CAMBRIDGE SYSTEMATICS

Think Forward

Aimsun Model Review Training

Day 2: Calibration Review

Caltrans On-Call Traffic Simulation Training

presented to

Caltrans District 7

presented by

Cambridge Systematics & Aimsun

Keir Opie

Laura Torres

What is Calibration?

- Calibration is the adjustment of model parameters to improve the model's ability to reproduce time-dynamic system performance observed under specific operational conditions.

What is Validation?

- Process where the analyst checks the overall model-predicted traffic performance for a street/road system against field measurements of traffic performance, such as traffic volumes, travel times, average speeds, and average delays.

Observed Datasets

- Common
  - Volumes
  - Travel Time
  - Bottleneck Speeds
  - Queues

- Emerging (big data from connected devices)
  - OD data
  - Route choice

Calibration Criteria: Traditional Methods

- Traffic Analysis Tools Volume III (2004)
  - "FHWA criteria"
  - (Actually Wisconsin)
- Other guidelines
  - MULTITUDE

Criteria and Measures	Calibration Acceptance Targets
Hourly Flows, Model Versus Observed	
Individual Link Flows	
Within 15%, for 700 veh/h < Flow < 2700 veh/h	> 85% of cases
Within 100 veh/h, for Flow < 700 veh/h	> 85% of cases
Within 400 veh/h, for Flow > 2700 veh/h	> 85% of cases
Sum of All Link Flows	Within 5% of sum of all link counts
GEH Statistic < 5 for Individual Link Flows*	> 85% of cases
GEH Statistic for Sum of All Link Flows	GEH < 4 for sum of all link counts
Travel Times, Model Versus Observed	
Journey Times, Network	
Within 15% (or 1 min, if higher)	> 85% of cases
Visual Audits	
Individual Link Speeds	
Visually Acceptable Speed-Flow Relationship	To analyst's satisfaction
Bottlenecks	
Visually Acceptable Queuing	To analyst's satisfaction

Key Concerns with Previous FHWA Guidance

- Fully Integrate Time-Dynamic Representation of Congestion
- Require Better Representation of Recurrent and Non-Recurrent Conditions
- Remove Subjective Calibration Criteria
- Emphasize Accurate Bottleneck Modeling

New FHWA Guidance

- Select Performance Measures
  - Calibrate selectively, only for key performance measures.
  - Performance measures for calibration must have good observed data.
- Calibration Process (For each travel condition)
  1. Identification of representative days.
  2. Preparation of variation envelopes.
  3. Assessment of simulation results against four calibration criteria:
     - Control for Maximum Number of Outliers
     - Control for Minimum Number of Inliers
     - Bounded Average Error
     - Bounded Systematic Error

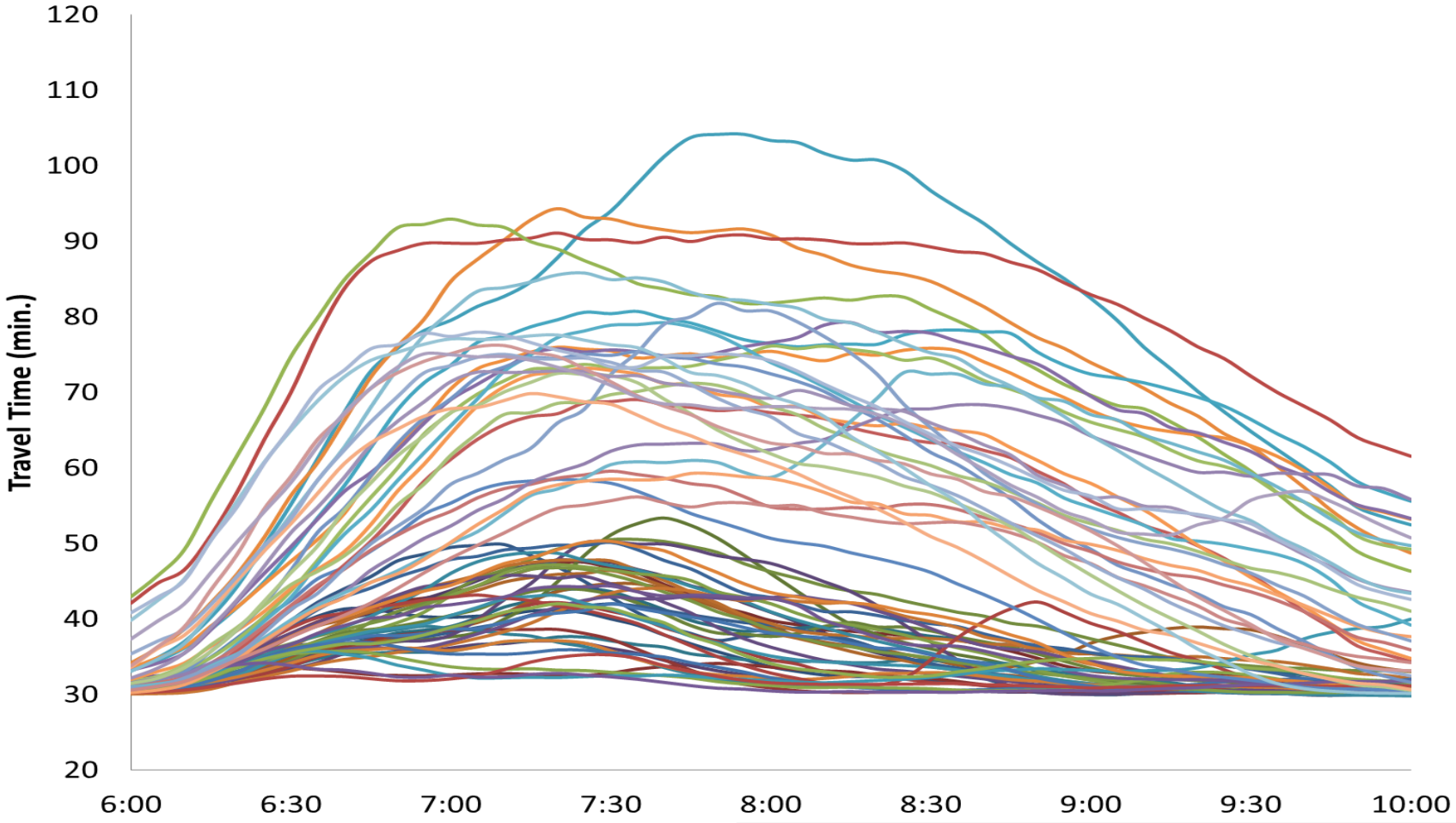
Source: FHWA Volume III Update Workshop

Caltrans

CAMBRIDGE SYSTEMATICS

Real Systems Have Good Days and Bad Days

2012 Southbound AM Peak Travel Times, I-405 Corridor

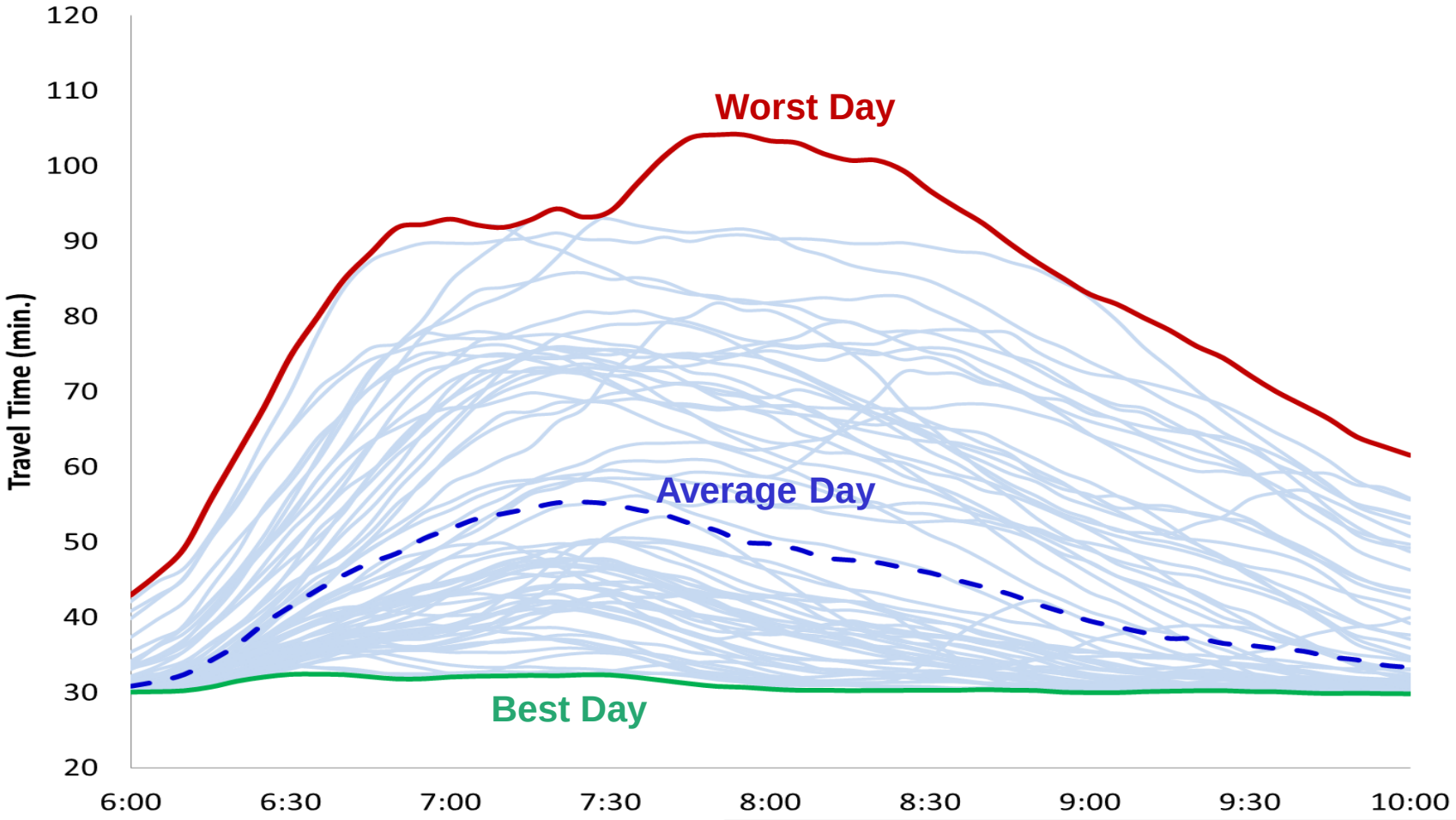


Source: FHWA & Noblis "TAT Volume III Guidelines for Microsimulation" presentation

Caltrans

CAMBRIDGE SYSTEMATICS

Even An Average Day Captures Only a Fraction of System Dynamics



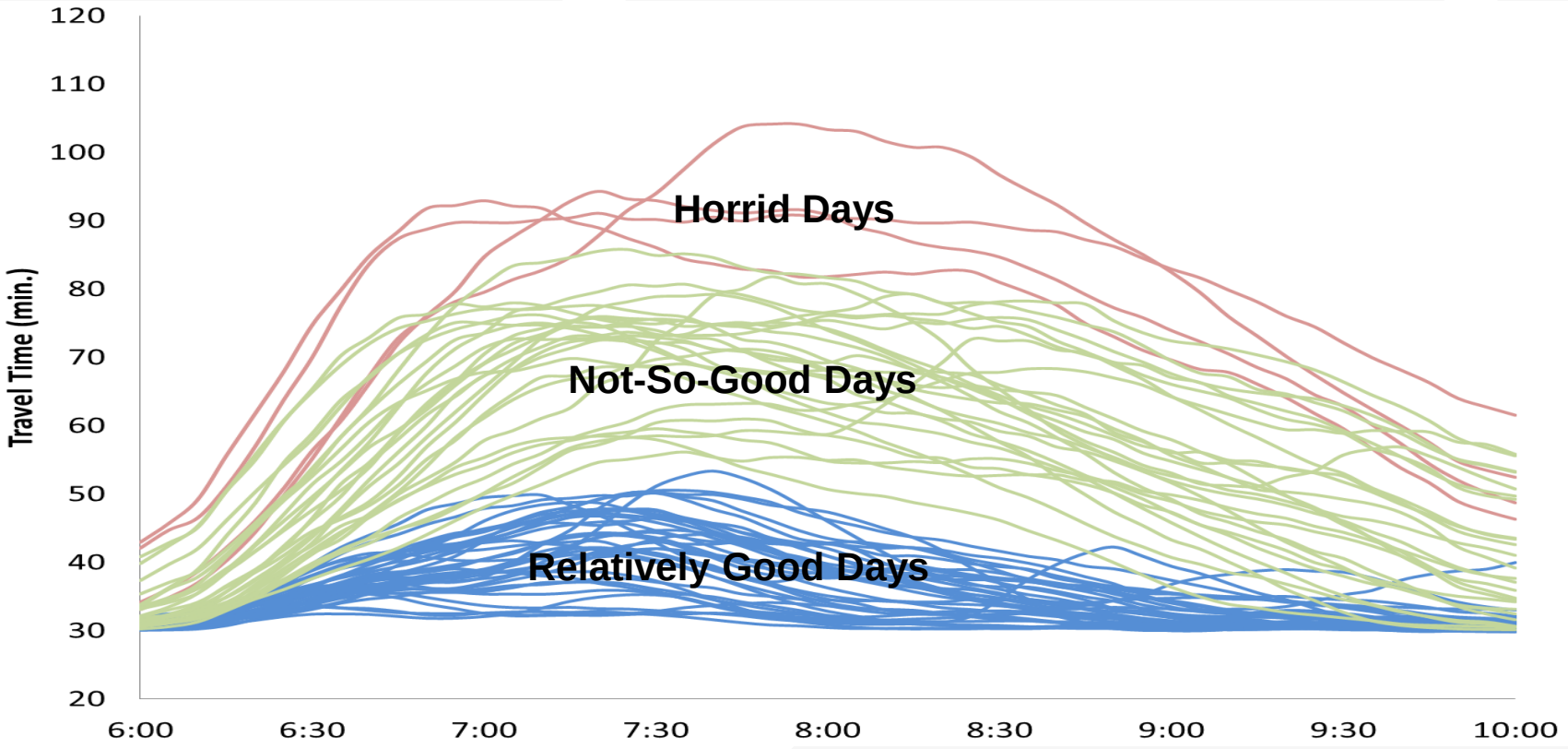
Source: FHWA & Noblis "TAT Volume III Guidelines for Microsimulation" presentation

Caltrans

CAMBRIDGE SYSTEMATICS

Use Cluster Analysis to Identify Distinct, Dissimilar Operational Conditions

Cluster Analysis Done for Many Attributes, Not Just One Measure… (But We Can Only Show So Much In 2-Dimensions)



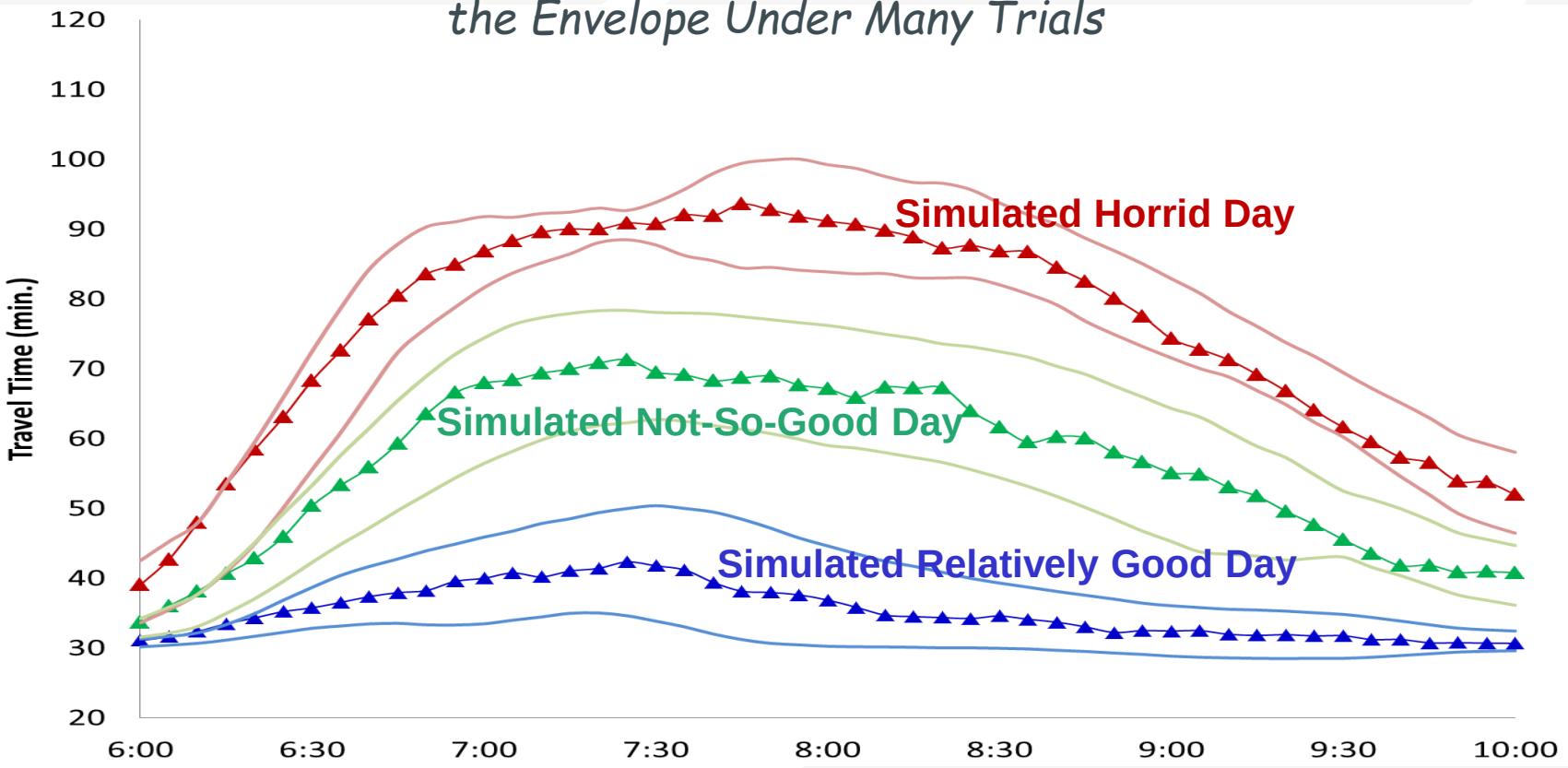
Source: FHWA & Noblis "TAT Volume III Guidelines for Microsimulation" presentation

Caltrans

CAMBRIDGE SYSTEMATICS

Simulations Are Calibrated to Lie Within the Statistical Envelope

We Perform Statistical Testing to Determine if the Simulated Day Falls in the Envelope Under Many Trials

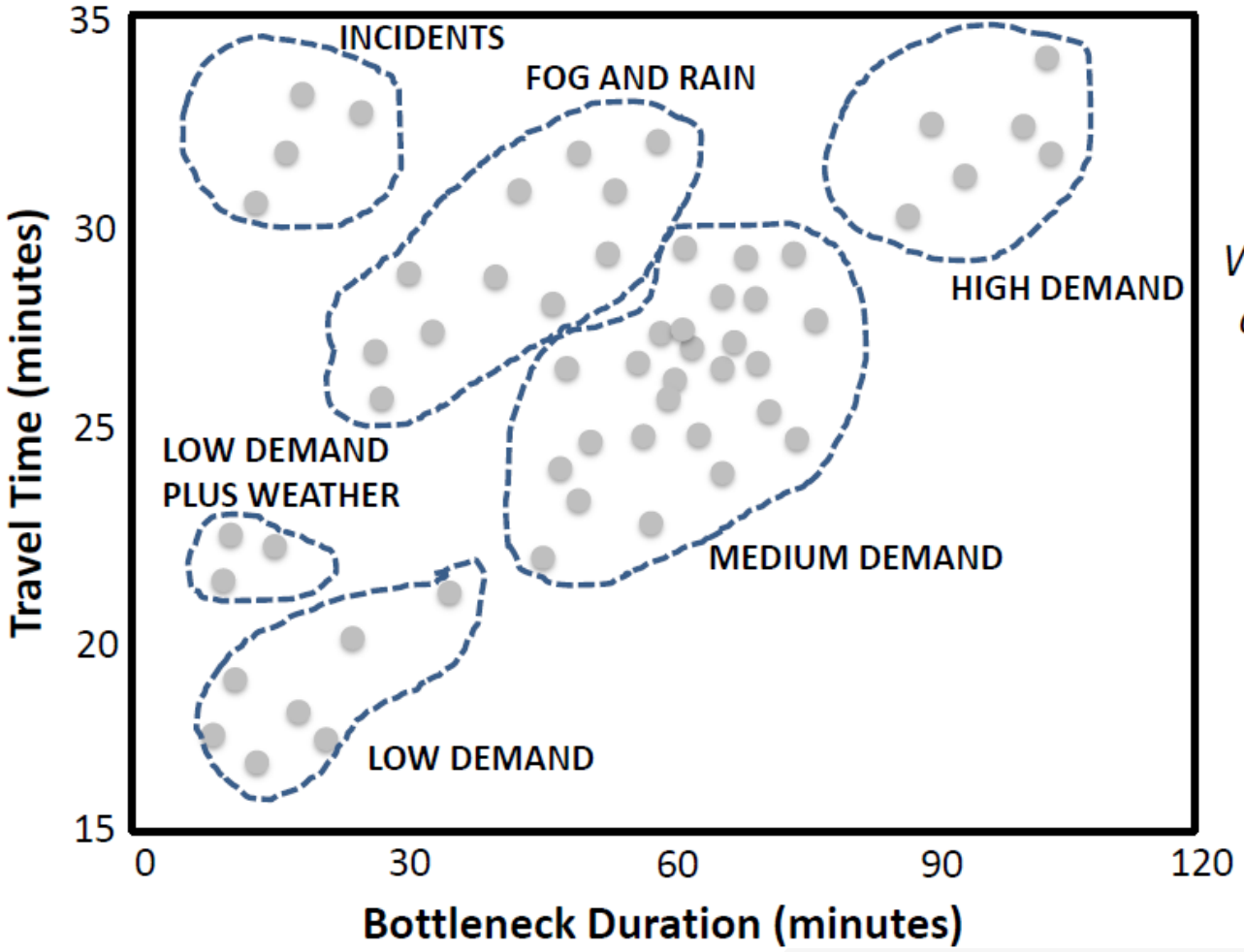


Source: FHWA & Noblis "TAT Volume III Guidelines for Microsimulation" presentation

Caltrans

CAMBRIDGE SYSTEMATICS

Develop Clusters of Conditions



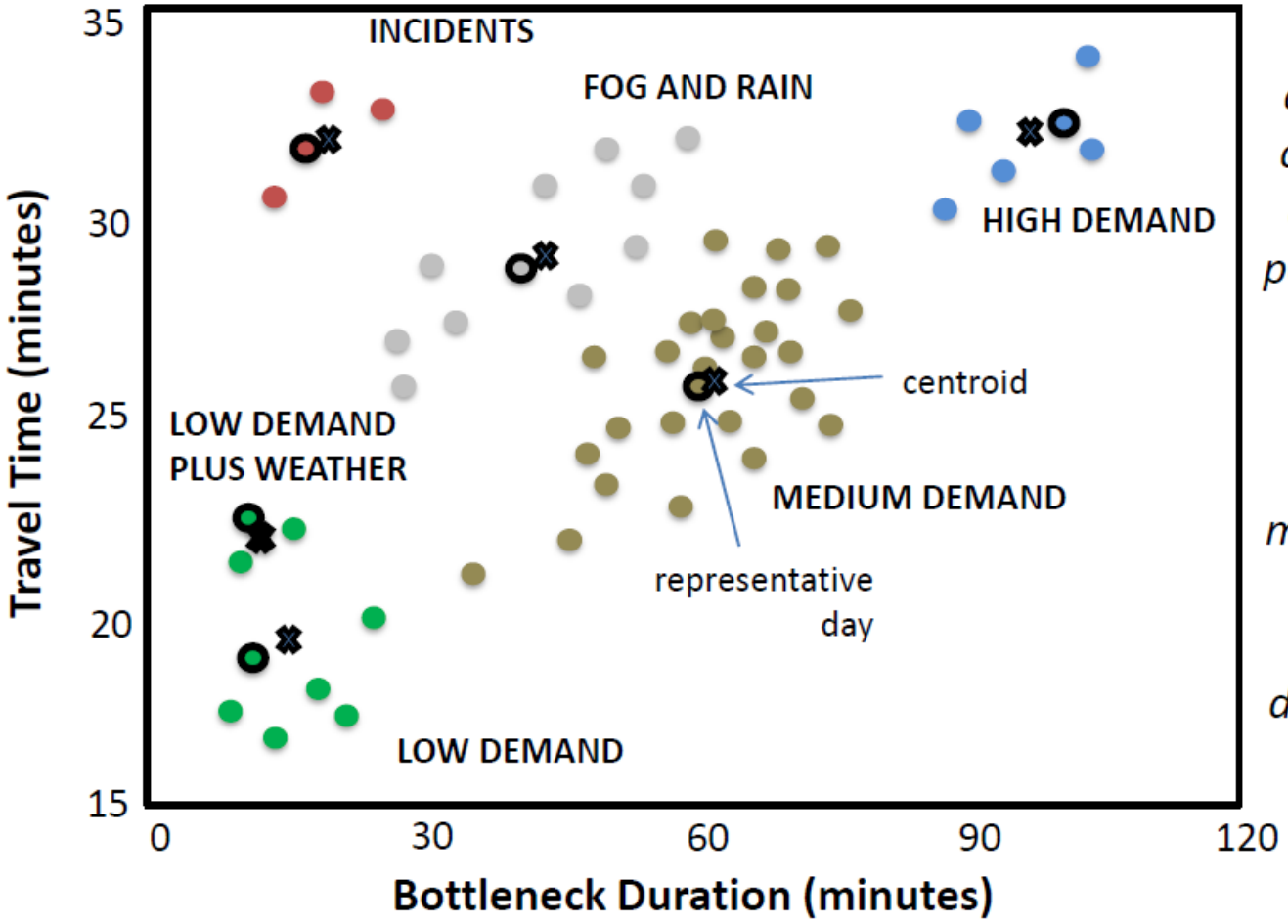
We group observed data using cluster analysis to identify distinct travel conditions.

Source: FHWA Volume III Update Workshop

Caltrans

CAMBRIDGE SYSTEMATICS

Select Representative Days



We calculate a centroid for each cluster that is the arithmetic mean performance in the cluster.

Then, we use relatively simple methods to find an actual day (i.e., representative day) that is closest to the centroid.

Source: FHWA Volume III Update Workshop

Caltrans

CAMBRIDGE SYSTEMATICS

San Diego ICM - AMS Scenarios

Summary of Best Matching Incident Results

#	Baseline Cluster by Direction and Time Period	Information from Baseline Cluster Analysis			Baseline Period	Post-Deployment Period			
		Days in Cluster	Total Cluster Day Impact (min.)	% of Total Analysis Time Period	Date	Date	DSS Event ID	DSS Plan Type Implemented	DSS Response ID
1	NB PM 4	25	63.25	24.0	10/12/12	7/7/14	639956	Ramps, Signals, ATIS	19536
2	SB AM 2	39	108.03	37.5	10/2/12	2/9/15	754666	Signals, ATIS	27929
3	NB PM 5	3	18.75	2.9	11/21/12	2/19/15	760369	Signals, ATIS	28292
4	SB AM 3	8	34.64	7.7	10/1/12	5/7/15	804238	Ramps, Signals, ATIS	30028
5	n/a, hypothetical	-	-	-	-	5/26/15		None. Managed lanes opened.	
6	SB AM 1	29	49.88	27.9	1/30/13	5/27/15	817649	Signals	30332
7	NB PM 2	8	23.36	7.7	1/15/13	6/9/15	842085	Ramps, Signals	30451
8	NB PM 1	17	41.82	16.3	1/28/13	6/16/15	845922	Ramps, Signals, ATIS	30617
9	NB PM 3b	36	99.72	34.6	1/30/13	5/5/14	853963	Ramps, Signals, ATIS	31039

Caltrans

CAMBRIDGE SYSTEMATICS

Calibration Review Preparation

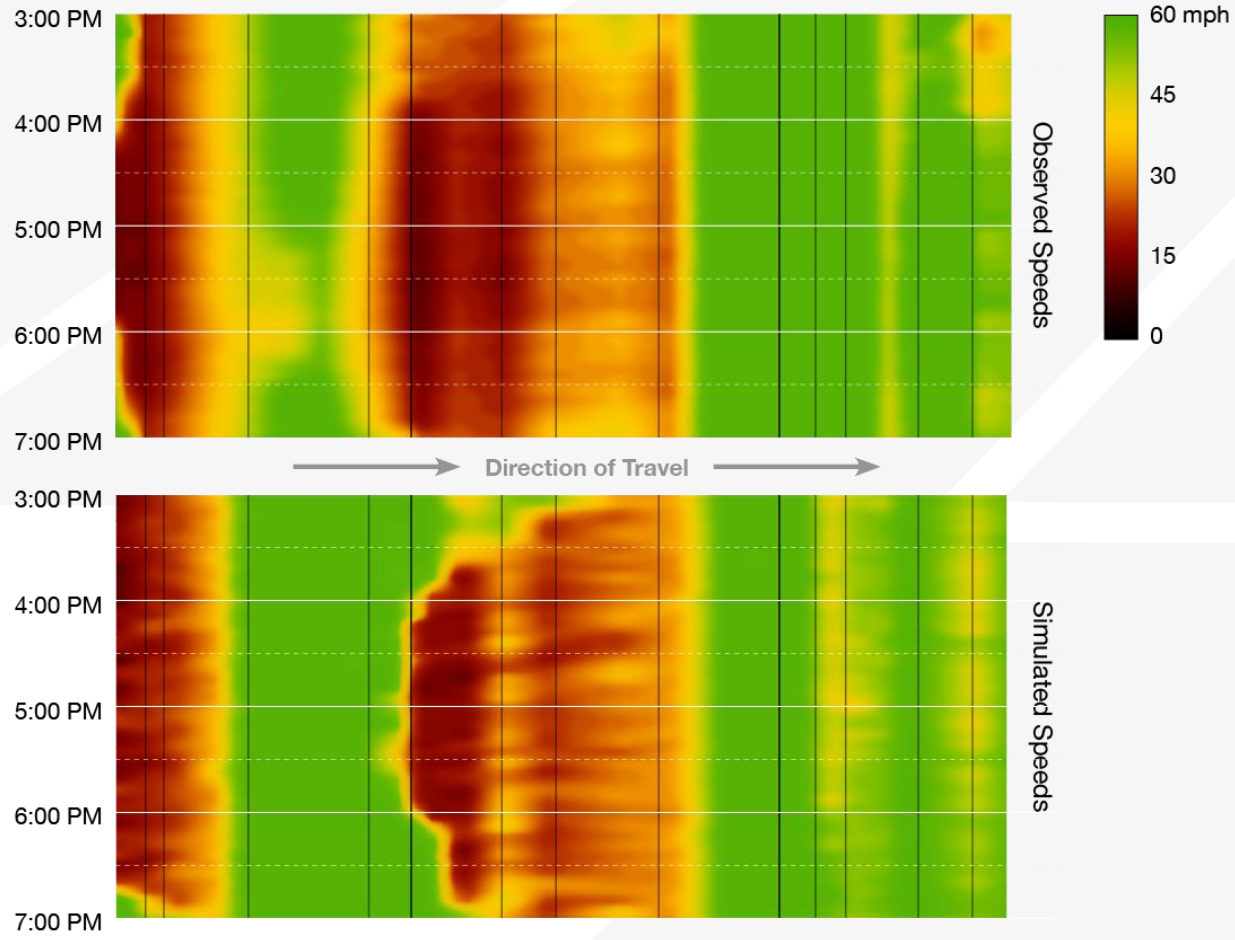
- Model files
  - Aimsun ANG model file
  - Input files (Path files, ODs, real data sets, etc.)
  - Output results (SQLite/Access database, etc.)
- Model Documentation
  - Development and Calibration reports
  - User's Manual
- Data Preparation
  - Data sources/processing
  - Real Data Sets (RDS)

Calibration Methods

- Traffic Network Calibration
- Route Choice Calibration
- Demand Calibration

- Ideally in that order
- Reality is an iterative process

Speed & Bottleneck Validation

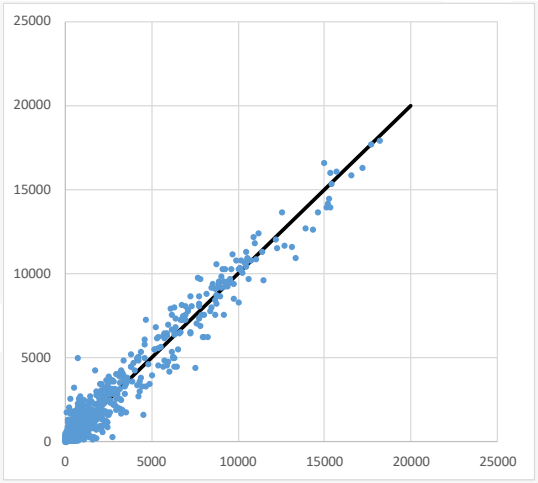


Caltrans

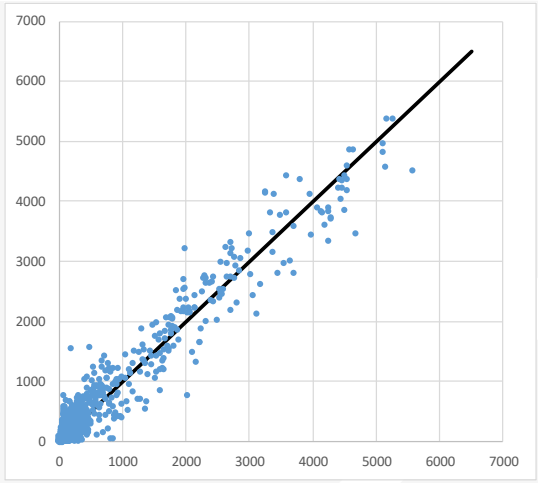
CAMBRIDGE SYSTEMATICS

Volume Validation Scatterplot

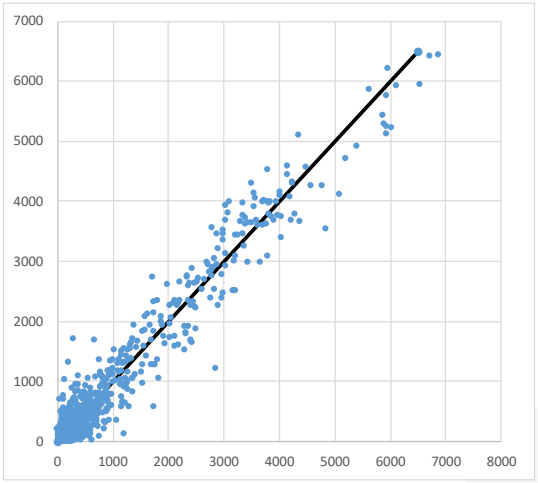
AM6-9 Period Flow - Entire DTA



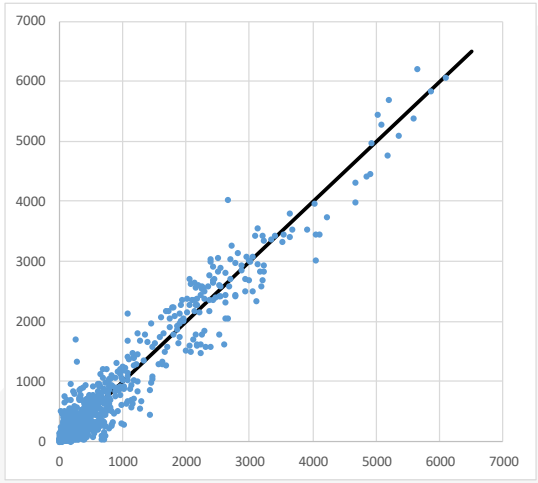
AM6-7 Hour Flow - Entire DTA



AM7-8 Hour Flow - Entire DTA



AM8-9 Hour Flow - Entire DTA



Caltrans

CAMBRIDGE SYSTEMATICS

Volume Validation

AM Peak Period - All Counts

Fac#	Facility	Counts	Sum Count	Sum Model	Average Count	Average Model	Avg Error
1	Freeways	148	1,235,701	1,223,770	8349	8269	-1%
2	Expressways	26	112,550	104,913	4329	4035	-7%
3	Princ.Art	130	203,504	191,701	1565	1475	-6%
5	Minor Art.	158	120,446	114,681	762	726	-5%
7	Collector	98	57,701	50,216	589	512	-13%
8	Ramp	273	220,404	260,226	807	953	18%
9	Fwy-Fwy Ramp	63	105,742	117,568	1678	1866	11%
>0	All Roads	896	2,056,048	2,063,075	2295	2303	0%

RSME% by Hour - All Counts

Facility	6-7 AM Hour	7-8 AM Hour	8-9 AM Hour	3 Hour AM Peak
Freeways	0.16	0.15	0.15	0.12
Expressways	0.35	0.20	0.27	0.22
Princ.Art	0.65	0.41	0.41	0.42
Minor Art.	1.01	0.86	0.83	0.83
Collector	0.77	0.77	0.83	0.72
Ramp	0.82	0.57	0.60	0.59
Fwy-Fwy Ramp	0.61	0.50	0.55	0.52
All Roads	0.38	0.33	0.34	0.30

AM Peak Period - Focus Area Counts

Fac#	Facility	Counts	Sum Count	Sum Model	Average Count	Average Model	Avg Error
1	Freeways	31	227,697	229,431	7345	7401	1%
2	Expressways	12	49,723	48,087	4144	4007	-3%
3	Princ.Art	17	18,822	12,563	1107	739	-33%
5	Minor Art.	30	25,709	19,232	857	641	-25%
7	Collector	31	18,873	12,116	609	391	-36%
8	Ramp	64	57,590	58,866	900	920	2%
9	Fwy-Fwy Ramp	20	43,868	49,873	2193	2494	14%
>0	All Roads	205	442,281	430,168	2157	2098	-3%

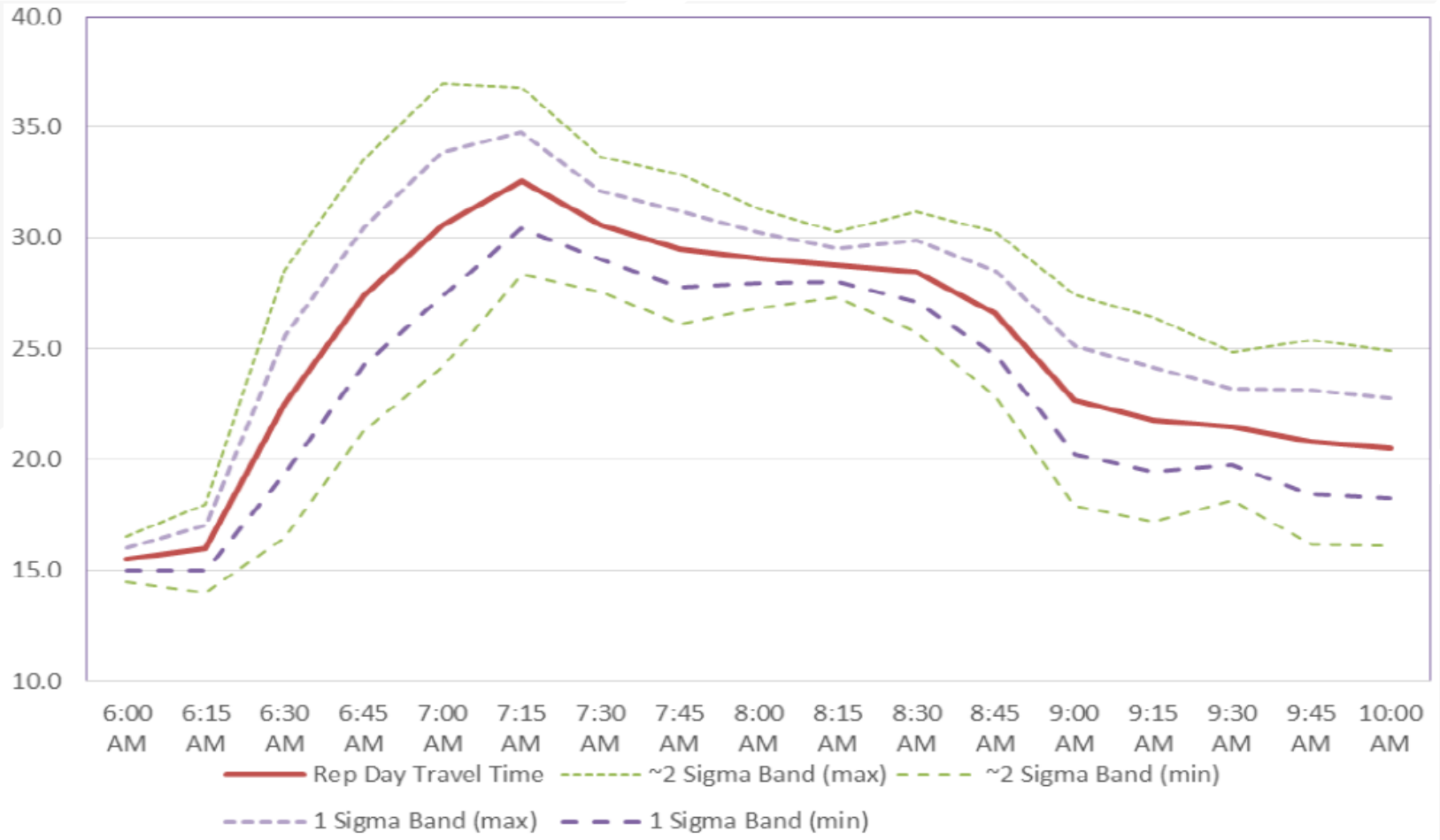
RSME% by Hour - Focus Area Counts

Facility	6-7 AM Hour	7-8 AM Hour	8-9 AM Hour	3 Hour AM Peak
Freeways	0.16	0.19	0.18	0.16
Expressways	0.40	0.17	0.31	0.23
Princ.Art	0.66	0.48	0.56	0.51
Minor Art.	0.87	0.81	0.78	0.76
Collector	0.89	0.73	0.72	0.69
Ramp	0.85	0.56	0.60	0.57
Fwy-Fwy Ramp	0.37	0.35	0.41	0.34
All Roads	0.40	0.35	0.38	0.33

Caltrans

CAMBRIDGE SYSTEMATICS

Time Variant Variations



Caltrans

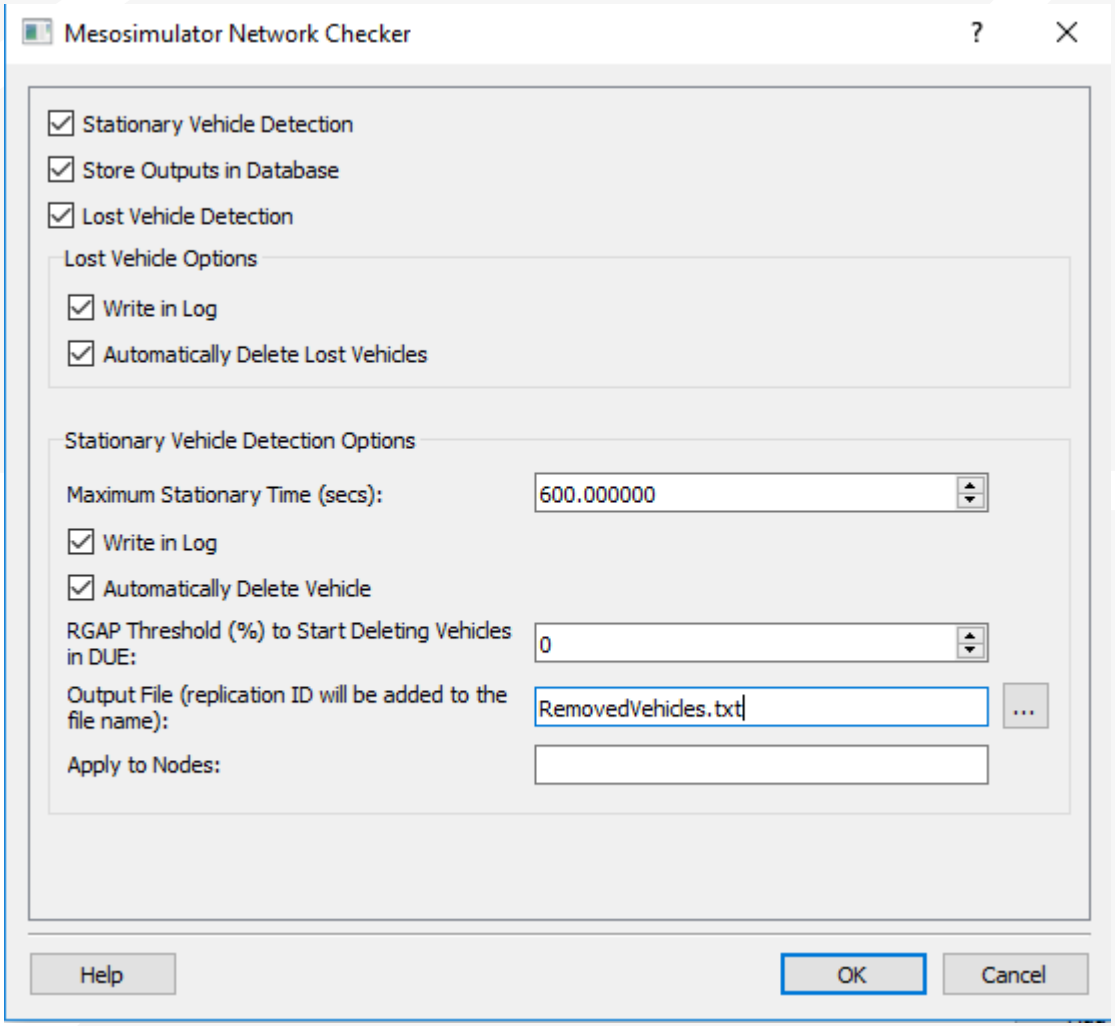
CAMBRIDGE SYSTEMATICS

Review of Calibration Results

- Test Simulation Runs
  - Replicate the existing calibration results
  - Review / identify problematic areas
    - Areas of poor fit
    - Low speeds
    - High densities
    - Low flow rate
    - Prolonged queuing
    - Unintuitive routes

Microsimulation Network Checker

- Are checker APIs being used?
- Are settings reasonable?
- Are outputs reasonable?



Calibration Parameter Checks

- Use of heavy local adjustments is not good calibration
  - Some are evitable
- Global and roadtype adjustment are preferred
  - Or rules based application of parameter changes
- Adjusting too many parameters is not good practice
  - Adjust key parameters the modeler has confidence in

Network Calibration Parameters

- Micro:
  - Simulation Step & Reaction Times
  - Lane change zone distances
  - Car following (aggressiveness, cooperation, braking intensity, imprudent lane change)
  - Two lane car following
  - Queue discharge
  - Side lane model parameters

Network Calibration Parameters

- Meso
  - Jam density (meso)
  - Reaction times and factors
  - Look ahead distance
  - Gap Acceptance

Route Choice Parameters

- Cost functions
- User costs
- Capacities and/or attractiveness
- Vehicle type restrictions
- DTA settings
- Value of time

Demand Calibration

- Initial OD source / estimation
- OD adjustment process
  - Static
  - Dynamic
- Temporal profiles

Additional Validations

- Ideally validate to a second set of data
  - A similar representative day
- Model stability tests
  - Test different random seeds
  - ‘Local link removal’ test
- Model reasonableness tests
  - Does the model respond in a logical way to a change?