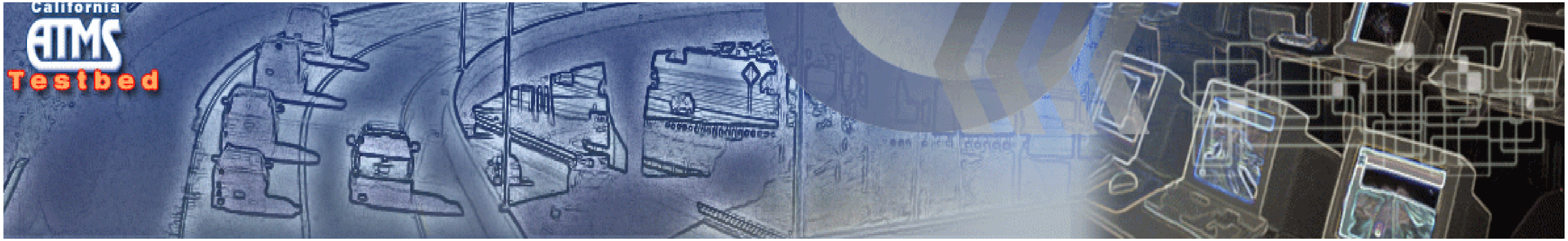

Using Micro-simulation to Evaluate Traffic Delay Reduction from Workzone Information Systems

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Introduction

- Work zone
  - Noticeable source of accidents and congestion
- AWIS:
  - Automated Workzone Information Systems
  - Components:
    - Sensors
    - Portable CMS
    - Central controller
  - Benefits:
    - Provide traffic information
    - Potentially
      - Improve safety
      - Enhance traffic system efficiency

Introduction (cont.)

- AWIS systems in market
  - ADAPTIR by Scientex Corporation
  - CHIPS by ASTI
  - Smart Zone by ADDCO Traffic Group
  - TIPS by PDP Associates
  - Quixote, Road Traffic Technology
  - Intelligent Zones, National Intelligent Traffic Systems (NITS)
- Evaluation studies
  - Most
    - System functionalities
    - Reliability
  - Few
    - Effectiveness
    - Delay saving

Study site and CHIPS system

- Site Location
  - City of Santa Clarita, 20 miles north of LA
  - On I-5: 4-lane freeway with the closure of one lane on the median side
  - Construction zone: 1.5 miles long
  - Parallel route: Old Road
  - Congestion: occurred in Holidays and Sundays
- CHIPS configuration
  - 3 traffic sensors
  - 3 message signs

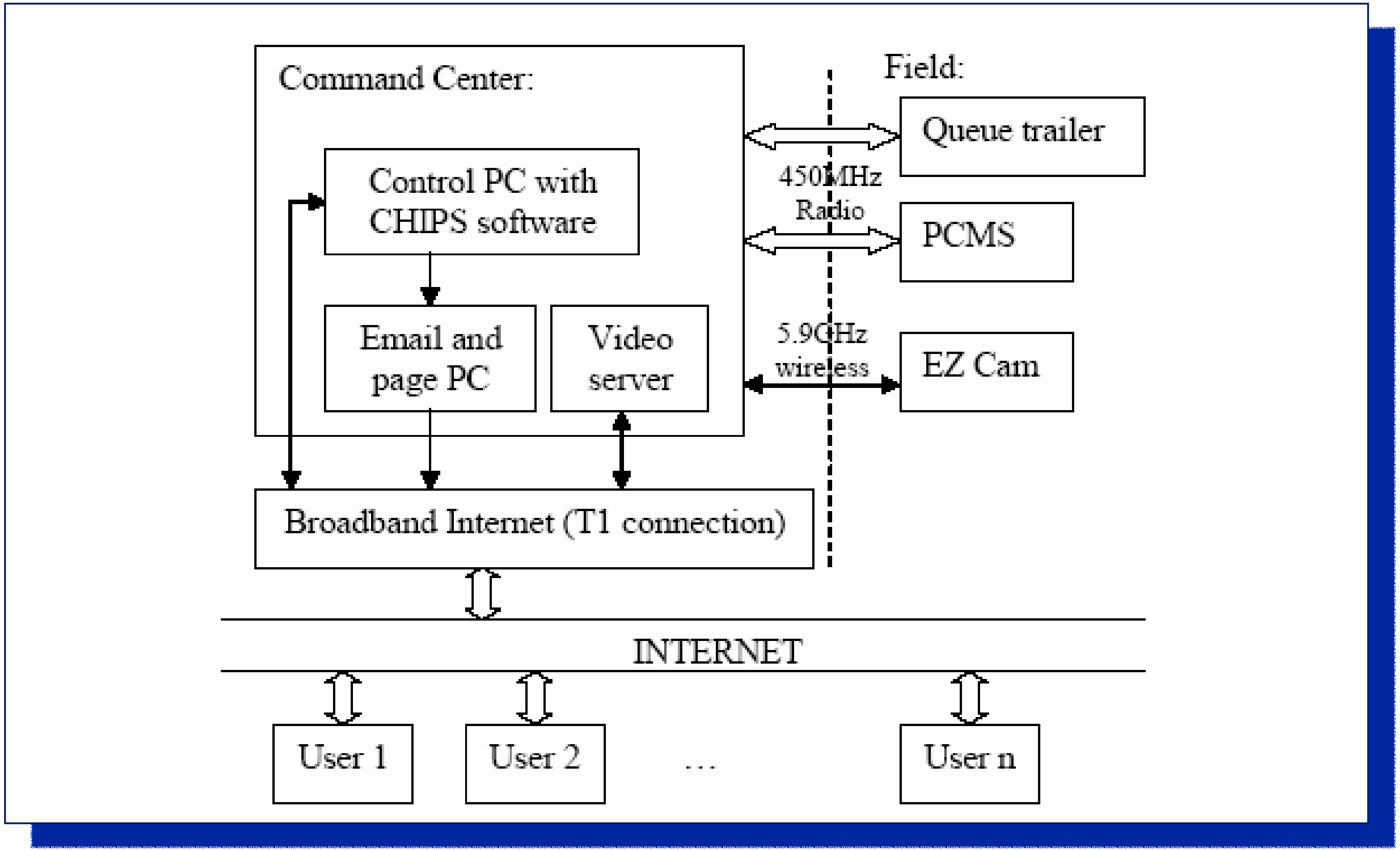
System Setup

Scenario	Queue Detector			CMS Combo Message				
	RTMS-1	RTMS-2	RTMS-3	PCMS-1	PCMS-2	PCMS-3	PCMS-4	PCMS-5
SBS01	F	F	F	CMB01	CMB01	CMB01		
SBS02	T	F	F	CMB02	CMB03	CMB05		
SBS03	T	T	F	CMB06	CMB07	CMB03	CMB10	
SBS04	T	T	T	CMB06	CMB07	CMB08	CMB09	CMB11

T = Queue being detected, F = No queue being detected

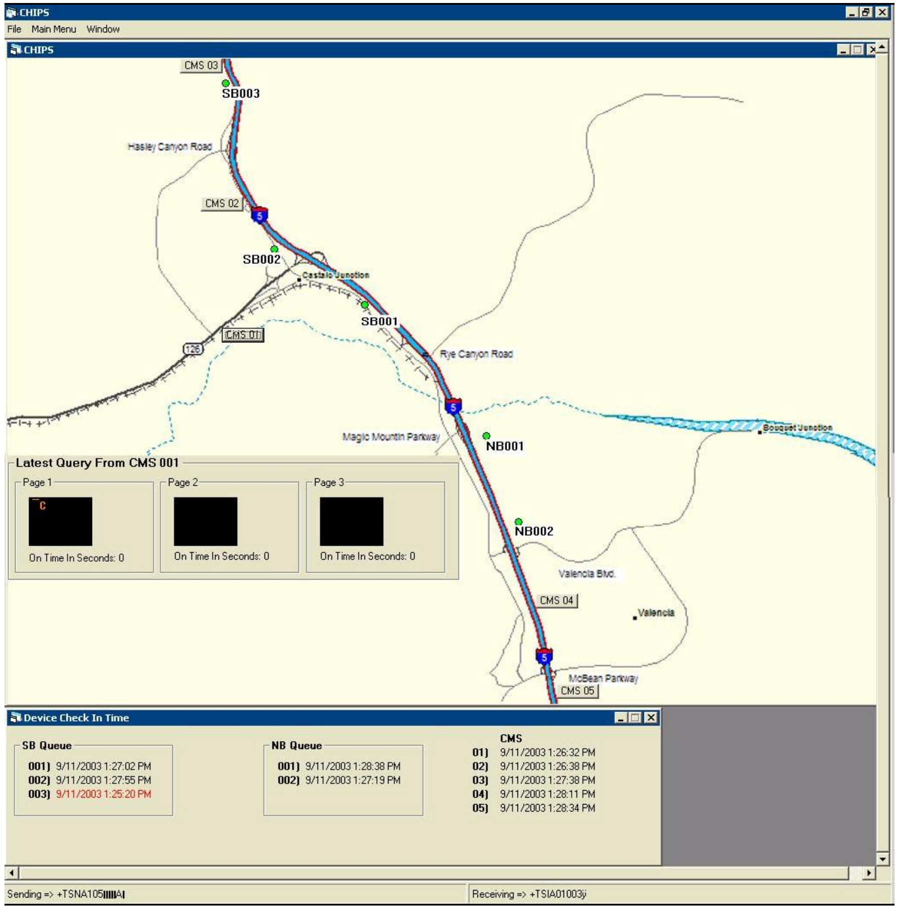
- **CMB06 : SOUTH 5/TRAFFIC/JAMMED, AUTOS/USE NEXT/EXIT**
- **CMB07 : JAMMED/TO MAGIC/MOUNTAIN, EXPECT/10 MIN/DELAY**
- **CMB08 : JAMMED/TO MAGIC/MOUNTAIN, EXPECT/15 MIN/DELAY**
- **CMB09 : JAMMED TO MAGIC MTN, AVOID DELAY USE NEXT EXIT**
- **CMB11: SOUTH 5 ALTERNAT ROUTE, AUTOS USE NEXT 2 EXITS**

CHIPS System Structure



California ATMS Testbed

CHIPS



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ITS

Caltrans pilot evaluation study

- Evaluation aspects
  - Functionality
  - Reliability
  - Effectiveness
    - Safety
    - Diversion
    - Drivers' acceptance
  - Cost and benefits
- Method
  - Field operational test for the first three aspects

Purpose of this study

- Traffic delay reduction because of AWIS
  - Quantify delay reduction
  - To justify the benefits of AWIS
- Methods?
  - Field operational test
    - Uncontrolled factors, e.g. incidents, variations of demands
  - Traffic analysis tools
    - Microscopic simulation
      - Model vehicles in fine details
- When to select micro-simulation?
  - ITS strategy
  - System wide congestion that changes dynamically, etc
  - Diversion
- AWIS planning, last slice

Microscopic simulation introduction

- **Microscopic simulation**
  - a software tool to model traffic system, including roads, drivers, and vehicles, in fine details.
  - models: AIMSUN, CORSIM, MITSIM, PARAMICS, TransModeler, VISSIM…
- **Why simulation?**
  - Can capture detailed traffic flow dynamics
  - Can be calibrated to reproduce real world scenarios
  - Can provide a visualization tool to evaluate traffic management and operational strategies
  - answer "what if" questions

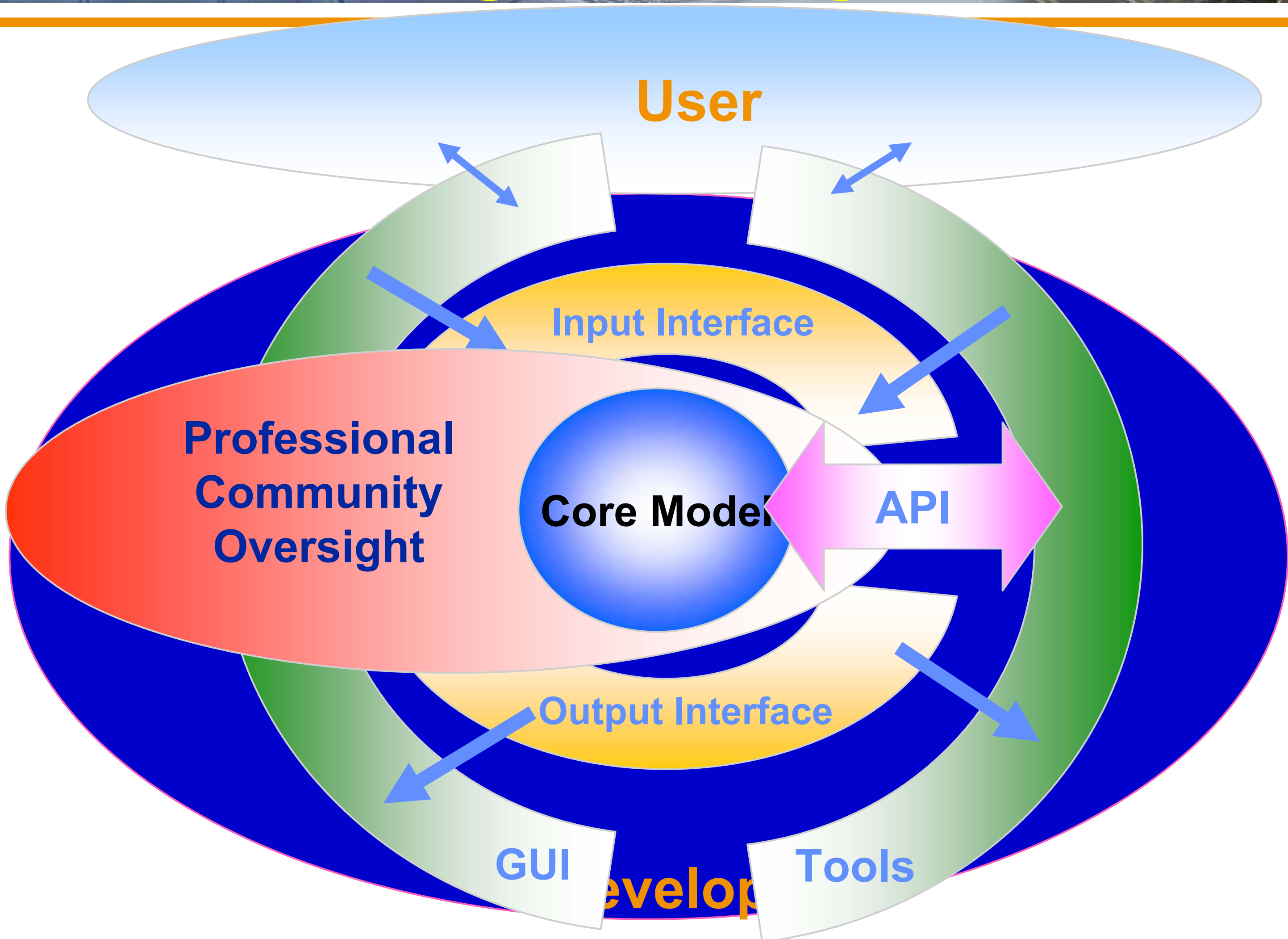
Applications

- Traffic control
  - Signal
  - Ramp metering
- ITS evaluation
- Policy investigation
- Operational improvement
- Corridor management planning
- Construction management
- TMC operator training

Paramics model

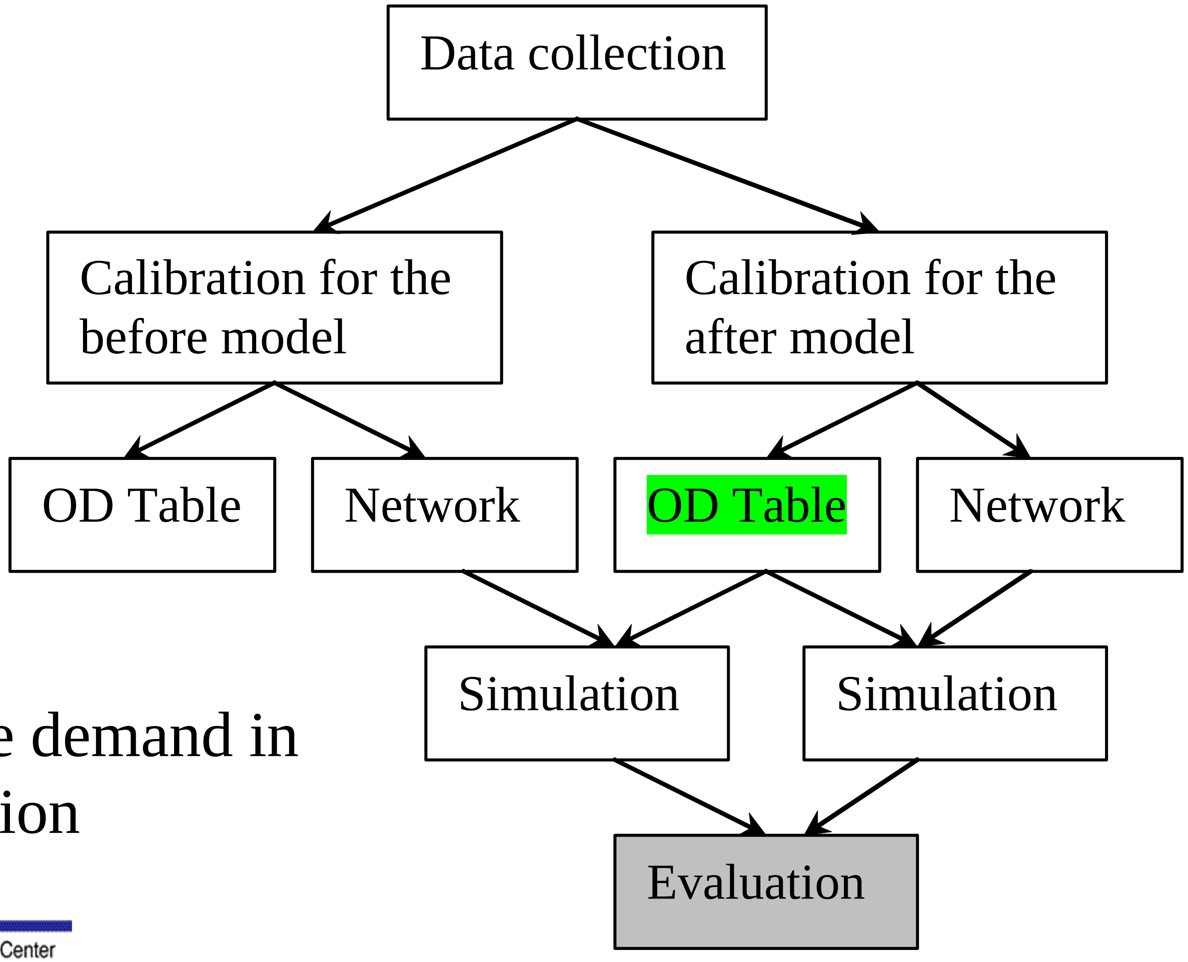
- PARAMICS: PARAllel MICroscopic Simulation
  - a suite of software tools for micro traffic simulation, including:
    - Modeller, Analyzer, Processor, Estimator, Programmer
  - developer: Quadstone, Scotland
- Features
  - large network simulation capability
  - modeling the emerging ITS infrastructures
  - OD estimation tool
  - Application Programming Interfaces (API)
    - access core models of the micro-simulator
    - customize and extend many features of Paramics
    - model complex ITS strategies
    - complement missing functionalities of the current model

How to model ITS: Application Programming Interfaces



Methodology

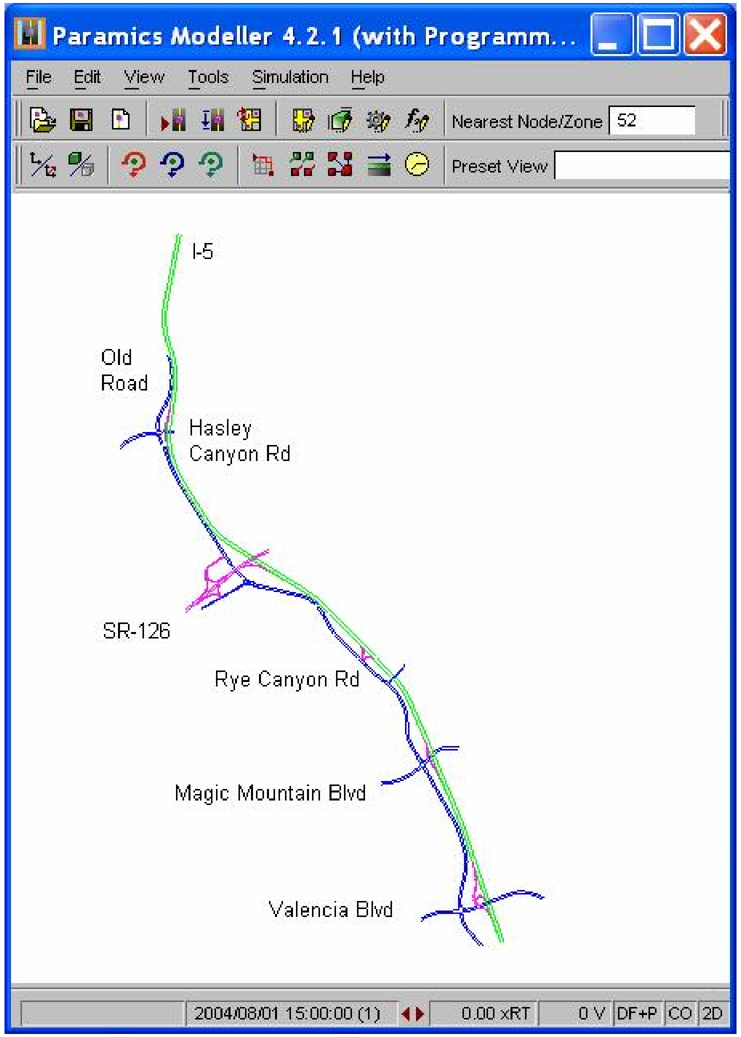
- Delay saving after the use of AWIS: Before-after study



* Use same demand in the evaluation

Building network

- **Based on**
  - **aerial photos**
  - **geometry maps**
- **inputs:**
  - **roadway network,**
  - **traffic detection,**
  - **traffic control,**
  - **vehicle data,**
  - **driving behavior**
  - **route choice**
  - **traffic analysis zones**



Calibration

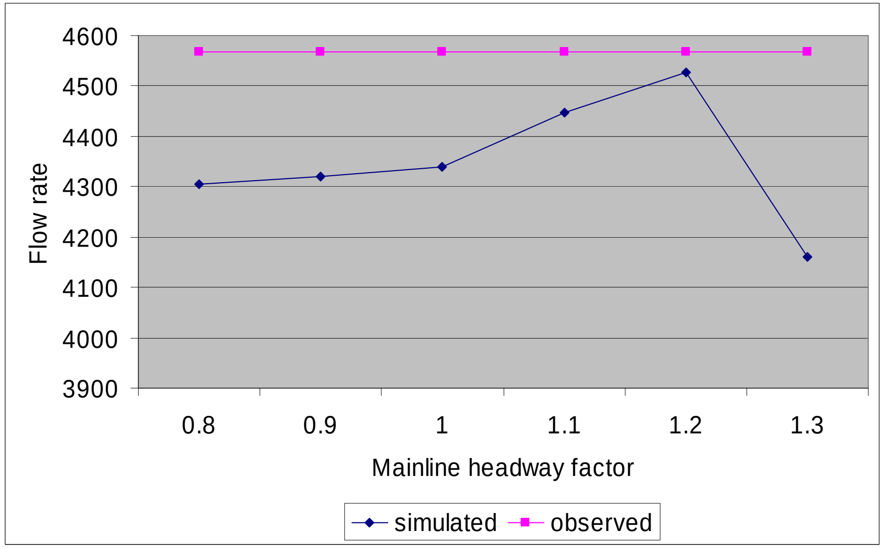
- Calibration:
  - Adjust model parameters to obtain a reasonable correspondence between the model and observed data
  - Time-consuming, tedious
  - Models need to be calibrated for the specific network and the intended applications
- Methods
  - Trail-and-error method
  - Gradient- based and GA
- Proposed 3-step method:
  - Capacity calibration
    - One major bottleneck, i.e. lane drop (4->3 lanes)
  - Simultaneous estimation of OD matrix and route choice
  - Network performance calibration & validation

Data collection

- Before: May 18th, 2003
- After: Sep 1st, 2003 (Labor Day)
- Link flows:
  - 3 on-ramps and off-ramps
  - Several link/cordon flows
  - RTMS-1 and RTMS-3
  - Loop detector station at Hasley Canyon Rd
- Probe data
  - Two routes:
    - Mainline and the Old road
  - GPS-equipped vehicles

Capacity Calibration

- Calibrate capacities at major bottlenecks
- Three parameters:
  - Mean headway
  - Drivers' reaction time
  - Headway factor for mainline links



- Trial-and-error method
  - Choose several parameter combinations
  - Check their performances

- Results:
  - Mean headway = 0.9
  - Drivers' reaction time = 0.8
  - ML Headway factors
    - Before model: 1.0
    - After model: 1.2

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Simultaneous estimation of OD and routing parameters

- **Connected and affected each other**
- **Formulated as**

$$Min \quad L(q^{rs},\theta) = \sum_a \left[x_a^{sim} - x_a^{obs} \right]^2$$

$$x_a^{sim} = \sum_{rs} q^{rs} \cdot \left(\sum_k P_k^{rs}(\theta) \cdot \delta_{ak}^{rs} \right)$$

s.t.

$$q^{rs} \geq 0$$

- **Solution algorithm:**
  - Heuristic search method

Solution algorithm

- (1) Choose n routing parameters $\theta 1$ *to* θn
- (2) Let i = 1, set $\theta = \theta i$.
- (3) Use PARAMICS OD estimator to estimate OD table Γ i.

$$Min\quad L(\theta)=\frac{1}{N}\sum_{a=1}^{N}GEH(x_a)=\frac{1}{N}\sum_{a=1}^{N}(\sqrt{\frac{(x_a^{sim}(\theta)-x_a^{obs})^2}{x_a^{sim}(\theta)+x_a^{obs}}})$$

- (4) Use PARAMICS Modeler to run simulation with OD table Γ i and routing parameter θ *i*.

$$MAPE(i)=\frac{100}{N+M}\left\{\sum_{a=1}^{N}|(x_a^{obs}-x_a^{sim})/x_a^{obs}|+\sum_{b=1}^{M}|(p_b^{obs}-p_b^{sim})/p_b^{obs}|\right\}$$

- (5) If *i* < *n*, set *i* = *i*+1 and go to step 2; otherwise go to Step 6.
- (6) Obtain Γ_μ and θ_μ, whose combination yields the best calibrated OD table and routing parameter vector

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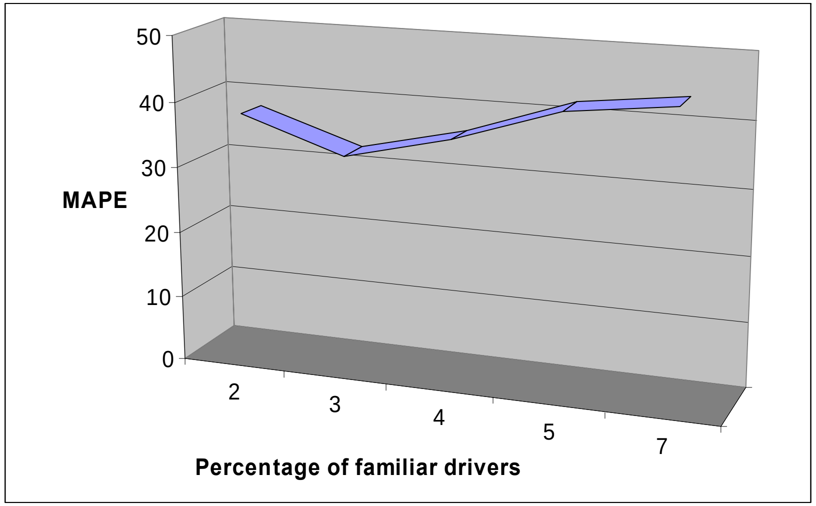
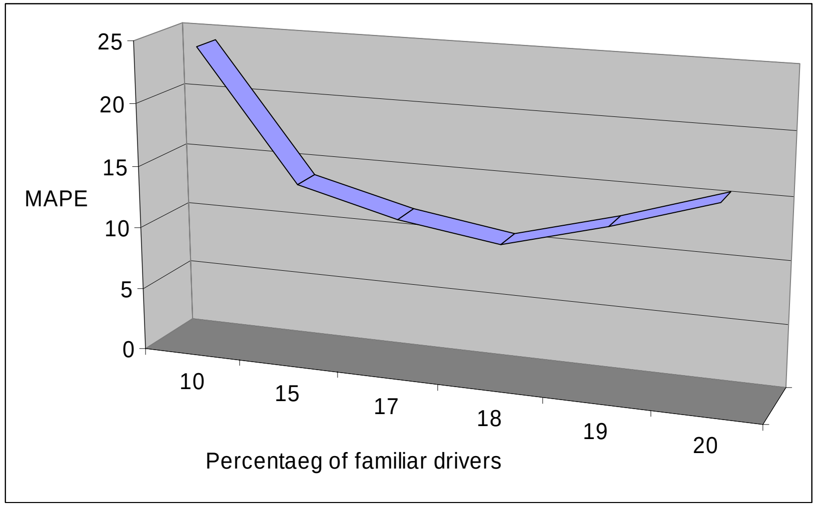
OD and routing calibration

- Route choice model
  - Dynamic feedback assignment
  - Parameters:
    - Feedback cycle (set to 1 min to simply the problem),
    - Compliance rate
- Routing parameter θ in solution algorithm:
    - 1 parameter: compliance rate
- Inputs to OD estimator:
  - Reference OD table from planning model
  - 6 cordon flows
  - 5 link flows
- Simulation period: 3-5 pm
  - Warm-up: 3-4 pm

OD and routing calibration results

- **Calibrated compliance rate**
  - **Before model: 3%**
  - **After model: 18%**
- **Calibrated OD table:**
  - **Before model: mean GEH = 4.51; After model: mean GEH = 2.46**





Calibrated "after" model

	Location/Route	Observed	Simulated	APE (%)
Traffic count (veh/hour)	main_Hasley	3890	3867	0.59
	main_Rye Canyon	4568	4526	0.92
	off_Hasley	764	813	6.41
	on_SR-126	480	477	0.63
	on_Magic Mountain	713	674	5.47
Travel Time (min)	Mainline	13	13.1	0.48
	Old Road	11	11.1	0.92
MAPE				2.20

Evaluation

- **Run two simulation models:**
  - **Demand: after OD table**
  - **Before:**
    - **Calibrated before network, 3% compliance rate**
  - **After:**
    - **Calibrated after network, 18% compliance rate**
- **Number of simulation runs**
  - **Median run with respect to VHT**

$$N = (t_{\alpha/2} \cdot \frac{\delta}{\mu \cdot \varepsilon})^2$$

Evaluation results

	Without AWIS	With AWIS	Reduction	Reduction Percentage
Total Mainline Delay (hr)	1133.4	672.3	461.1	40.7%
Average Mainline Travel Time (min)	21.8	13.5	8.3	38.1%

	Without AWIS	With AWIS	Increase	Percentage
Total Delay on the Old Road (hr)	7.6	29.9	22.3	293.2%
Average Travel Time on the Old Road (min)	9.1	11.1	2.0	22.0%

Evaluation results (cont.)

	Without AWIS	With AWIS	Reduction	Percentage
VHT (Vehicle Hours Traveled)	2266.7	1434.7	832.1	36.7%
VMT (Vehicle Miles Traveled)	27357.6	31350.9	-3993.3	-14.6%
Average Speed (mph) = VMT/VHT	12.1	21.9	-9.8	-81.0%

	Without AWIS	With AWIS	Increase
Diversion Volume on Hasley off-ramp	145	369	224
Diversion Rate on Hasley off-ramp	3.5%	7.8%	4.3%

Conclusion

- Contribution
  - Introduction of a microscopic simulation method to evaluate traffic delay reduction from AWIS
    - Calibration of two simulation models
  - Calibration
    - a simultaneous estimation of OD table and routing parameters
- Evaluation shows AWIS can effectively :
  - Reduce traffic delay
  - Improve overall performance of the traffic system
- Outreach: publications
  - TRB, TRR

Use of the method for AWIS planning

- Develop a simulation model for the existing network
  - Baseline OD table
- Build simulation model for the WZ case
  - Capacity calibration (i.e. calibrate mainline headway factor)
    - Use HCM capacity value as target value
  - Routing: compliance rate α
    - Network geometry
    - Percentage of familiar drivers
- Build simulation model for the WZ+AWIS case
  - Capacity calibration
    - Use an expected capacity value, or
    - Apply 1.2 headway factor derived from this study
  - Routing: compliance rate β could vary (maximum 20%)
    - Network geometry
    - Traffic information
- Simulation for two scenarios:
  - (1) WZ model with Baseline OD table and routing α
  - (2) WZ+AWIS model with Baseline OD table and routing β
- Delay/benefit calculation

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Some technical information about micro-simulation:
http://www.clr-analytics.com