CAMBRIDGE SYSTEMATICS

Think Forward

Citilabs CUBE Training

presented to

Caltrans District 4

presented by

Cambridge Systematics, Inc.

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November 30, 2016

Agenda

- Morning Session
  - Modeling 101
  - Trip-based vs Activity-based models
  - ACTC and MTC Models
- Afternoon Session
  - VMT Analysis
  - Model Convergence
  - Cube Overview and Navigation
  - Scripting in Cube
  - Model Validation/Post Processing

Introductions

- CS Staff Introductions
- Caltrans Staff Introductions
  - Roles and Responsibilities
  - Software Knowledge
- Training Goals

Modeling 101

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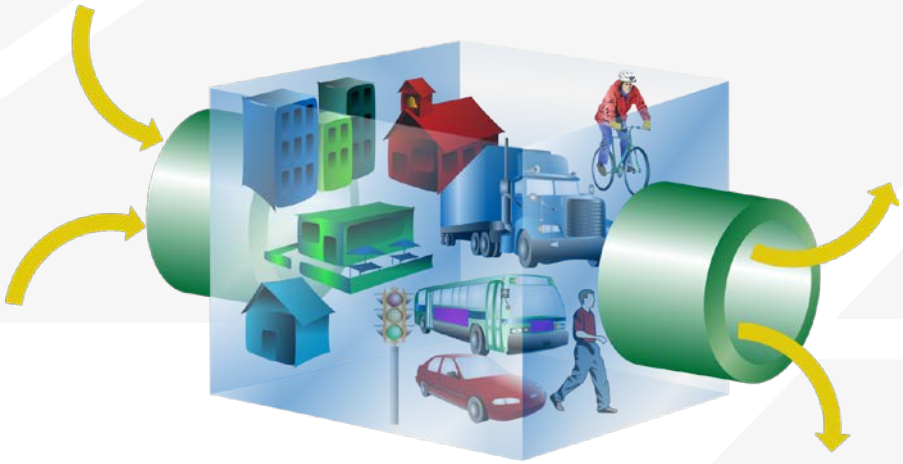
Modeling 101

Inputs

- Transportation Networks
- Socioeconomic Data
- External Data
- Special Generators
- Model Parameters



Outputs

- Trips by Mode
- Traffic Volumes
- Congested Speeds
- Transit Volumes
- Summary Information

Transportation Networks

Inputs

- **Transportation Networks**
- **Socioeconomic Data**
- **External Data**
- **Special Generators**
- **Model Parameters**

Roadway Networks

- Contains roadway characteristics
  - Number of Lanes
  - Roadway Type (Freeway, arterial, etc.)

Transit Networks

- All fixed route transit service
- The model is sensitive to transit level of service (frequency, speed, coverage)
- Local/Express Bus, BRT, Rail

Socioeconomic Data

Inputs

- **Transportation Networks**
- **Socioeconomic Data**
- **External Data**
- **Special Generators**
- **Model Parameters**

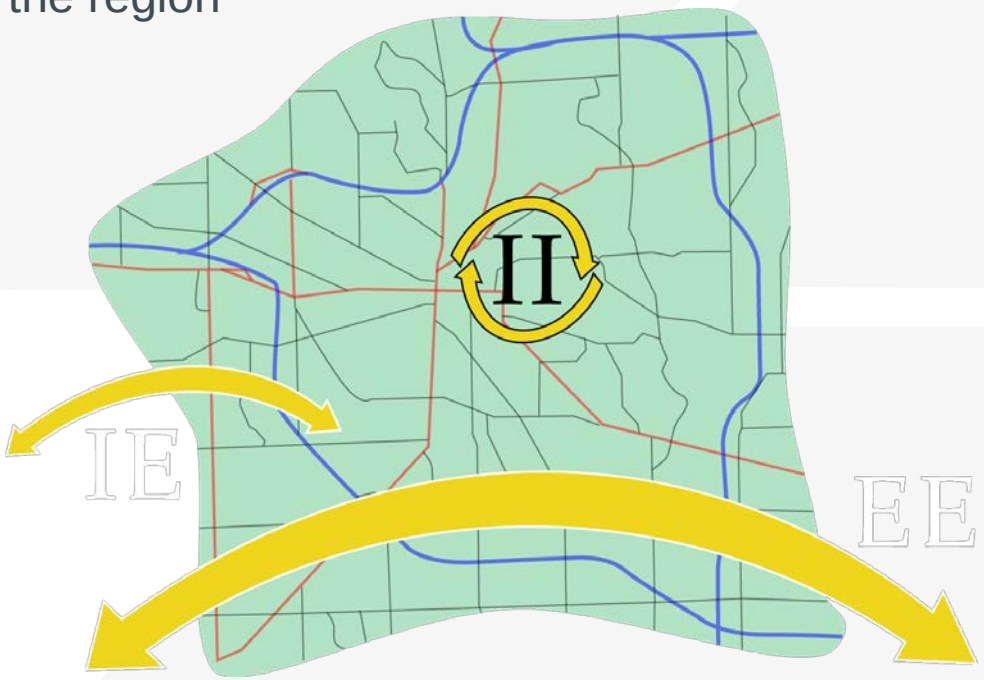
- Identifies **demand** for travel
- Household data
  - Average household **size**
  - Median household **income**
  - Number of resident **workers**
  - And more…
- Employment data
  - By industry
  - By wage level

External Travel

Inputs

- Transportation Networks
- Socioeconomic Data
- **External Data**
- Special Generators
- Model Parameters

- Model travel:
  - To/from the region
  - Through the region



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Special Generators

Inputs

- **Transportation Networks**
- **Socioeconomic Data**
- **External Data**
- **Special Generators**
- **Model Parameters**

- Unique locations not well represented by employment data
  - Ports
  - Airports

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Model Parameters

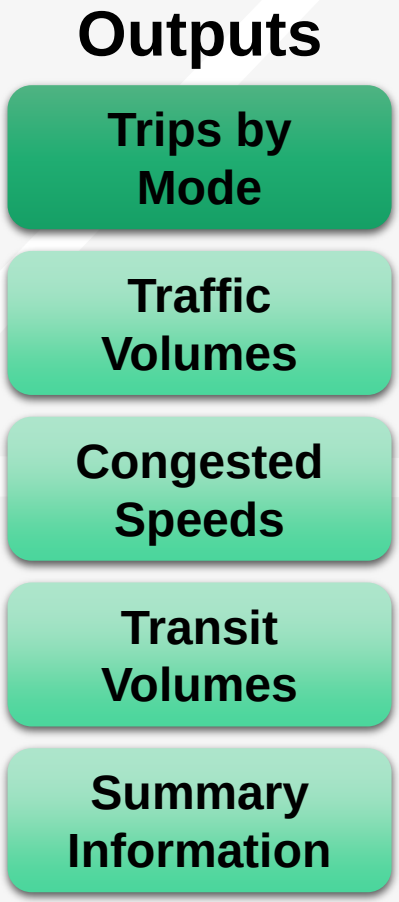
Inputs

- **Transportation Networks**
- **Socioeconomic Data**
- **External Data**
- **Special Generators**
- **Model Parameters**

- Represent the way people behave
  - How many trips are made?
  - How far will people travel?
  - What impacts decisions about travel mode?
  - How does congestion impact travel?
- Source Data
  - California Household Travel Survey
  - On-Board Transit Surveys
  - Speed Surveys
  - Big Data
  - Traffic Counts

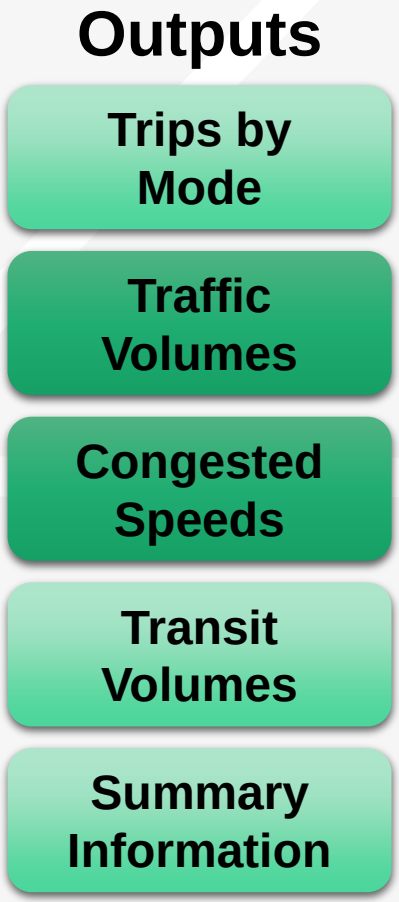
Outputs: Trips

- Information about each trip
  - Start/end
  - Time of day
  - Mode of travel
  - Purpose of trip
  - Trip time and distance



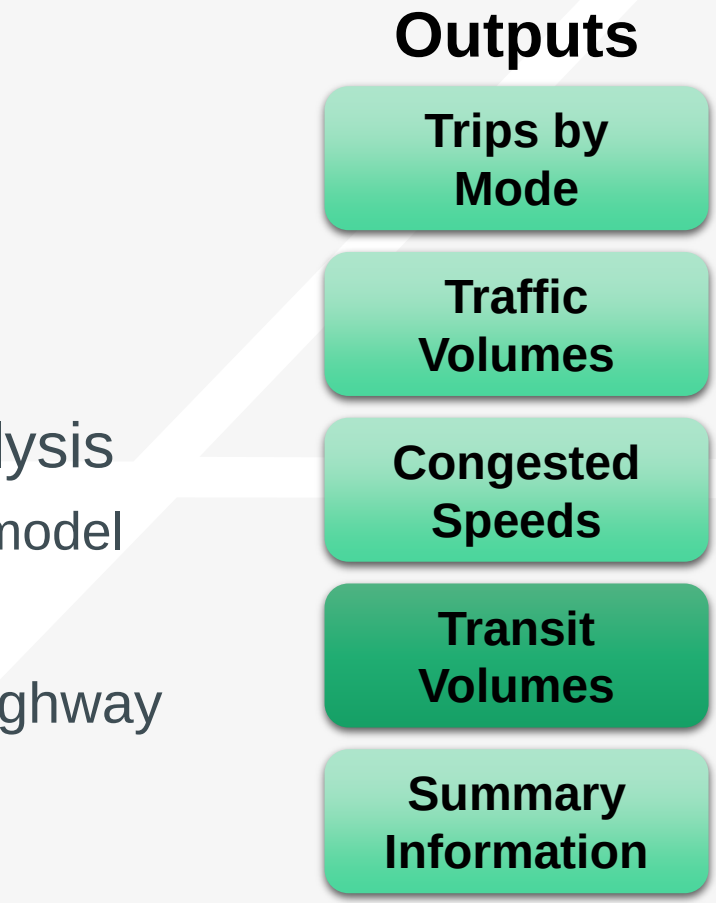
Outputs: Volumes and Speeds

- By Time of Day
  - Daily
  - AM, PM, Mid-Day, Evening, Night
  - AM and PM Peak Hours
- Turn Movements
  - Better estimated with assistance of base-year counts
- Congested speed based on volume



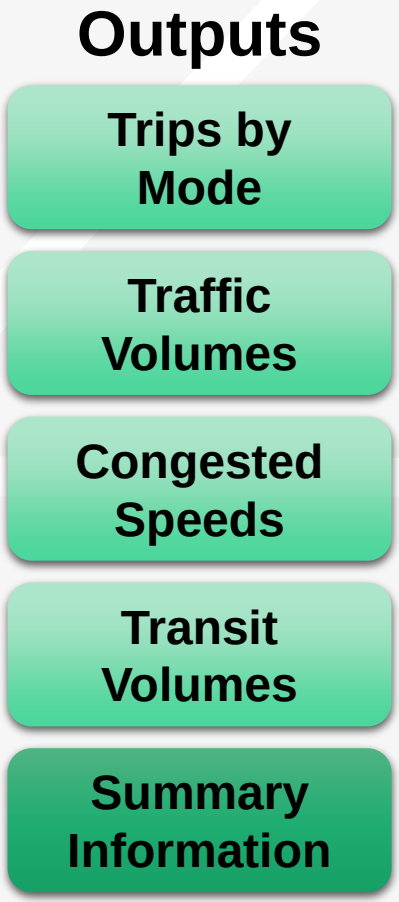
Outputs: Transit Volumes

- By Time of Day
  - Peak and Off-Peak
  - Daily sum
- By route or route group
  - Also by stop, but with less accuracy
- Useful for Big-Picture transit analysis
  - Detailed analysis requires localized model refinement
- Transit trips are removed from the highway network



Outputs: Summary

- Planning Tools
  - » Maps and charts
  - » Results presented for general understanding
    - VMT, VHT, Delay
    - Level of Service
    - Trip Lengths
    - Trip Patterns



Trip-based vs Activity-based Models

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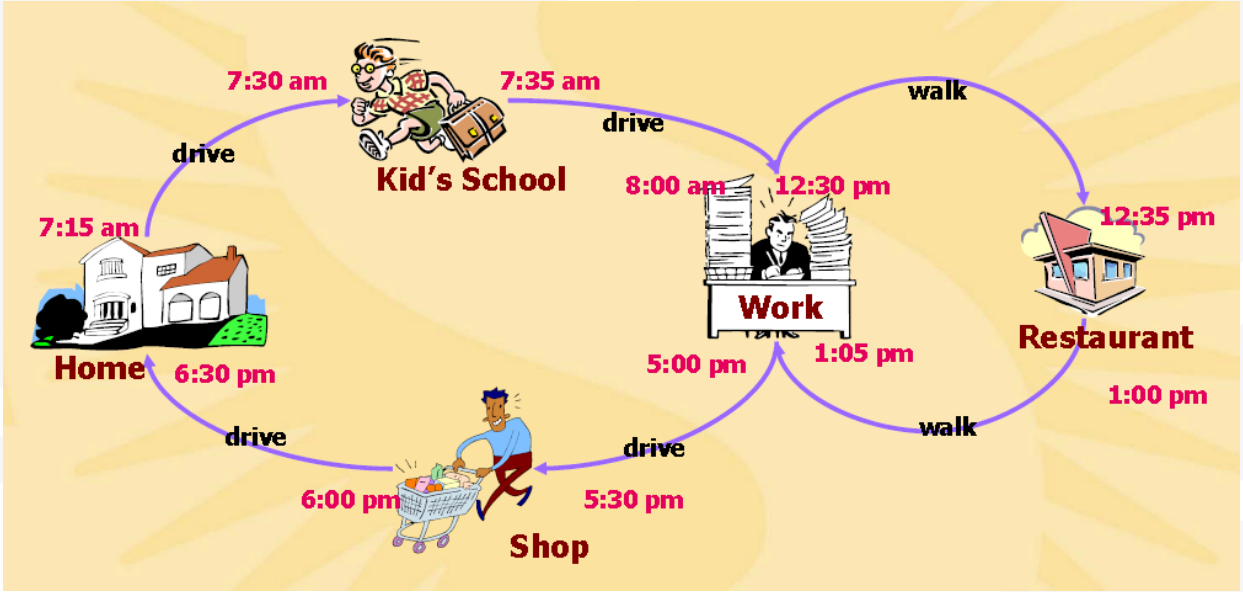
Trip Based Models

- Simplified trip-making decisions with no connections between trips or people making them
- Modeled at an aggregate zonal average level
  - Average zonal income, household size, number of workers/household

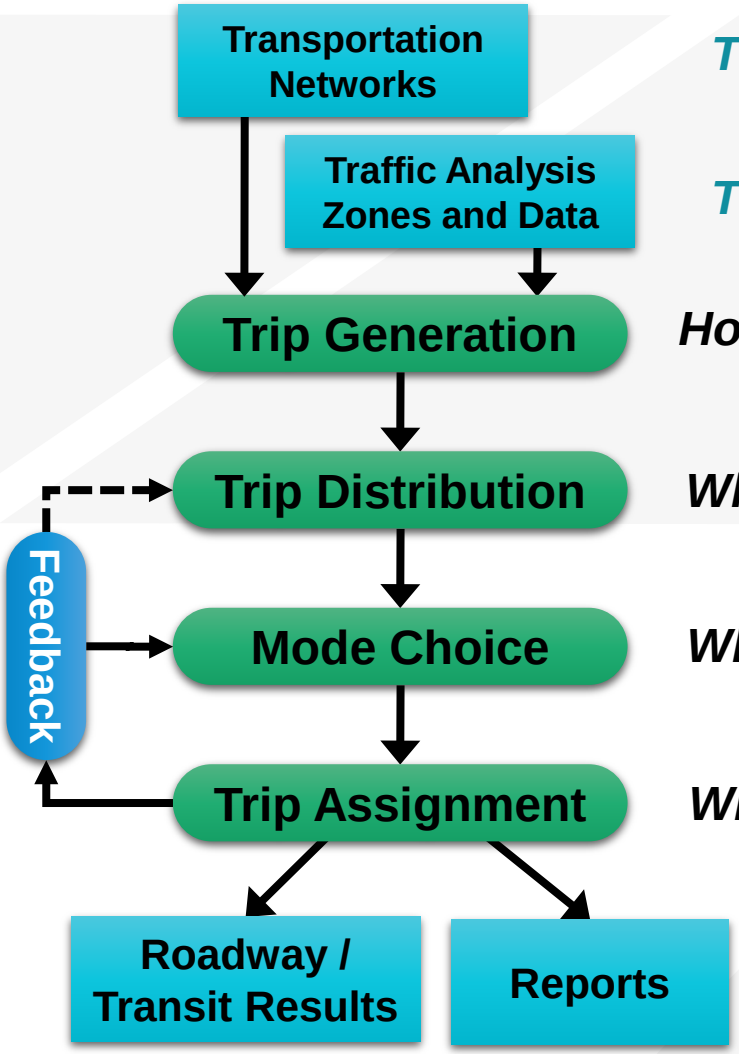
Trip- Based Example

- Real-life behavior



- Model translation: 6 independent trips
  - 1 home-based school trip
  - 1 home-based other trip
  - 4 work-based trips

Trip-based Model (ACTC)



Transportation Supply

Transportation Demand

How many trips?

Where will they go?

What mode?

What route?

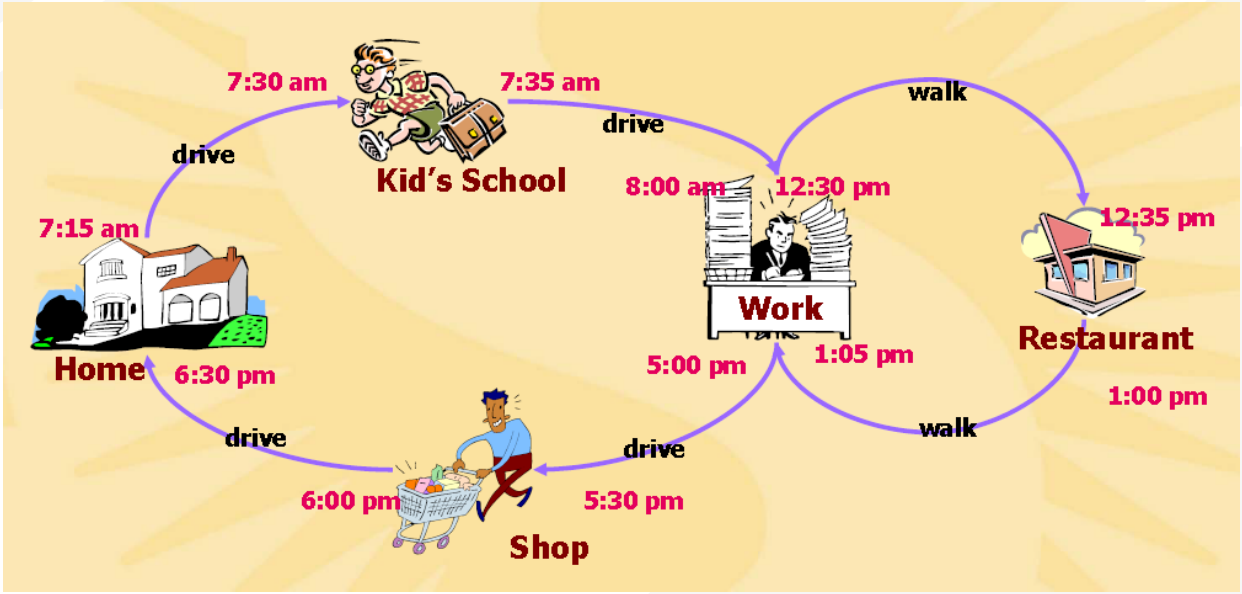
Forecasts

Tour-based Models

- Trips are grouped into home-based or work-based tours resulting in consistency within the tour
  - Mode choice is consistent between all legs of the tour
- However, there is still no connection between tours or persons making them
- Modeled at a disaggregate level
- Travel example from before
  - 1 home-based tour with intermediate stops
  - 1 work-based tour

Activity-based Models

- Based on activities
  - Temporal connections between tours
  - Members of a household considered together when selecting an activity-pattern (ie. parent dropping a child off at school)
  - Each activity has start time and duration



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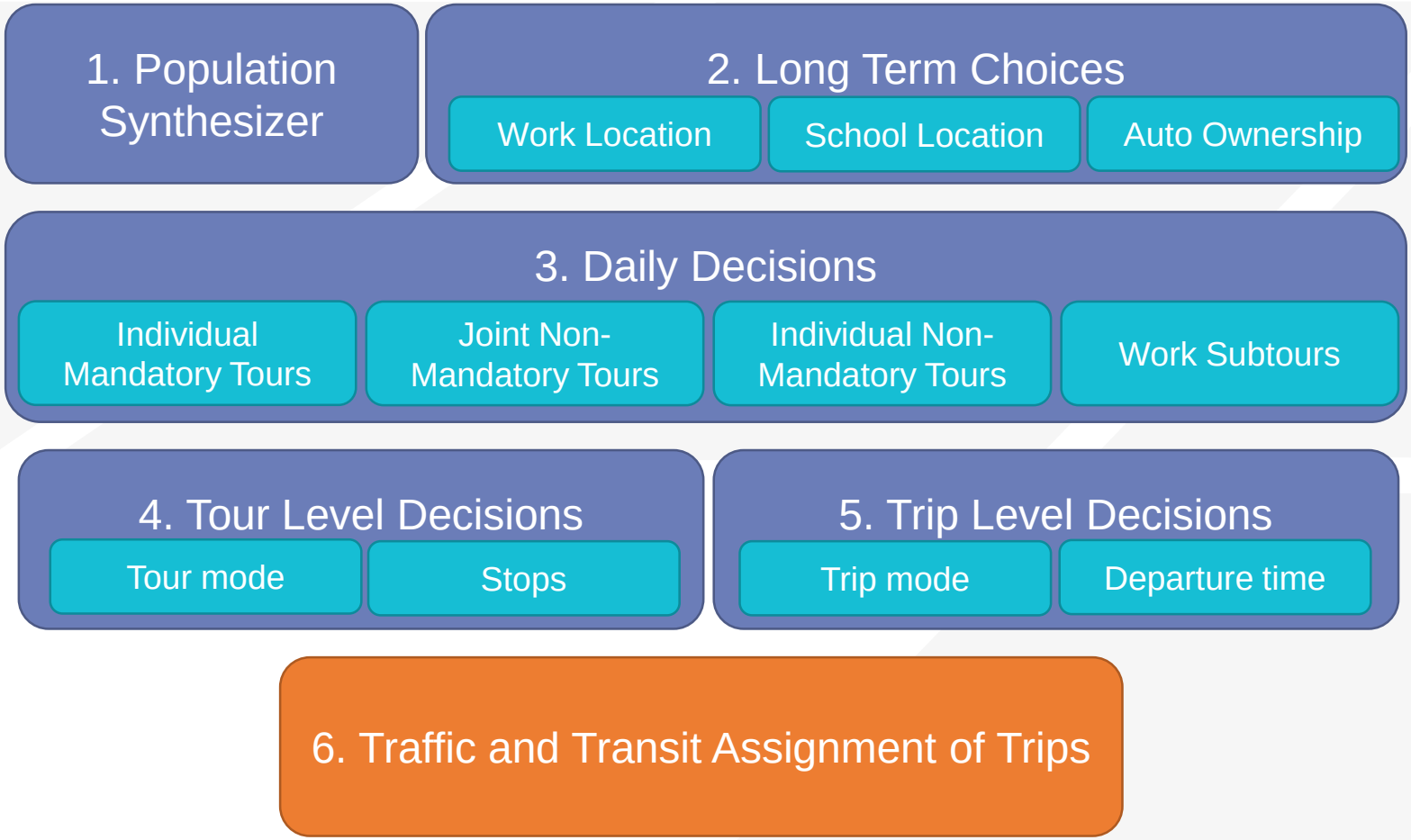
Activity-based Model (MTC)



Activity vs Trip-based Models

- Activity-based models predict travel at an individual level rather than TAZ averages
- A sample zone has 2 households
  - 3 persons, high income, 2 workers, 2 cars
  - Household 1: two working parents, one school-aged child
  - Household 2: two working adults, one senior
- Trip-based model may predict 6.8 work trips, 3.2 school trips, and 8 other trips at the zonal level
- Activity-based model may predict 8 work trips, 2 school trips, and 8 other trips
  - Trip patterns, destinations, time of departure would all be very different

Activity vs Trip-based Models

- Activity-based models guarantee consistency between trips within tours as well as tours and household members
- In activity-based models, trips can change time of departure based on congestion levels
- However, in activity-based models, you have less control over the process

MTC and ACTC Models

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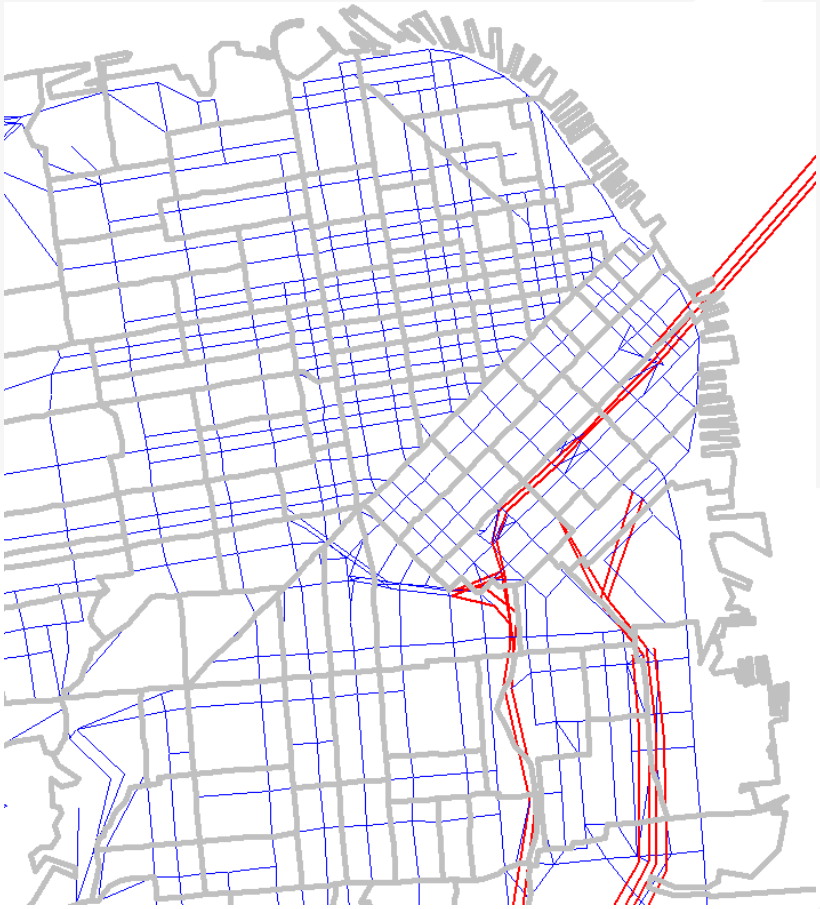
ACTC Model

- Trip-based model that includes 10 counties
  - 9 Bay Area counties and San Joaquin County
- Most recently re-calibrated in December 2015
- Uses Citilabs Cube software to run
- Uses the Plan Bay Area land use through year 2040
- Includes more zones than the MTC model (4500 vs 1454)
- Much higher resolution in Alameda County and Contra Costa County

MTC Model

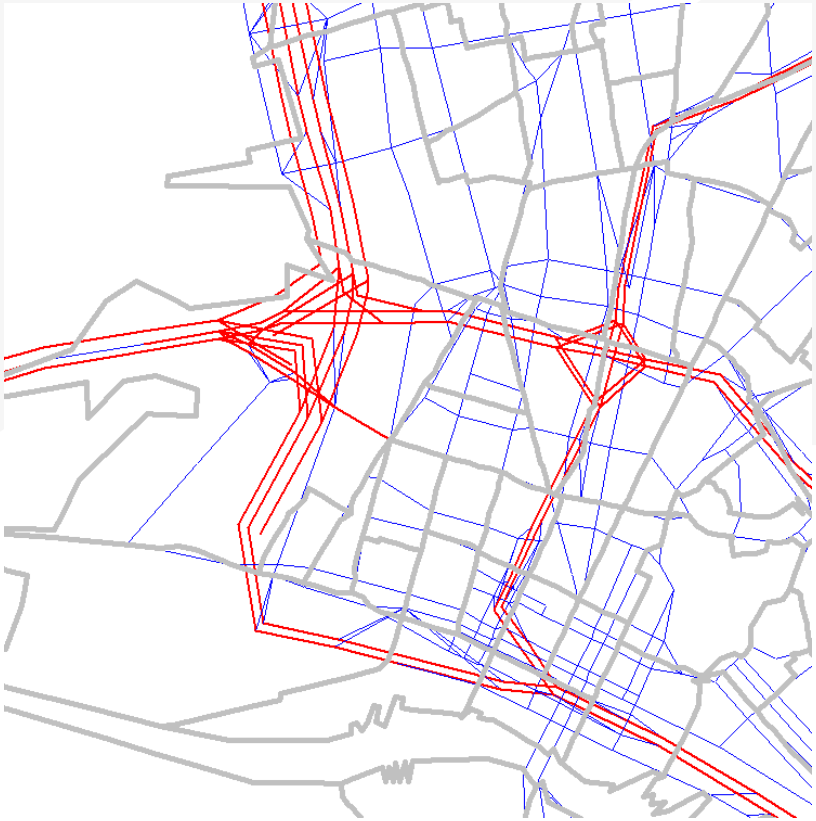
- Activity-based model with 9 Bay Area counties
- Current version is Travel Model One 0.6
  - Very recently updated
- Uses Plan Bay Area land use through 2040
- Used to evaluate projects for the RTP
- Large part of the model is a “black box”: many of the components are written in Java and Python and pre-compiled
- Highway and transit assignment are implemented in Citilabs Cube

MTC vs ACTC Model Zone Detail
Downtown SF



MTC vs ACTC Model Zone Detail
Downtown Oakland

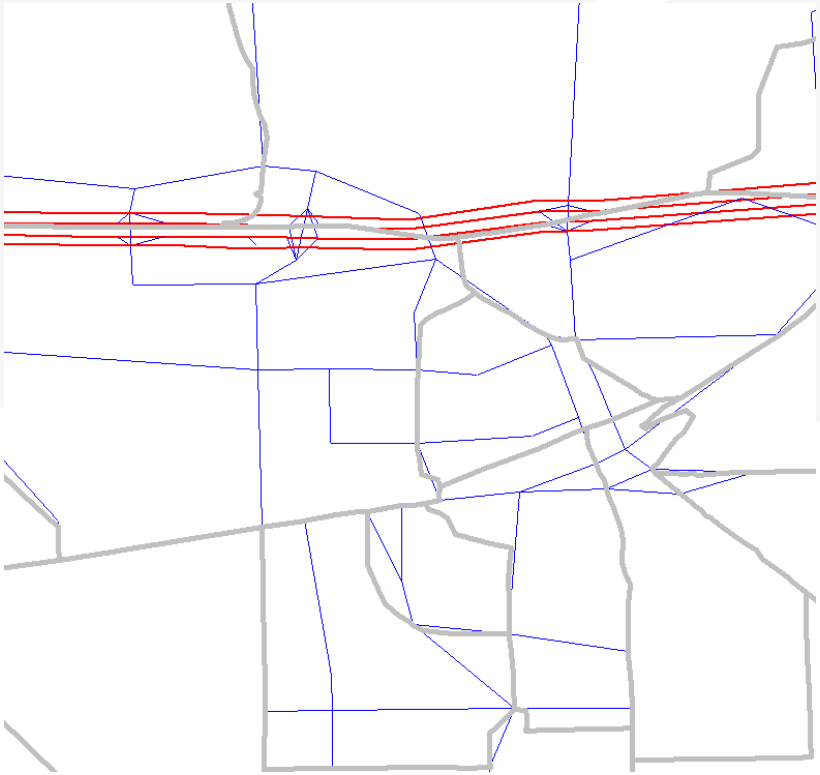
MTC



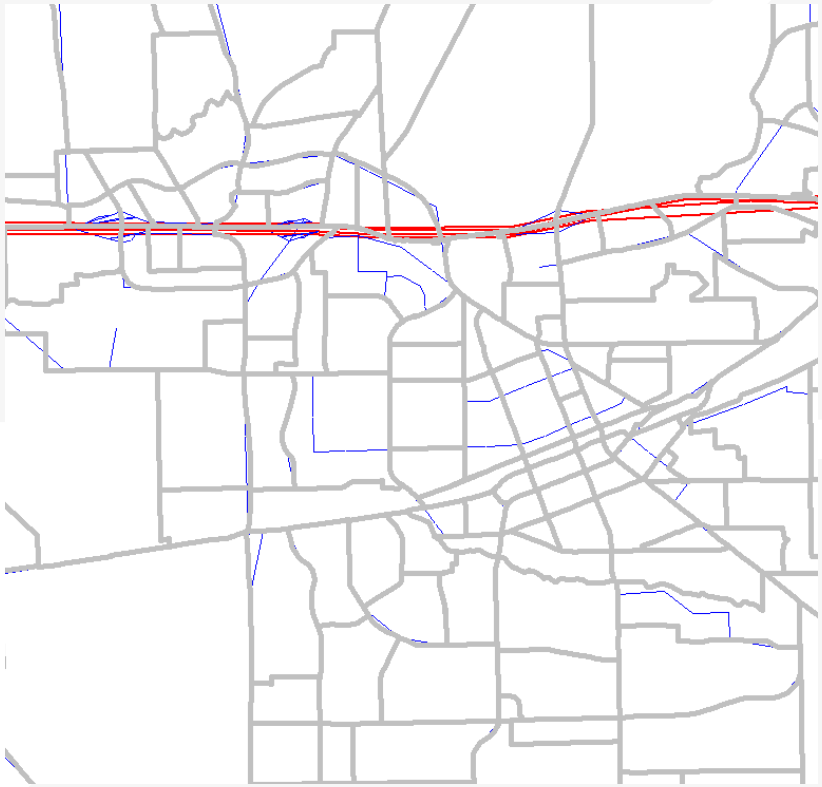
ACTC

MTC vs ACTC Model Zone Detail
Livermore

MTC



ACTC



MTC vs ACTC Model Zone Detail
Richmond/El Cerrito

MTC

ACTC

When to Use MTC vs ACTC

- MTC
  - Analysis outside Alameda or Contra Costa County
  - Express lanes analysis
  - Benefit/cost analysis
- ACTC
  - Alameda County, Contra Costa County, San Joaquin County
  - Transportation projects that are large but unlikely to result in changes to where people work or live

CS Projects Using MTC and ACTC Models

- MTC
  - Core Capacity Study
  - Inter-regional Express Lanes
  - Analysis of BART State of Good Repair
- ACTC
  - BART to Livermore DEIR
  - Alameda County Goods Movement
  - Port of Oakland Study

MTC vs ACTC Projects

- What are some Caltrans projects using the two models?

VMT, VHT, and other acronyms

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VMT Background

- Vehicle-miles-traveled is an important metric correlated with Greenhouse Gas Emissions (GHG)
- California law (SB743) requires all new development projects be assessed in terms of their impact on VMT
  - OPR has issued guidance on how land use and transportation projects need to be evaluated
  - New projects should meet the threshold of 15% below average regional VMT (more on this later)

VMT Analysis

- Highway- facility VMT analysis that calculates VMT on particular facility or set of facilities
  - Can be conducted for different geographical areas such as counties
  - Can be conducted based on facility type or speed at which the facility operates
  - This has been done by many agencies over the years
- Zonal VMT analysis that calculates travel generated by a set of zones
  - This is the analysis required by SB 743

Facility VMT

- Calculated by multiplying daily number of vehicles by link distance
- If VMT is segmented by speed bin, each facility is grouped into a speed bin based on operational speed and then the VMT is calculated
- VMT that occurs within each county of jurisdiction can be calculated by identifying all highway facilities within the jurisdiction and adding up VMT

Zone-based VMT

- For a given TAZ system, can get vehicle trip tables, combine them with skims and calculate vehicle-miles traveled
- For activity-based models, can get total household VMT by adding up all auto trips in the trip list multiplied by trip length
  - Since the home zone of the trip maker is known for all trips, the total VMT will include non-home-based VMT
- For trip-based models, can only get home-based VMT because home zone is not available for non-home based trips

VHT and VHD

- Vehicle-hours traveled is another metric frequently used in transportation analyses
  - » Calculated by multiplying the link travel time by link volume (should be done by time period)
- Vehicle-hours of delay is a metric used to evaluate the impact of a project on system-wide level of congestion
  - » Calculated by multiplying the difference in congested link travel minus free-flow link travel time by link volume

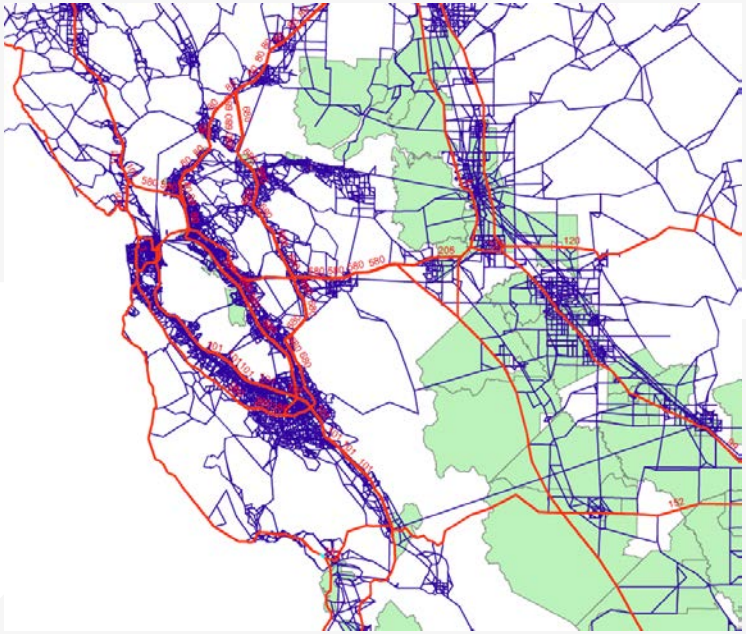
PMT, Vehicle Occupancy

- Passenger-miles traveled is a metric used to capture the total travel including non-auto travel
  - Calculated by multiplying the distance between origin and destination (based on skims) by the number of trips occurring between origin and destination
- Vehicle occupancy refers to the total number of auto person trips divided by number of vehicles
- Vehicle ridership refers to the total number of motorized trips divided by number of vehicles (includes transit trips)

VMT Calculation Example

- Corridor VMT that falls within different non-attainment areas (PM25, Ozone) as well as economically disadvantaged areas
- California Statewide Travel Demand Model (CSTDM) was used to determine volumes on different facilities
- The loaded networks were overlaid with non-attainment area zones in ArcGIS to extract facilities that fell within these areas

Economically Disadvantaged Areas



Model Convergence

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Background

- Model convergence can refer to either:
  - Traffic assignment convergence
  - Model feedback convergence
- Travel demand models typically use user equilibrium traffic assignment algorithm, where each user minimizes his or her travel time and is assumed to have prefect knowledge of the system travel time
- Paths are built and vehicle are re-assigned until any paths that are being used between an origin and a destination have the same travel time

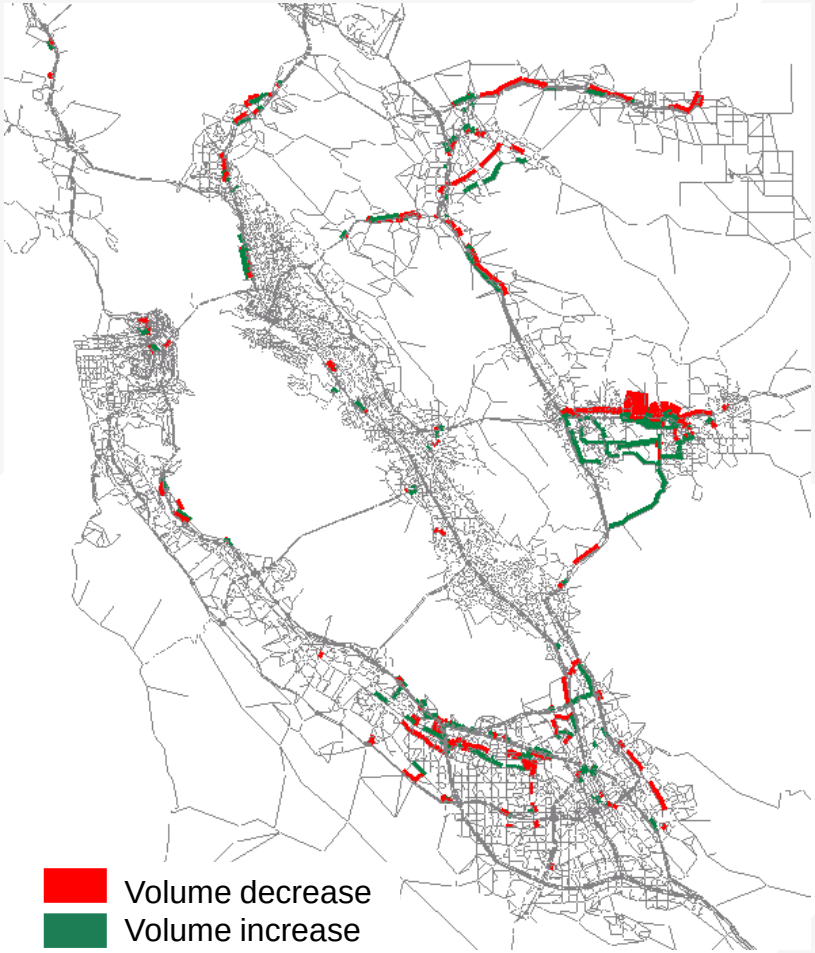
Traffic Assignment Convergence

- There is no deterministic solution to the user equilibrium assignment process- it's an iterative process
- At the end of each iteration a relative gap parameter is calculated that represents the change from previous iteration- the smaller the change, the closer you are to convergence
- Many models use relative gap of 0.01, which usually is insufficient to reach convergence
- Some other models including the ACTC model use a maximum number of iterations, instead of relative gap, which is not ideal
- When the assignment is not well converged, a local change to the highway network results in volume differences far away

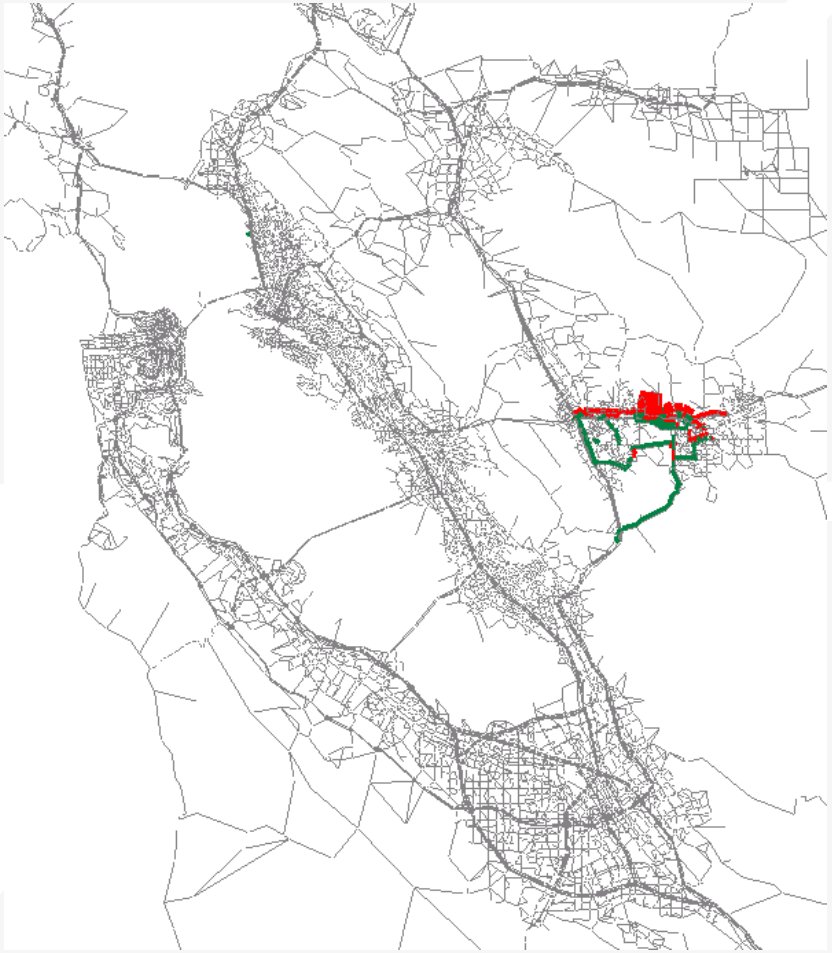
Traffic Assignment Convergence

Volume Diff: No Dublin Blvd extension in Livermore

MaxIters=50



Relative gap=0.0001



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Speed Feedback Convergence

- Most urban area models run speed feedback in order for trip distribution and mode choice steps to respond to the congested speeds on the highway network
  - If free-flow speeds are used for trip distribution and mode choice, there will be too many long trips as well as a high auto mode share
  - If congested speeds from a prior run with no speed feedback are used, there will be too many short trips and transit trips

Should Speed Feedback be Run?

- YES
  - Significant addition of capacity on the highway (new express lane on I-580)
- NO
  - Interchange project
  - Addition of one lane-mile on a minor arterial

Upcoming Homework

- Add I-580 HOT lanes near Livermore
- Run with and without speed feedback
- Run with higher level of traffic assignment convergence
- Compare different model runs to No Project scenario

Cube Overview

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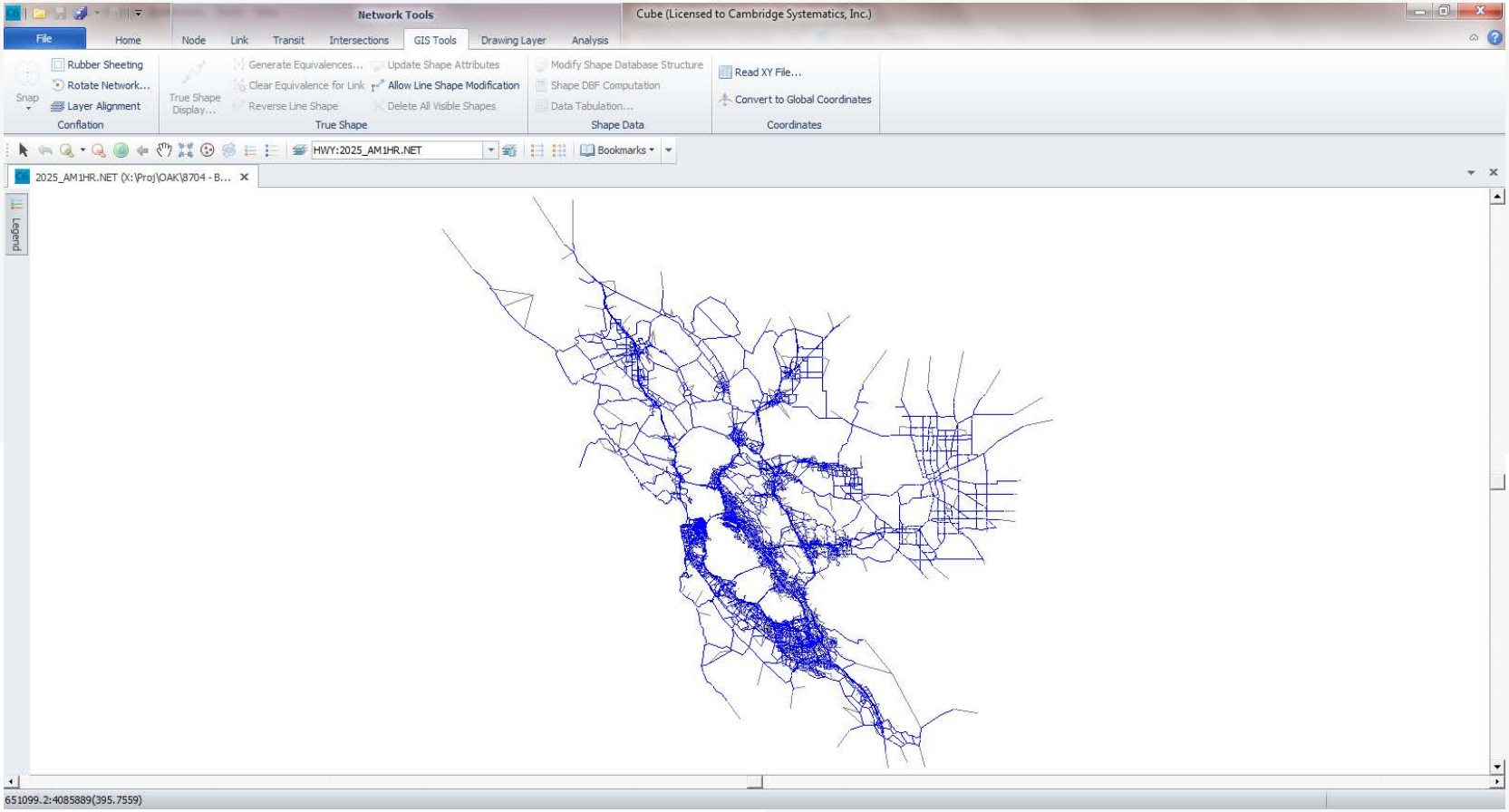
Cube Software Overview

- Cube Base includes the interface
- Cube Voyager executes scripts
- Cube Scenario Manager allows to manage scenarios
- Cube Application Manager maintains the model and allows running it using a flowchart structure
- Cube GIS incorporates ESRI interface into Cube
- Version & build
  - Version I have open: Version 6.1.0

Cube Overview

- Most models implemented in Cube use either a bat file to run the model or the Scenario Manager
  - California Statewide Travel Demand Model uses scenario manager
  - In all cases, routines are implemented using scripts
- Some of the more common procedures include matrix calculation, highway assignment, trip generation, trip distribution and transit assignment
- Cube Base is used to view files, edit networks, and analyze results

Cube Base User Interface



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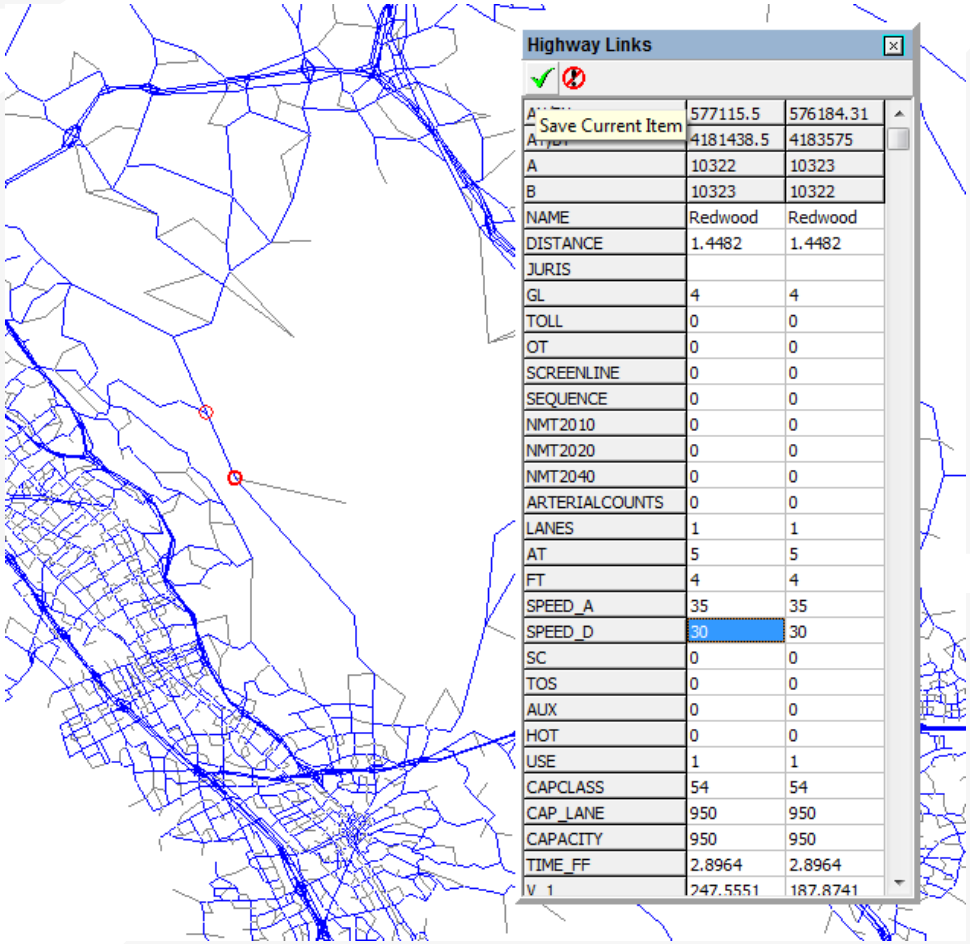
Editing Link Attributes

- Click on Link
- Double-click on attribute
- Make desired changes
- Click on ✓ to save changes or ⊘ to cancel changes
- Click on “Save Edit Log” to save log file
- Saved log file can be played on a different network to apply the same changes



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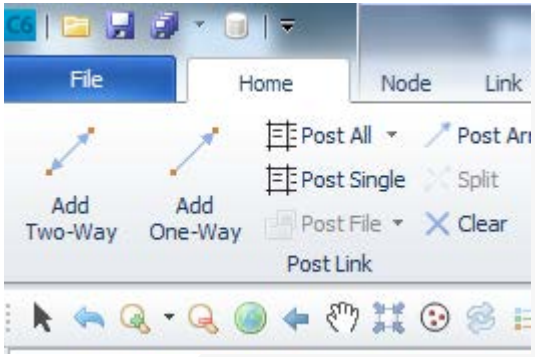
Adding New Links

- Right-click on similar link and click copy
- Right-click on desired location and click paste
- Drag and drop mouse from start to end of new link
- Edit link attributes (note that the distance field populates itself and rest of attributes are copied from previous link)
- In order to create a new link without any attributes, click on Add Two-way or Add One-Way in the Home tab



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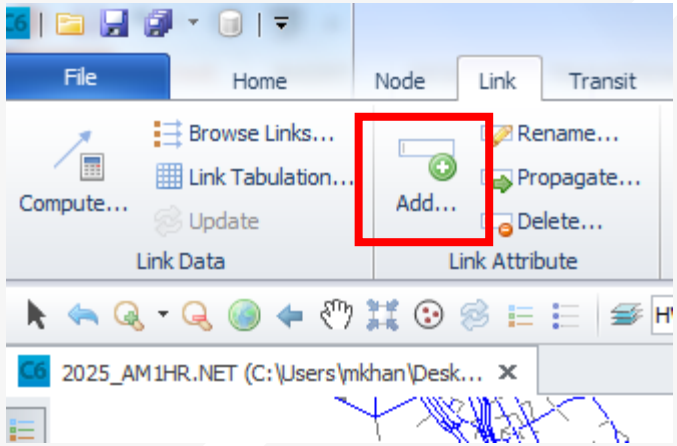
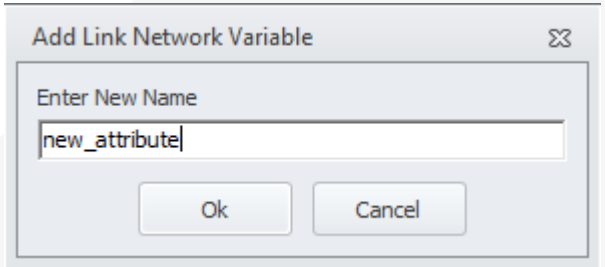
Adding Attributes

- In order to create a new attribute, click on Add in the Link tab
- Name new attribute and click OK
- Click on a link and scroll all the way down to check new attribute. The default value of the attribute is 0, but this can be changed by editing and saving.





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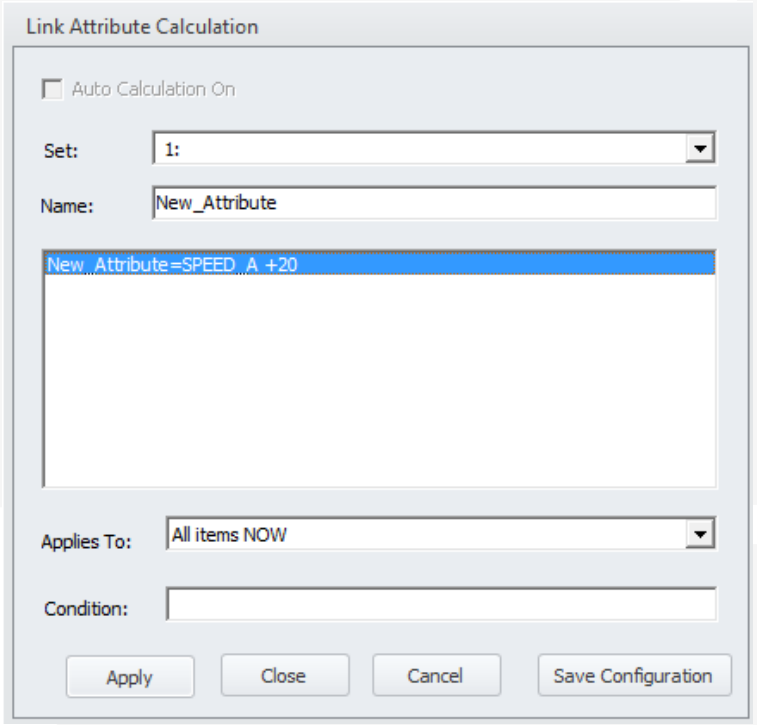
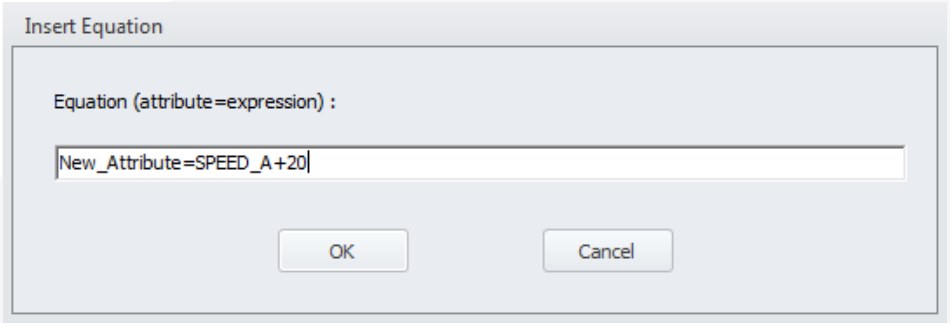
Adding Attributes (Calculate)

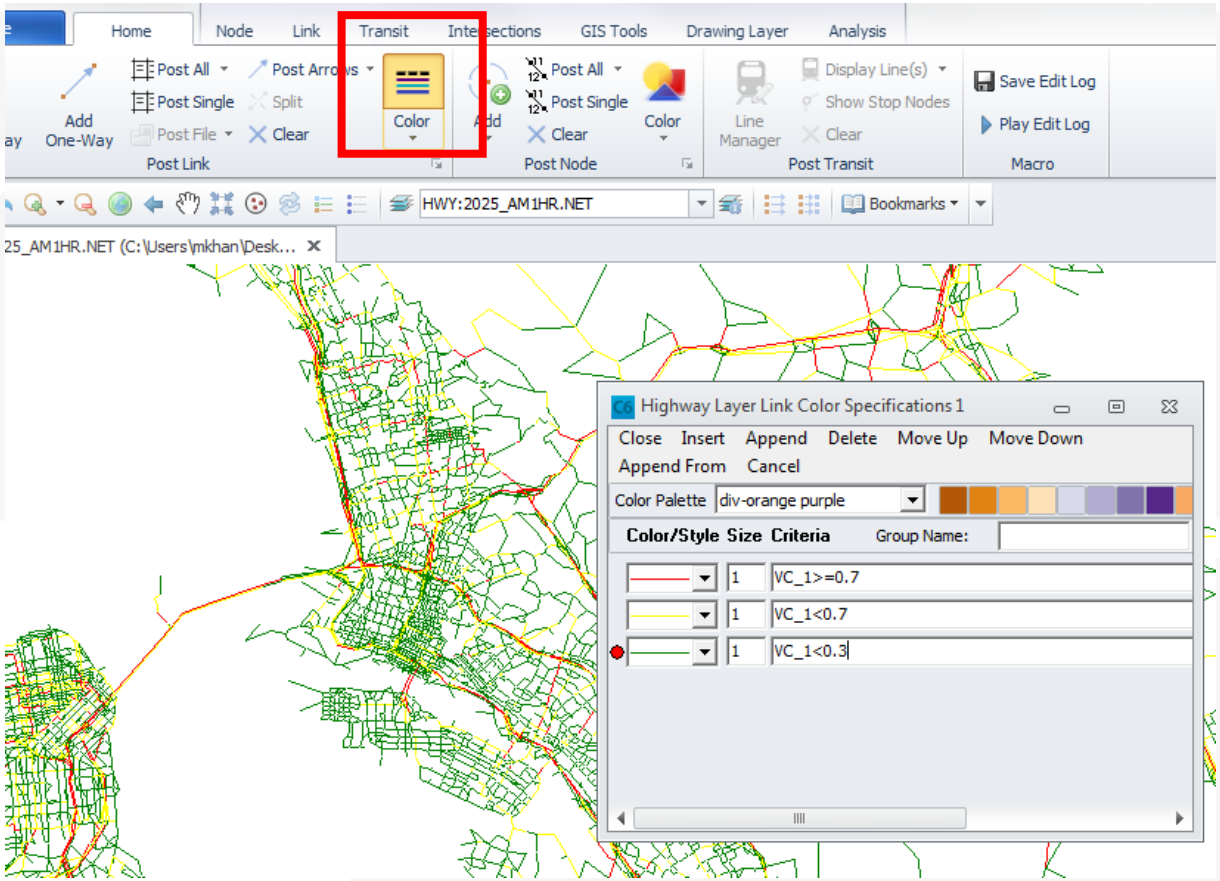
- Click on Compute under Link Tab
- Name the new attribute
- Right click inside white window and click Insert
- Type formula for new attribute
- Type formula under Condition to select the links which are to be computed, remaining links will have a default value of 0. If no condition is specified, all links are computed.
- Click Apply and then Close





Adding Color Scheme

- Click on Color in Home Tab
- Click on Insert and then choose desired settings
- Rows can be moved up or down to choose how the theme appears
- Save project file to save changes to the theme



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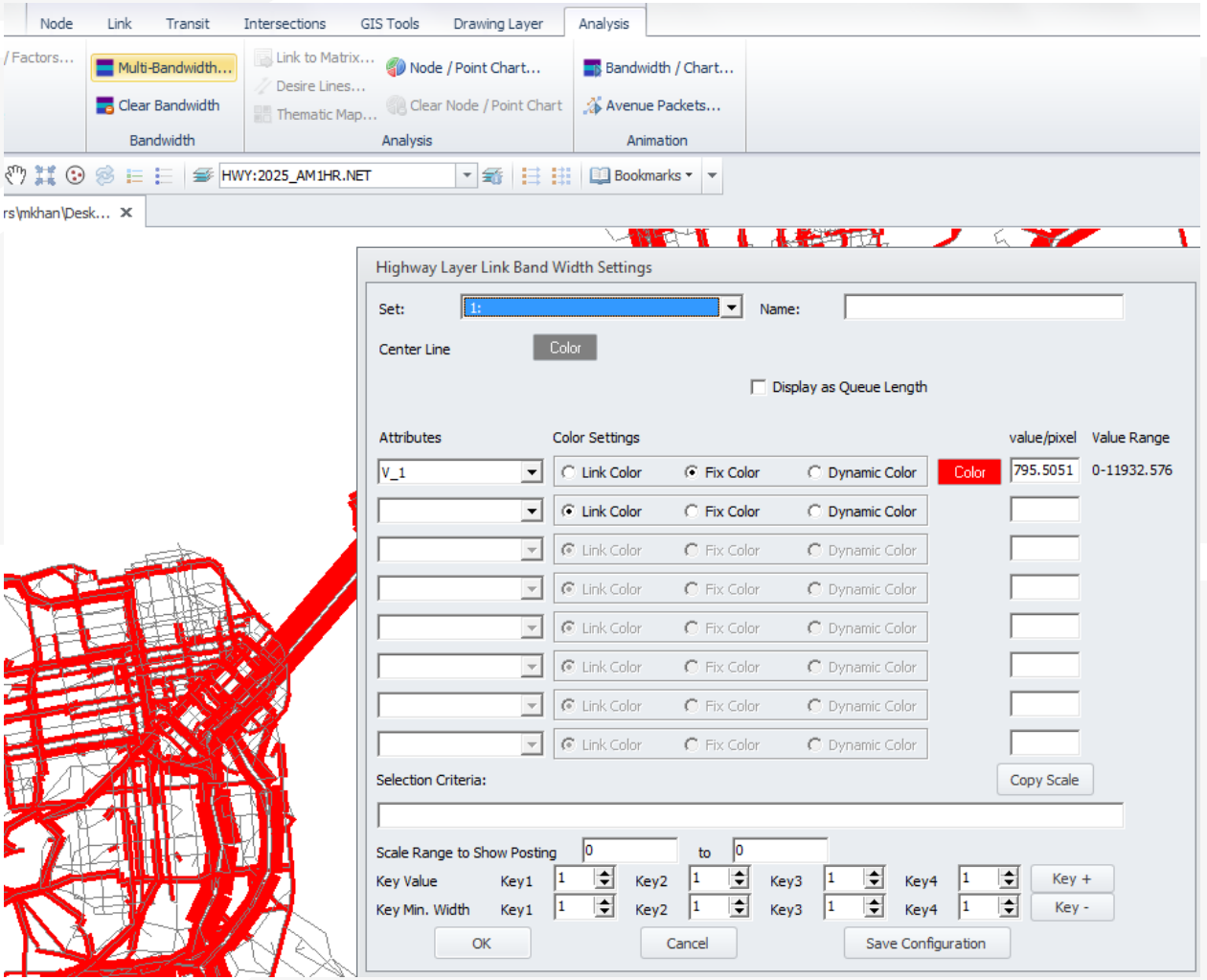
Bandwidth Plots

- Click on Multi-Bandwidth in Analysis Tab
- Choose attribute(s), Color and Size. Up to 8 attributes can be chosen
- Click Ok



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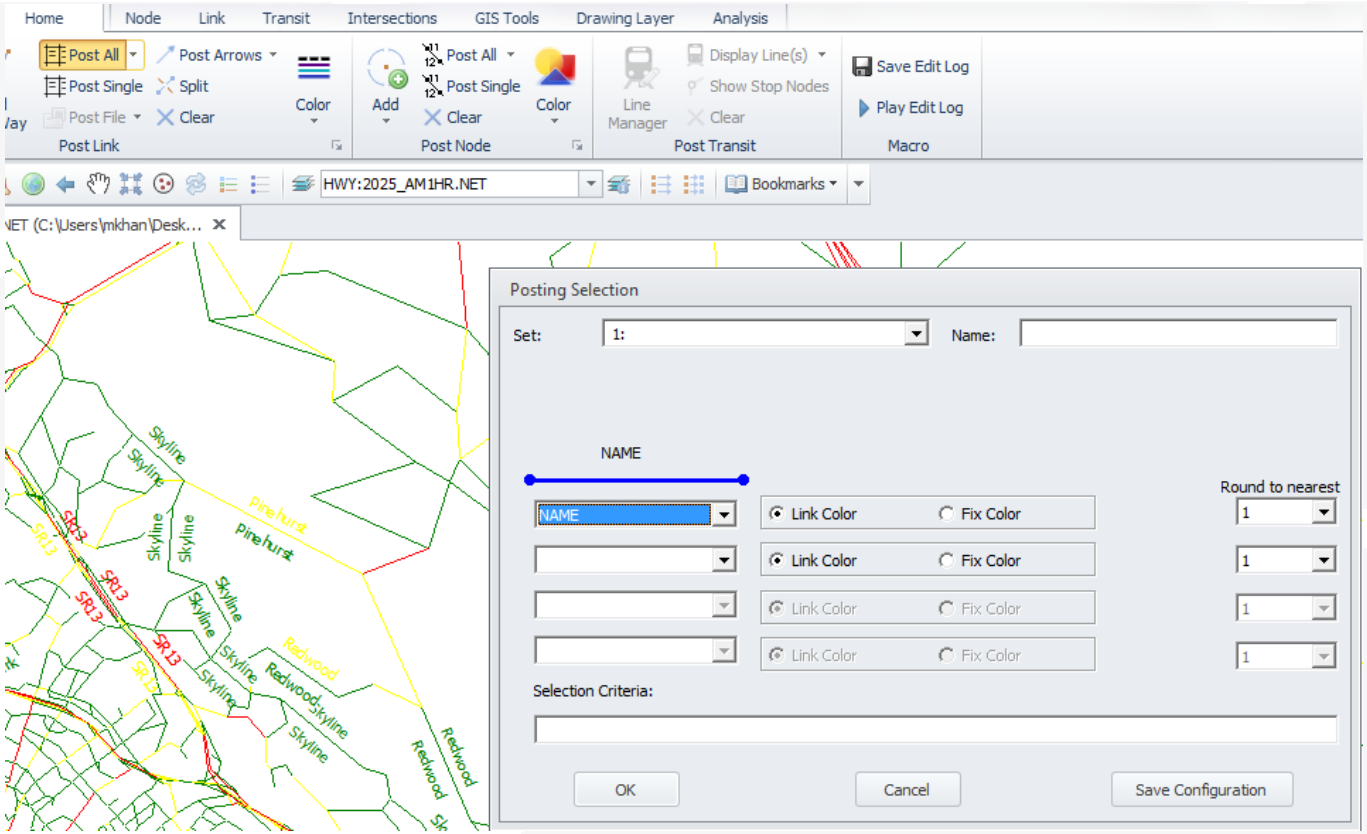
Adding Labels

- Click on Post All in Home Tab in the Post Link section
- Choose attributes to Label and appropriate settings
- The Post Single option can be used to label links by clicking on them instead



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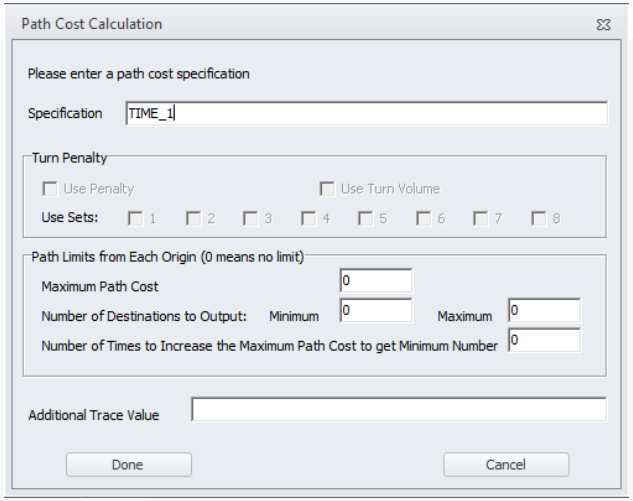
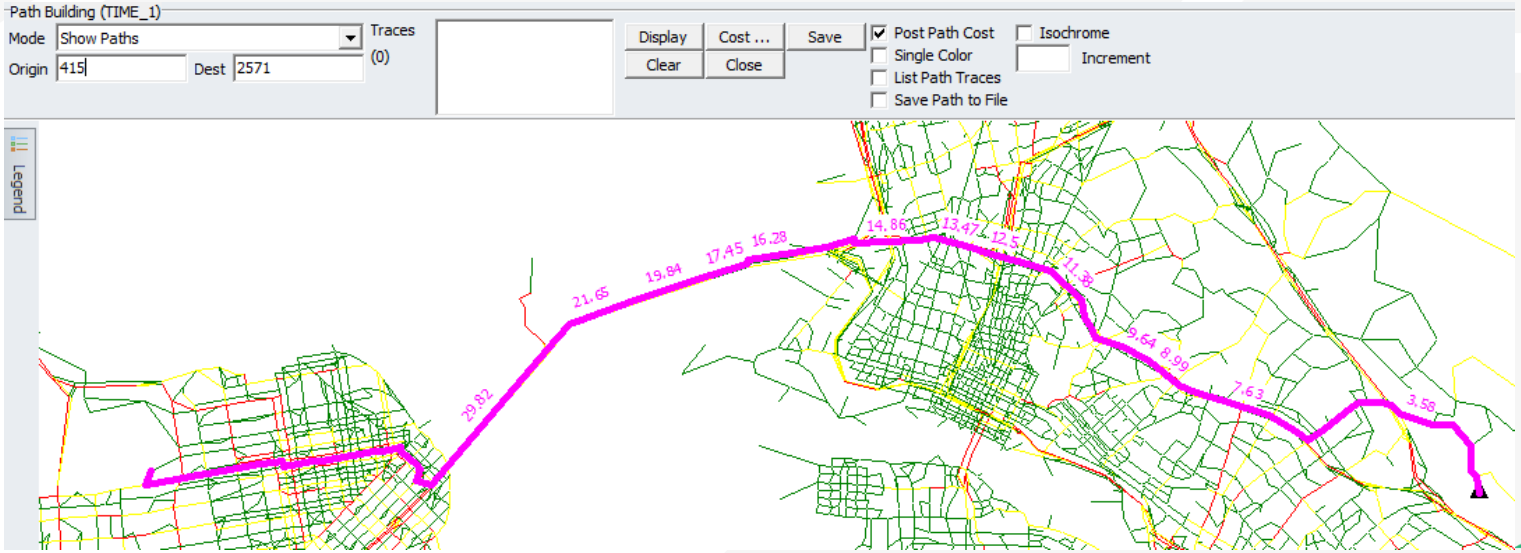
Displaying Paths

- Click on Build in Analysis tab
- Specify attribute for shortest path calculation and click Done
- Type in Origin and Dest zones (you may also click on the map to select zones). Click on Display





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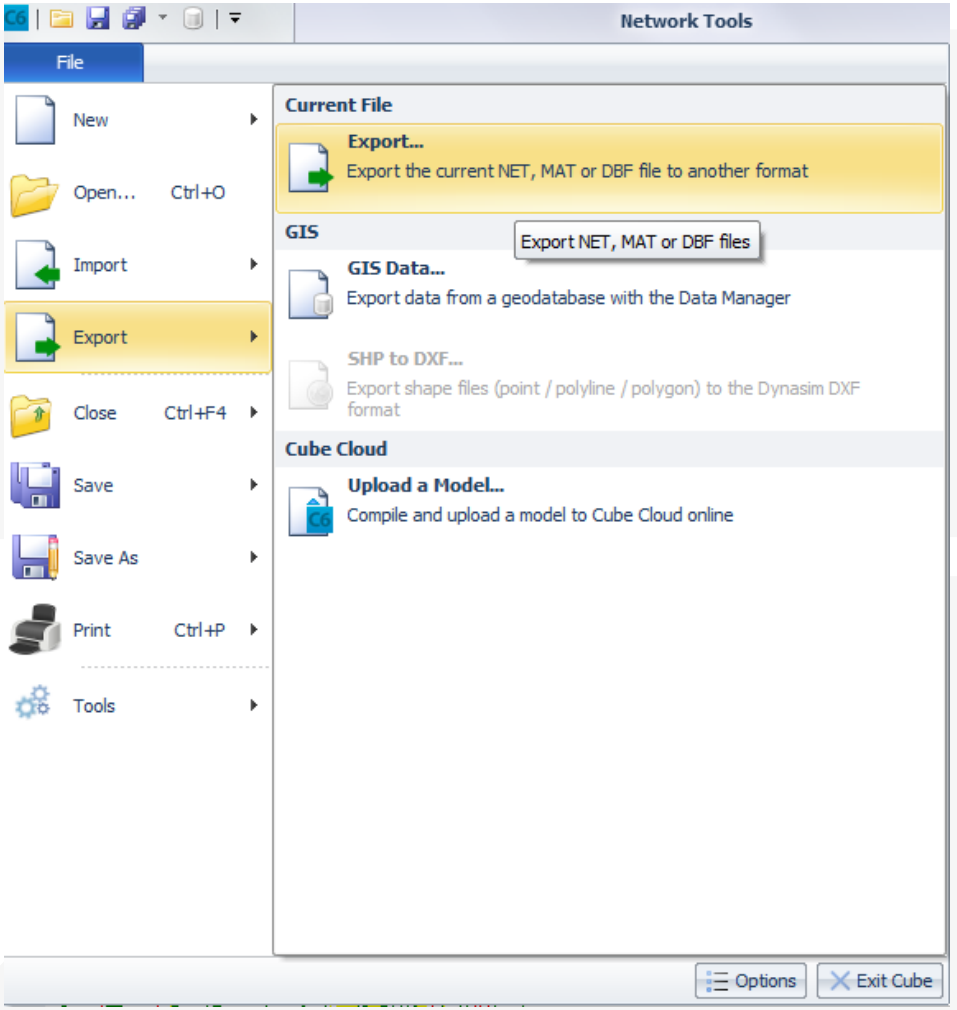
Exporting Links

- Go to File -> Export -> Export
- Select location and filename
- Select “save as type” to save any of the following:
  - Link Shape File
  - Node Shape File
  - Link DBF file
  - Node DBF file
- Shape files are output as standard GIS Shape Files
- DBF files are output as single DBFs with all the links/nodes as rows



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Scripting in Cube

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Adding Matrices

```
;Add matrices
RUN PGM=MATRIX

FILEI MATI[1] = "InputDirectory\InputMatrix1.MAT" ; Input Matrix 1
FILEI MATI[2] = "InputDirectory\InputMatrix2.MAT" ; Input Matrix 2
FILEO MATO[1] = "OutputDirectory\OutputMatrix.MAT", MO=1-3, NAME=SUM1,SUM2,SUM3

ZONES=4000 ; Number of zones

; Perform the additions
MW[1]=mi.1.1 + mi.2.1
MW[2]=mi.1.2 + mi.2.2
MW[3]=mi.1.3 + mi.2.3

ENDRUN
```

Aggregating Matrices

```
;Aggregate matrices
RUN PGM=MATRIX

FILEI MATI[1] = InputMatrix.MAT

FILEO MATO[1] = AggregatedMatrix.mat, MO=1-2, NAME=Aggregated1,Aggregated2

MW[1]=mi.1.1
MW[2]=mi.1.2

RENUMBER FILE = TAZ_AGGREGATION_CORRESPONDENCE.CSV,
ZONES=20, MISSINGZI=M, MISSINGZO=M

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```

1	5
2	5
3	5
4	5
5	4
6	4
7	19
8	19
9	19
10	17

Sample Correspondence file:

- No headers
- First column TAZ, second column aggregation index

Converting Matrix to .csv

```
;Convert matrix to csv
RUN PGM=MATRIX

FILEI MATI[1] = InputMatrix.mat
FILEO PRINTO[1] = OutputCSV.csv

mw[1] = mi.1.1

; Print column headers
IF (i=1)
print csv=T, printo=1, list="Origin", "Destination","Matrix1", "Matrix2", "Matrix3"
ENDIF

; Output data into csv
JLOOP
print csv=T, printo=1,list=i,j,mw[1],mw[2],mw[3]
ENDJLOOP

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```
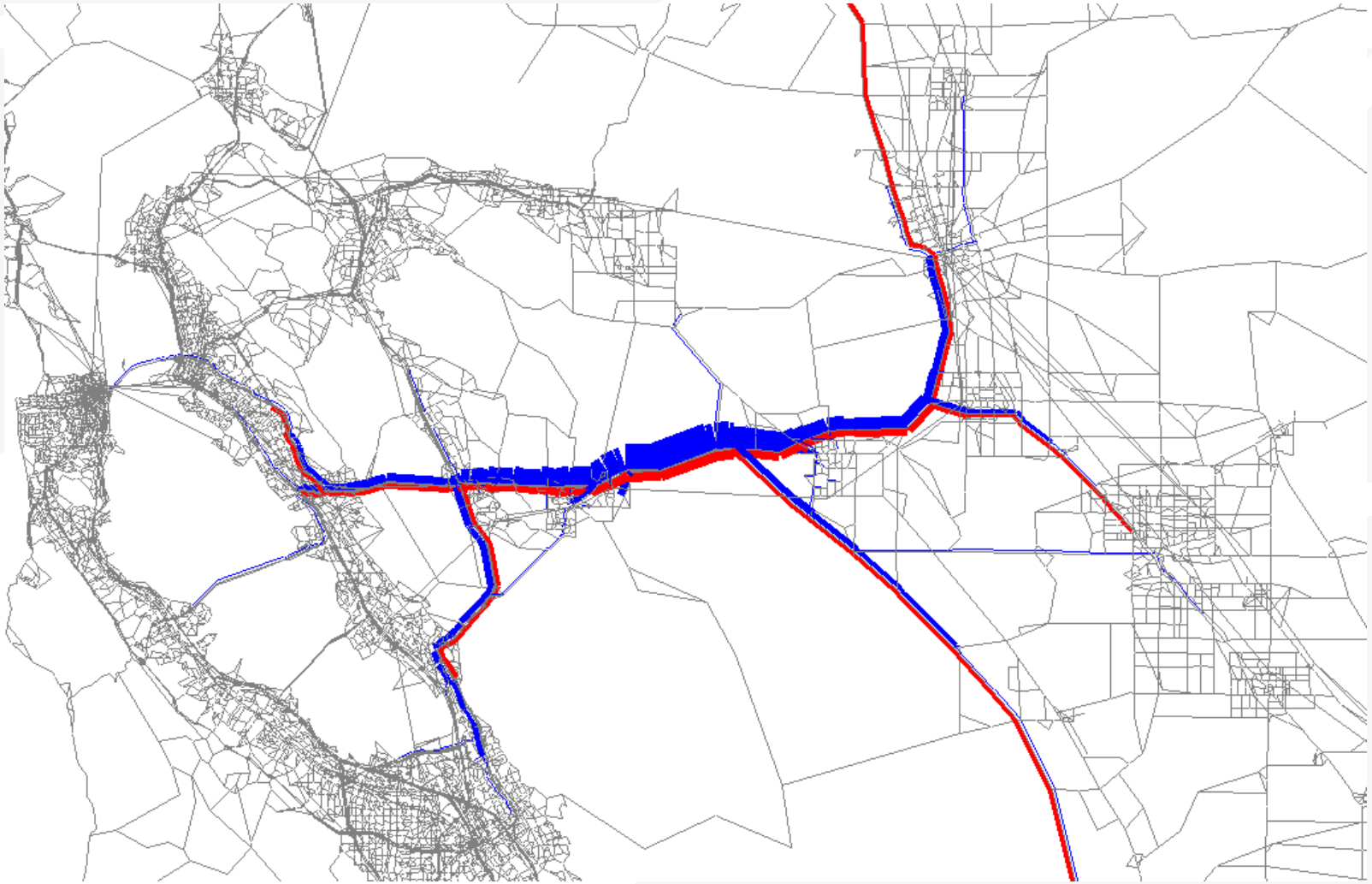

Select Link Analysis

```
PHASE=ILOOP
      PATHLOAD PATH=COST,EXCLUDEGRP=23, TOLLMATI=1,1,TOLLFACTOR=5.0,
      MW[11]=mi.1.16 + mi.1.22 + mi.1.26, SELECTLINK=(L=22518-21336),
      MW[16]=mi.1.16 + mi.1.22 + mi.1.26, SELECTLINK=(L=21299-22522),
      VOL[1]=mi.1.16 + mi.1.22 + mi.1.26,
      VOL[6] = MW[11],
      VOL[11] = MW[16];SOV Short, Value of Time of $12/hr

      PATHLOAD PATH=COST,EXCLUDEGRP=3,VOL[2]=mi.1.17 + mi.1.23 + mi.1.27,TOLLMATI=1,2,TOLLFACTOR=2.5,
      MW[12]=mi.1.17 + mi.1.23 + mi.1.27, SELECTLINK=(L=22518-21336),
      MW[17]=mi.1.17 + mi.1.23 + mi.1.27, SELECTLINK=(L=21299-22522),
      VOL[2]=mi.1.7 + mi.1.23 + mi.1.27,
      VOL[7] = MW[12],
      VOL[12] = MW[17]; HOV2 Short,


      PATHLOAD  PATH=COST,EXCLUDEGRP=5,VOL[3]=mi.1.18 + mi.1.24 + mi.1.28,TOLLMATI=1,3,TOLLFACTOR=1.49,
      MW[13]=mi.1.18 + mi.1.24 + mi.1.28, SELECTLINK=(L=22518-21336),
      MW[18]=mi.1.18 + mi.1.24 + mi.1.28, SELECTLINK=(L=21299-22522),
      VOL[3] = mi.1.18 + mi.1.24 + mi.1.28,
      VOL[8] = MW[13],
      VOL[13] = MW[18]; HOV3+ Short, Assuming 3.36 people

      PATHLOAD  PATH=COST,EXCLUDEGRP=23,VOL[4]=mi.1.19,TOLLMATI=1,1,TOLLFACTOR=5.0,
      MW[14]=mi.1.19, SELECTLINK=(L=22518-21336),
      MW[19]=mi.1.19, SELECTLINK=(L=21299-22522),
      VOL[4] = mi.1.19,
      VOL[9] = MW[14],
      VOL[14] = MW[19]; Light TRUCK Short, VOT=$20/hr

      PATHLOAD  PATH=COST,EXCLUDEGRP=4,VOL[5]=mi.1.20 + mi.1.21 + mi.1.25 + mi.1.29 + mi.1.30,TOLLMATI=1,4,TOLLFACTOR=3.0,
      MW[15]=mi.1.20 + mi.1.21 + mi.1.25 + mi.1.29 + mi.1.30, SELECTLINK=(L=22518-21336),
      MW[20]=mi.1.20 + mi.1.21 + mi.1.25 + mi.1.29 + mi.1.30, SELECTLINK=(L=21299-22522),
      VOL[5] = mi.1.20 + mi.1.21 + mi.1.25 + mi.1.29 + mi.1.30,
      VOL[10] = MW[15],
      VOL[15] = MW[20]; Medium and heavy truck
```

West Bound

East Bound

Select Link Analysis Results



Comparing Network Volumes

```
;Compare network volumes
RUN PGM=NETWORK

FILEI NETI[1] = InputNetwork1.net
FILEI NETI[2] = InputNetwork2.net
FILEO NETO = OutputNetwork.net, INCLUDE=A B VOL_DIFF

VOL_DIFF = LI.2.V_1 - LI.1.V_1 ; Difference in volume of Network 2 from Network 1

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```
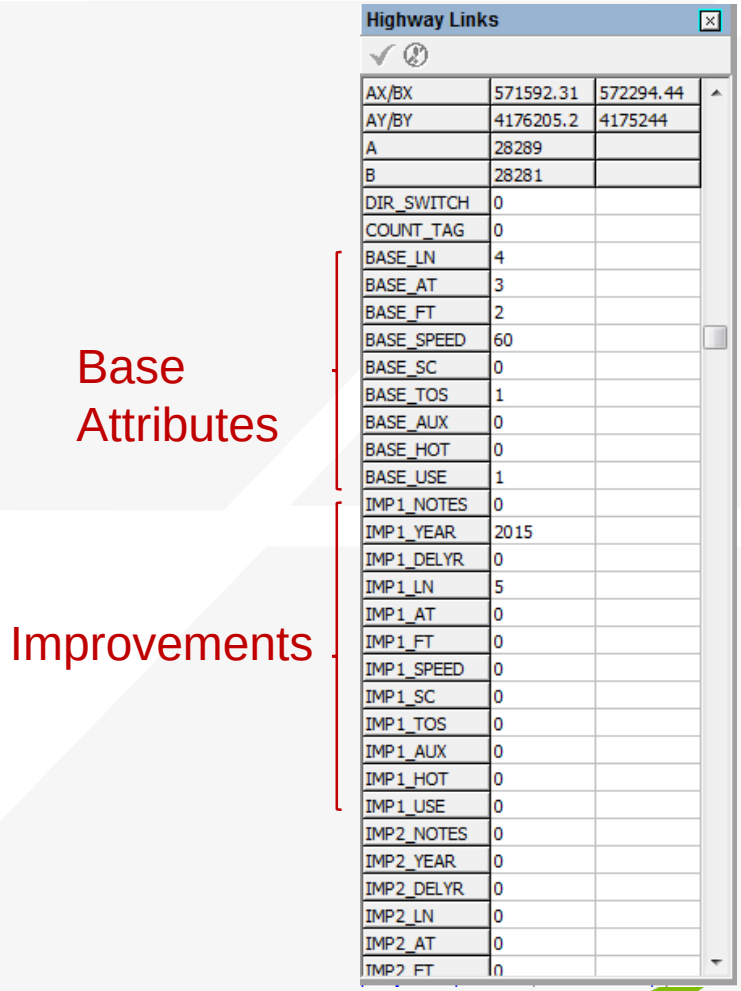

Exporting Network Links

```
;Exporting network links
RUN PGM=NETWORK

NETI[1]=InputNetwork.net
LINKO=OutputNetwork.dbf, INCLUDE=A, B, V_1 ; Include as many attributes as desired in the output

IF (V_1=0) DELETE      ; Delete links that are not desired as outputs

ENDRUN
```

Working with Master Networks

- By defaults all base attributes from Master Network are transferred to the output year network
- If improvement year of a project is less than the desired output year, then non-zero attributes from the improvement are transferred to the output year network
- For example, in this instance if a 2020 network is output, the number of lanes for the specific link shown will be 5, and the rest of the attributes will be the same as base
- The ACTC master network has up to three improvements listed, but the network and script can be modified to accommodate for more



AX/BX	571592.31	572294.44
AY/BY	4176205.2	4175244
A	28289	
B	28281	
DIR_SWITCH	0	
COUNT_TAG	0	
BASE_LN	4	
BASE_AT	3	
BASE_FT	2	
BASE_SPEED	60	
BASE_SC	0	
BASE_TOS	1	
BASE_AUX	0	
BASE_HOT	0	
BASE_USE	1	
IMP1_NOTES	0	
IMP1_YEAR	2015	
IMP1_DELYR	0	
IMP1_LN	5	
IMP1_AT	0	
IMP1_FT	0	
IMP1_SPEED	0	
IMP1_SC	0	
IMP1_TOS	0	
IMP1_AUX	0	
IMP1_HOT	0	
IMP1_USE	0	
IMP2_NOTES	0	
IMP2_YEAR	0	
IMP2_DELYR	0	
IMP2_LN	0	
IMP2_AT	0	
IMP2_FT	0	

Working with Master Network

```
; Set Link Attributes to Base Inputs
;
LANES =    BASE_LN         ; Number of Lanes
AT =       BASE_AT         ; Area Type
FT =       BASE_FT         ; Facility Type
SPEED_A =  BASE_SPEED      ; Speed used as input to Assignment
SC =       BASE_SC         ; Signal Coordination
TOS =      BASE_TOS        ; TOS Facility
AUX =      BASE_AUX        ; One of LANES is an Auxiliary Lane
HOT =      BASE_HOT        ; Toll Lane
USE =      BASE_USE        ; 1=All Vehicles, 2=HOV2, 3=HOV3+, 4=No Trucks, 6=Bus Only
;
; Update BASE link attributes for Improvement 1
;
IF (IMP1_DELYR <= @INP_NetYear@ && IMP1_DELYR <> 0 ) DELETE
;
IF (IMP1_YEAR <= @INP_NetYear@ && IMP1_YEAR <> 0)
  IF (IMP1_LN<>0)     LANES   = MAX(IMP1_LN, 0)
  IF (IMP1_AT<>0)     AT      = MAX(IMP1_AT, 0)
  IF (IMP1_FT<>0)     FT      = MAX(IMP1_FT, 0)
  IF (IMP1_SPEED<>0) SPEED_A = MAX(IMP1_SPEED, 0)
  IF (IMP1_SC<>0)     SC      = MAX(IMP1_SC, 0)
  IF (IMP1_TOS<>0)    TOS     = MAX(IMP1_TOS, 0)
  IF (IMP1_AUX<>0)    AUX     = MAX(IMP1_AUX, 0)
  IF (IMP1_HOT<>0)    HOT     = MAX(IMP1_HOT, 0)
  IF (IMP1_USE<>0)    USE     = MAX(IMP1_USE, 0)
ENDIF
```

Model Validation/Post Processing

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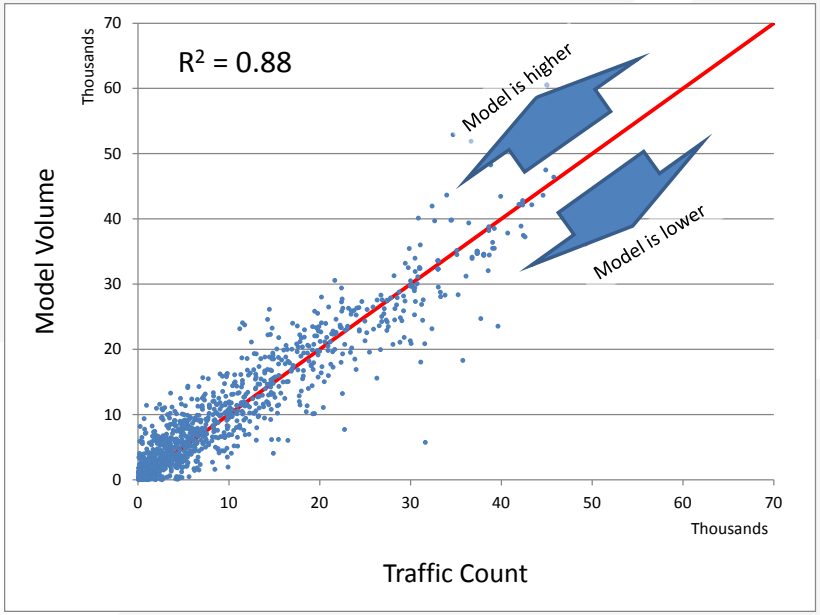
Model Validation

- Observed data sources:
  - California Performance Measurement System (PeMS)
  - Big Data- INRIX, TomTom, HERE, StreetLight, AirSage, ATRI
  - HPMS
  - Arterial counts
  - TAMS- Truck Activity Monitoring System (http://freight.its.uci.edu/tams/)

Model Comparison to Counts

- Statistics
  - R-Squared
  - % RMSE
  - Volume / Count Ratio
- Screenlines
- Corridor Review
- Highest Errors



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Post-Processing

- Pivot point approach is most commonly used for post-processing
  - Is the model too low in the base year?
    - Then the forecast is increased by the same amount
  - Is the model too high in the base year?
    - Then the forecast is decreased by the same amount
- Increases or decreases can be calculated as an absolute number or percent change

Post-Processing Approaches

Use % Growth *(e.g., traffic increases by 30%)*

$$Forecast_{ratio} = Raw\ Volume \cdot \frac{Count\ Volume}{Raw\ Base\ Year\ Volume}$$

Use Volume Growth *(e.g., traffic increases by 5,000 vehicles)*

$$Forecast_{diff} = Raw\ Volume + Count\ Volume - Raw\ Base\ Year\ Volume$$

Use the Average

$$Forecast_{avg} = \frac{Forecast_{ratio} + Forecast_{diff}}{2}$$

Future Topics

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Future Topics

- Intro to TransCAD and differences from CUBE
- Data collection methodology (PeMS)
- Detailed post processing spreadsheets
- CS-developed tools for district modelers

Additional Info

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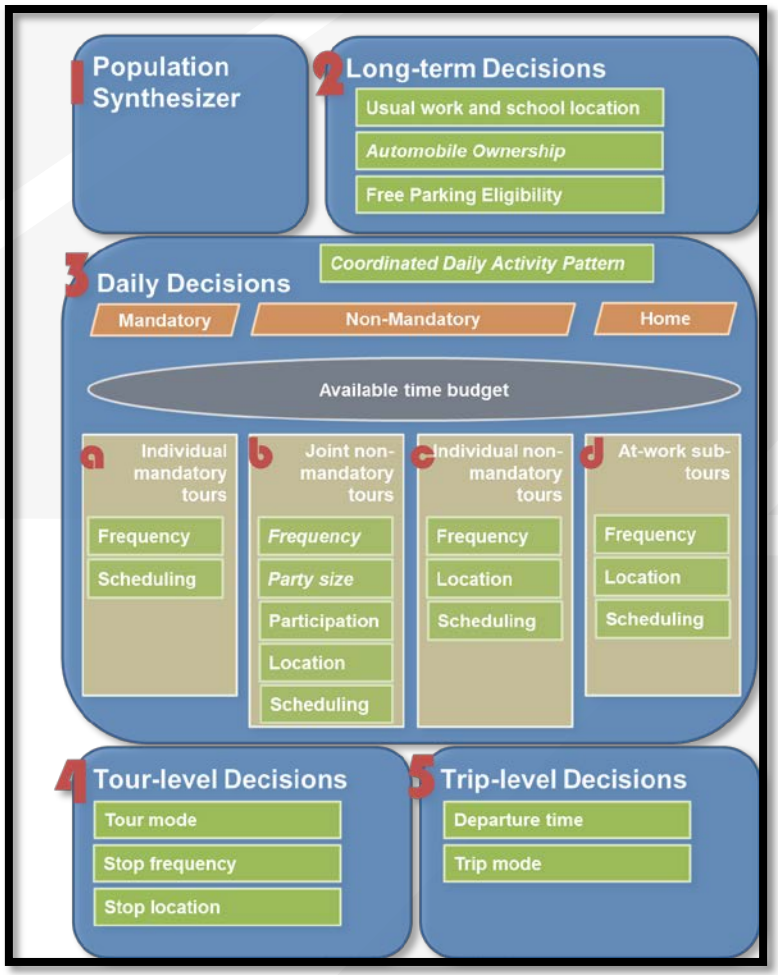
MTC Model Detailed Structure



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