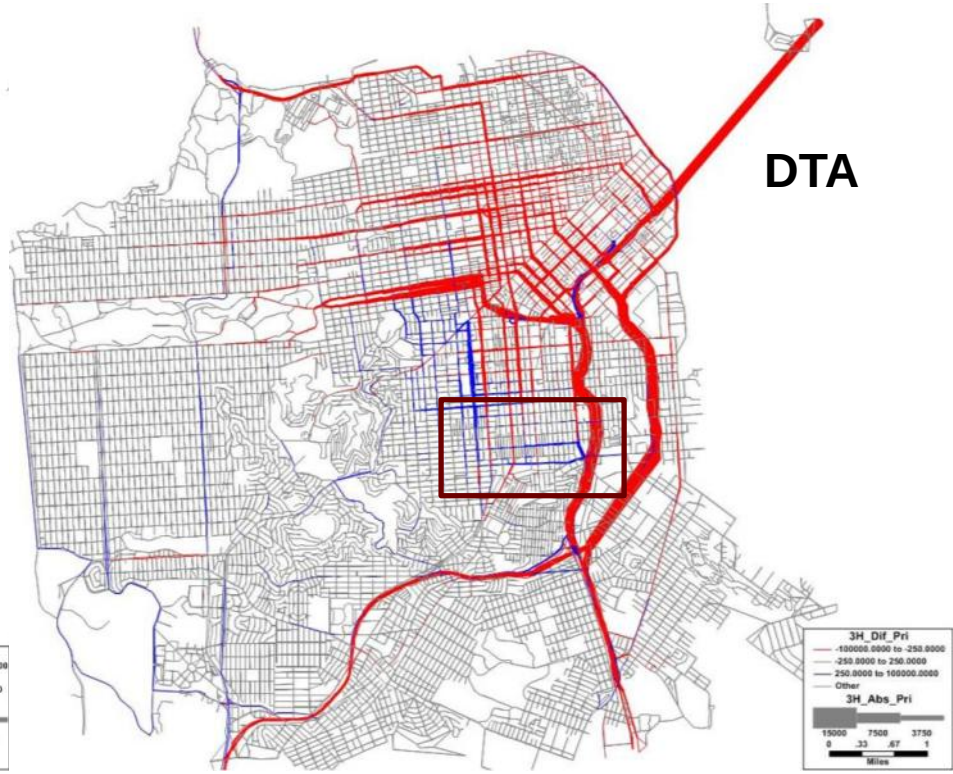
- DTA Model shows a much clearer diversion to paths outside the cordon
- Static model shows some odd shifts that in the Northern region including increases in EB traffic going toward the CBD

Static



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)

DTA

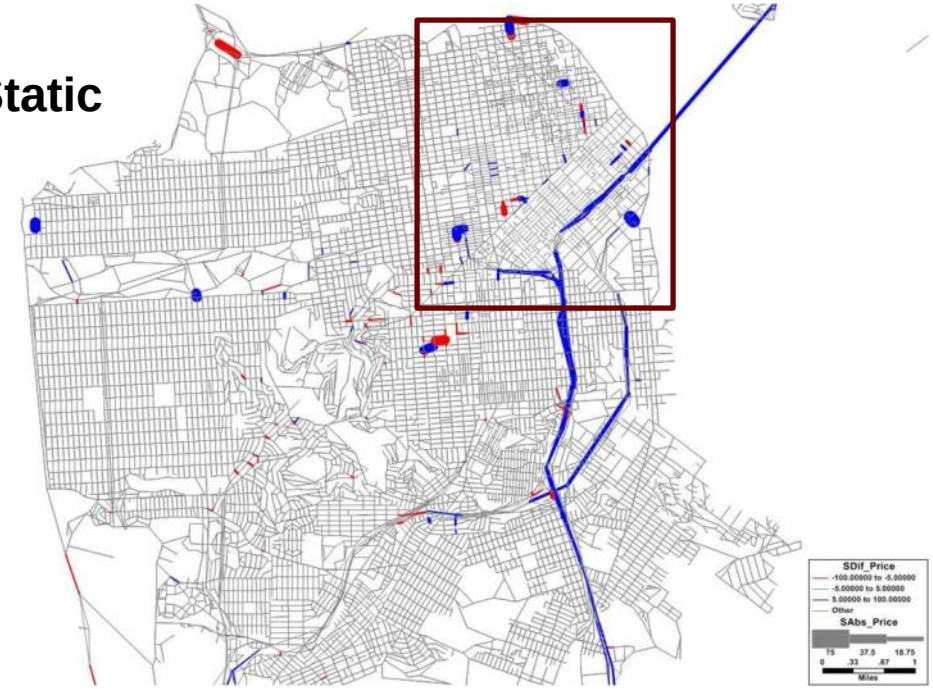


Map of Flow Change from DTA Pricing Test (Red links – flow loss of at least 250 vehicles, Blue links – flow gain of at least 250 vehicles)

Congestion Pricing Application Test – Static vs. DTA Speed Maps

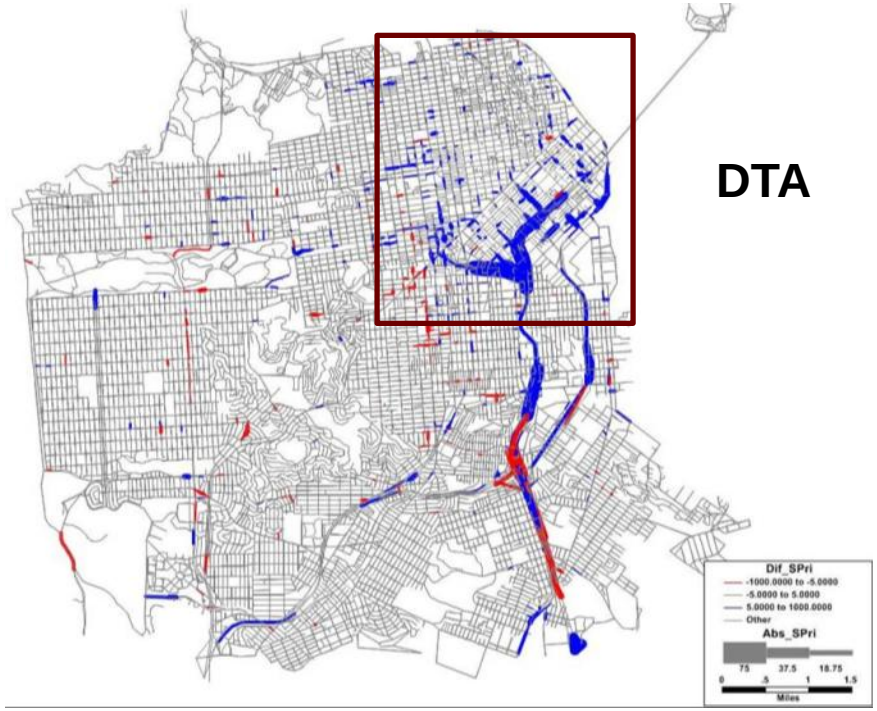
- DTA Model shows more widespread impacts on speed with faster speeds in most of the CBD.
- Using the static model results could greatly underestimate the potential travel time impacts in the CBD.

Static



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)

DTA



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

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

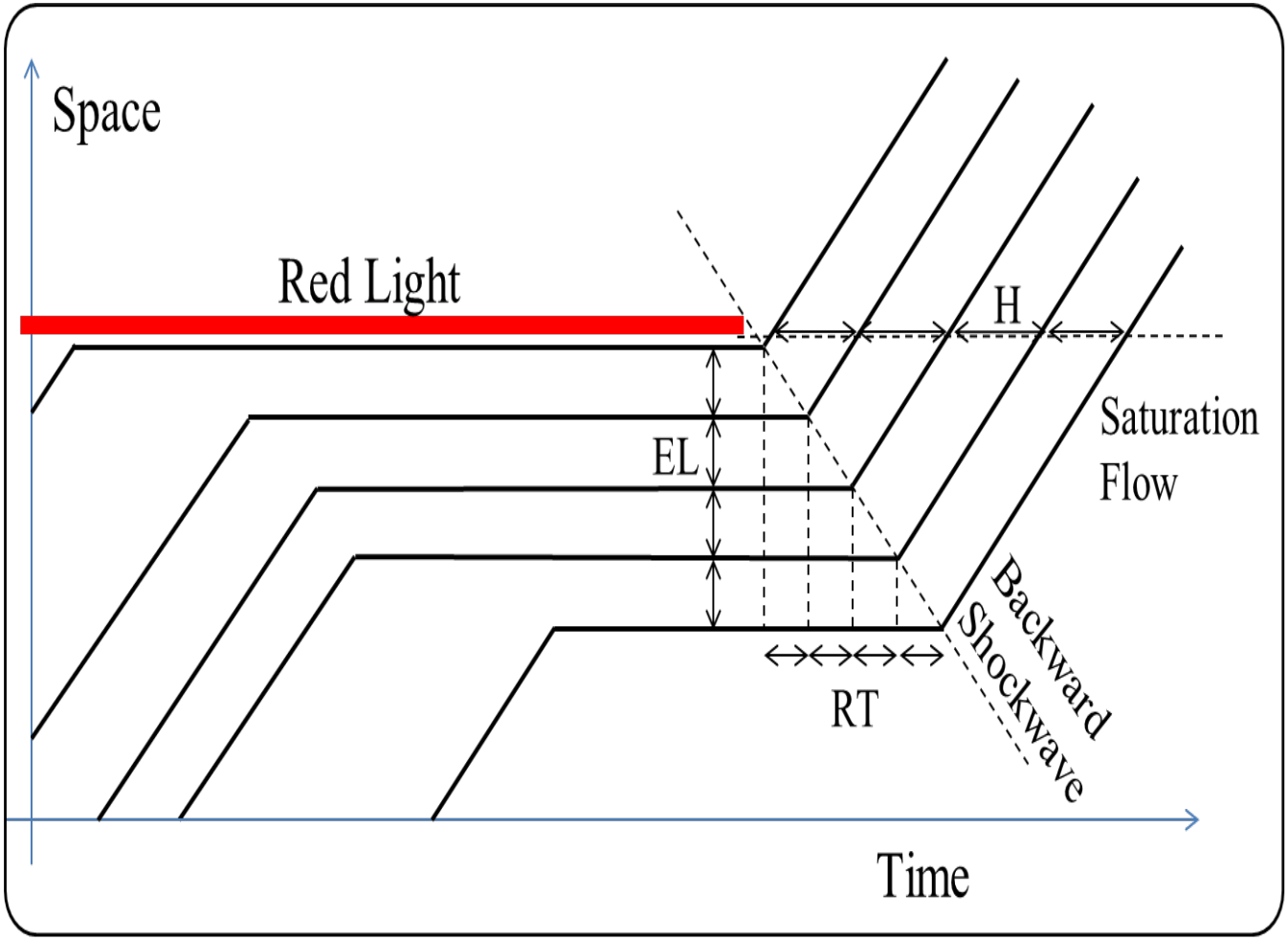
Neema Nassir (SFCTA/U of Arizona) – Traffic Flow Model

Michalis Xyntarakis – Early codebase development

www.sfcta.org/dta

dta.googlecode.com

Traffic Flow Parameter Measurement



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

FAST-TrIPs

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

DTA

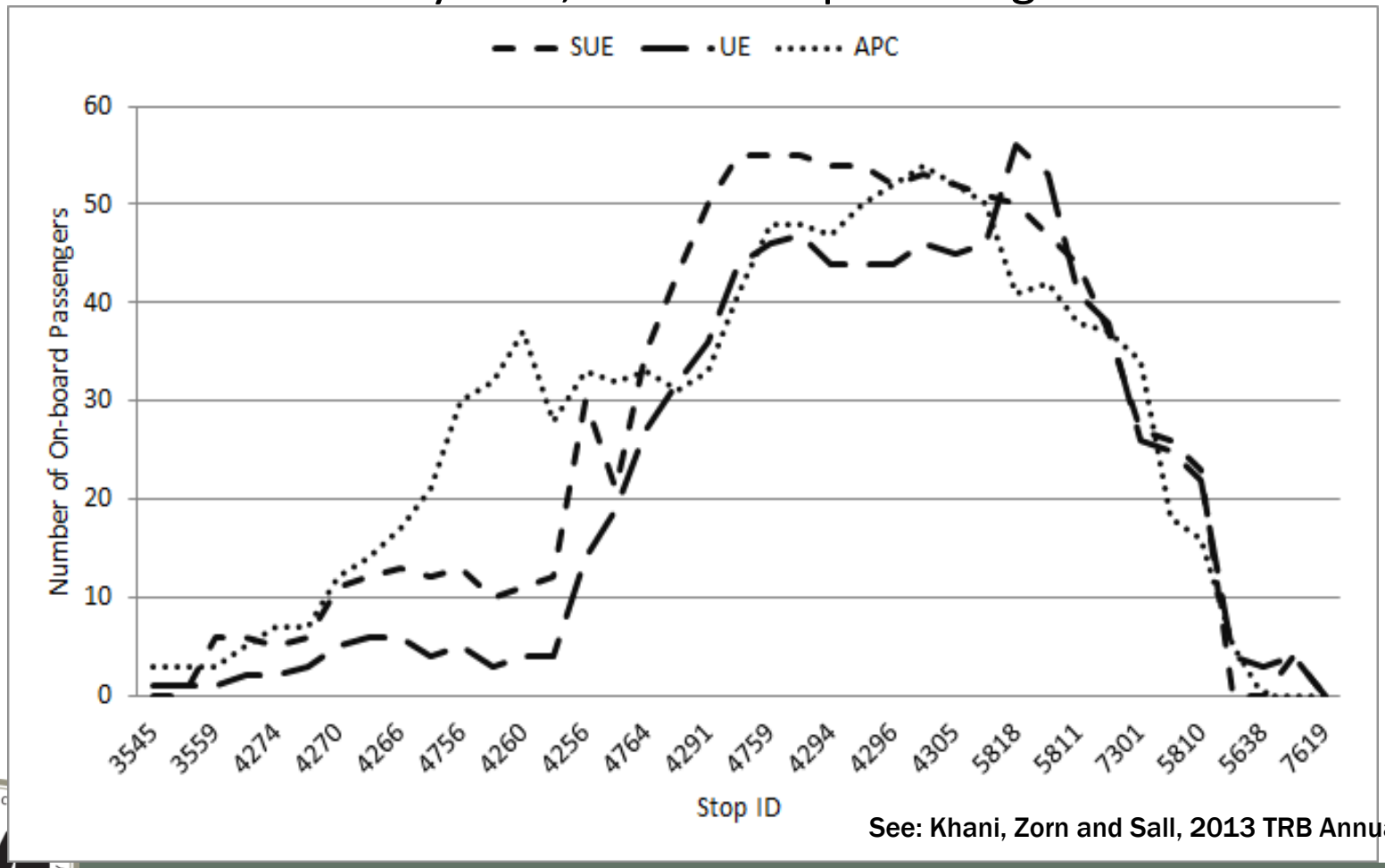
Update transit vehicles' dwell time f(FAST-TrIPs boarding and alightings)

- **Why?**
  - **Bus Bunching**
  - **Transit reliability**
  - **Capacities**
  - **Actual schedules**

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

Research: Person-based Transit Assignment FAST-TrIPs

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



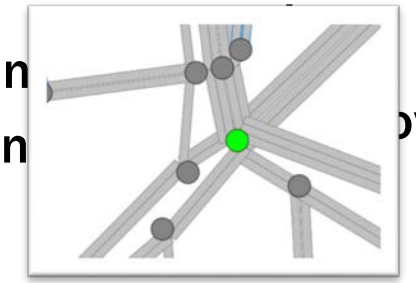
See: Khani, Zorn and Sall, 2013 TRB Annual Meeting

Research: Transit Reliability / FAST-TrIPs Development

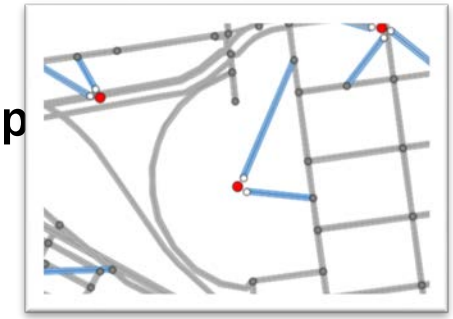
- **More FAST-TrIPs/DTA Integration**
  - Convergence methodologies
- **FAST-TrIPs/CHAMP Integration**
  - Use static assignment
  - Skimming
  - Sensitivity tests
- **Develop Reliability Metrics in FAST-TrIPs**
  - As function of demand profiles
  - As function of network and service characteristics

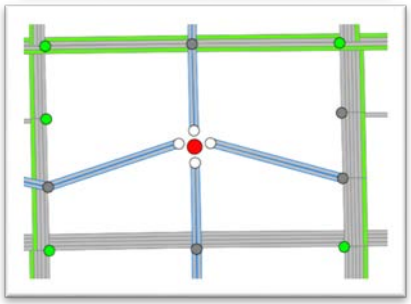
Convert Static Network → Dynamic

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, prohibitin most U-Turns, explicitly namin 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



overlap





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

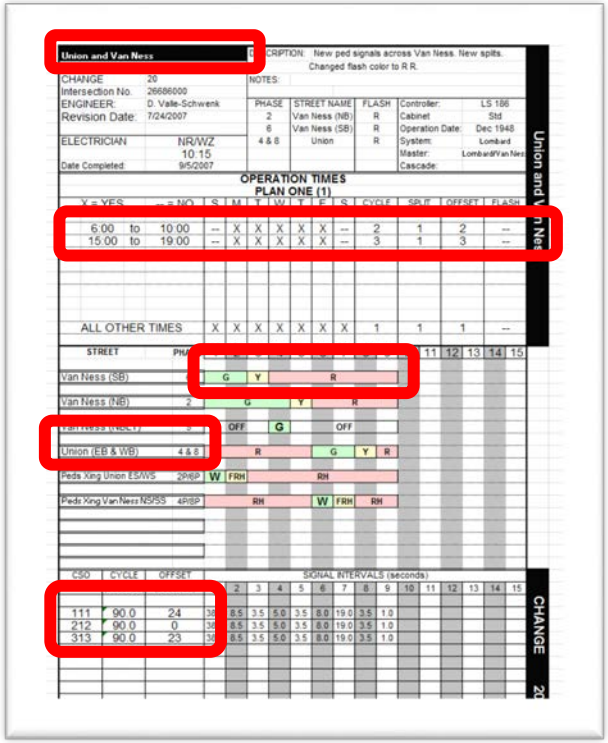
236	Transit Lines

Import Signals

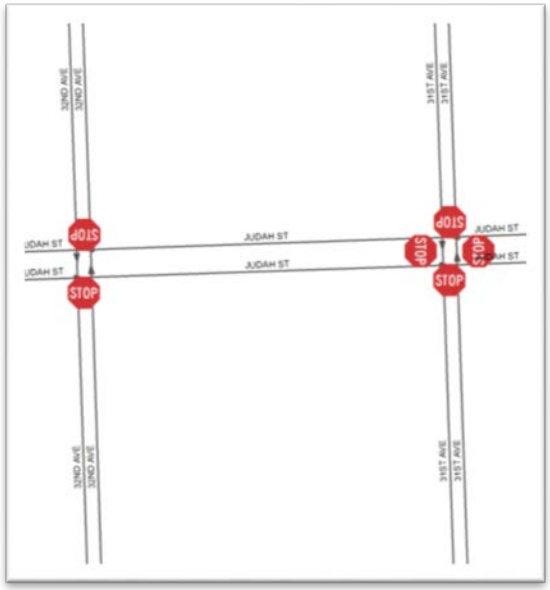
- Reads signal card data from Excel files in a SFMTA-defined format
- We search for the section specifying the weekday PM peak plan
- For errors and unique circumstances encountered (and there were many), responses could be:
  - Update signal card itself
  - Update signal-card reading code
  - Update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

1,100	Signal Time Plans

- We approximate the few actuated signals with their fixed time version
- Signal-reading code is not very re-usable



Import Stop Signs



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

- 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

Custom priorities for two-way stops where facility types tie

Import Demand

- 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