PATH Traffic Operations Research Program

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Caltrans/DRI Research Connection
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Agenda

Overview
• PATH traffic operations research
• PATH Task Orders 5000/6000 Series

Integrated Corridor Management (ICM)
• Program Objectives
• California Sites

Managed (HOV) Lanes
• Completed PATH Studies
• Related Studies
• Ongoing Studies

Active Traffic Management
Traffic Research Program: Overview

Modeling and Operating Strategies
- Modeling tools and simulation
- Operating Strategies
- Field Operational Tests

Surveillance and Data Processing
- Detector technologies
- Data processing and verification
- Performance measurement
I. Traffic Surveillance

- Existing infrastructure (single/double loop detectors)
- Existing Infrastructure (advanced loop detectors, IST)
- New detector technologies
  - Video image processing
  - Laser scanners
  - Probe vehicles
  - MeMS

II. Data Processing/Analysis/Performance Measurement

- Traffic flow fundamentals
- Performance measures estimation
- Congestion causes and impacts
- Incident impacts

- Berkeley Highway Lab (BHL)
- I-405 Test Bed

- Freeway Performance Measurement System (PeMS)
Technologies for Traffic Surveillance

- TO5301&TO5328-I: DOTBOT sensors
- TO5302: Extracting More Information from Existing Detectors
- TO 5303: Detector Diagnostics/BHL TestBed
- TO5304: Anonymous Vehicle Tracking
- TO5314: IST-222 Loop Detectors
- TO5327: Data fusion I-405 Test Bed
- TO5606: Development and Testing of a Laser Detector
- TO6300: Maintaining the Health of Caltrans Loop Detector System
- TO6302: Evaluation of Portable Automated Data Collection Tech
- TO6203: Bicycle Detection & Operational Concept at Signals
- TO6327: Systems Engng & Management for Loop Fault Detection
- TO6328: Optimal Sensor Requirements
- Video Image Processing/BHL (NGSIM FHWA)
Data Processing/Performance Measurement

- TO5306: Freeway Productivity Decline
- TO5307: Tool To Evaluate ITS Impacts on Safety
- TO5309/6309: New Approach to Bottleneck Capacity Analysis
- TO5315: Evaluation of Incorporating Hybrid Veh Use of HOV Lanes
- TO5319: Evaluation of PeMS to Improve Congestion Monitoring
- TO5320: Data Sensitivity Analysis
- TO5321: Finding the True Effect of Non-Recurrent Congestion
- TO6301: What is the Excess Capacity of HOV Lanes
- TO6304: Weave Analysis Evaluation and Refinement
- TO 5326/6326: Determining the Effectiveness of HOV Lanes
- PeMS Update
III. Modeling
- Enhancements to traffic simulation tools
  - New algorithms for congested traffic
  - Procedures for calibration/validation of simulation models
  - Origin-Destination estimation

IV. Operational Strategies
- Ramp metering
- Transit priority at traffic signals
- Incident management
- Traveler Information via CMS

NGSIM
FHWA Guidelines for Application of Simulation Models

ICM: Analysis, Modeling & Simulation

ICM Sites: I-880, I-15

CA Testbeds: I-210, I-8, El Camino Real
Modeling and Simulation

- TO5300: Integrated Construction Zone Traffic Management
- TO5305: Ramp Metering & Paramics
- TO5308: Calibration Tools for Simulation
- TO5310: Simulation for Large Networks
- TO5311: Hardware in the Loop Simulation
- TO5325: Development of a Simulation & Optimization Tool
- TO5330: A Hybrid Model of Traffic Flow
- TO5502: Path Flow Estimation for O-D Tables
- TO6611/6614: Tools for Operations Planning (TOPL)
- Oversaturated Freeway Flow (NGSIM Simulation, FHWA)
- Analysis/ Modeling/Simulation for ICM (FHWA)
Operating Strategies

- TO5312: On-Ramp Metering Experiments
- TO5313: CARTESIUS Field Test
- TO5316: Evaluation of Bay Area Incident Response (BAIRS)
- TO5322/6322: Adaptive Signal Control
- TO5323/6323: Optimal Control of Corridor Networks
- TO5324/6324: Cartesius and CTNET
- TO5329: Optimal Strategies for a Highway System
- TO5503: Adaptive Ramp Metering Strategies
- TO6303: Optimal Use of CMS for Displaying Travel Times
- TO6329: Ramp Metering Tools & Field Test
- TO6331: Evaluation of Ramp Metering in District 3
- TO6612: Integrated Corridor Management I-880, Bay Area (D4)
- TO6613/6333: Integrated Corridor Management I-15, San Diego (D11)
- TO6224: Mobility Applications for VII
- TO6115: California Networked Traveler-Safer Trip 21
I-210 West in Pasadena, CA (Los Angeles– D7)

14 miles long
- 20 controlled on-ramps
- 1 uncontrolled freeway connector (I-605N)
- 18 off-ramps

Heavy Congestion in commute hours
Queue Override failed to limit the queue within the limits

large variation in queue length
Ramp Metering: I-210W Results

Existing

Proposed

Improvements:
- 6% Travel Time
- 16% Delay Reduction
Demonstrate how operations strategies and ITS technologies can be used to efficiently and proactively manage the movement of people and goods in major transportation corridors through integration of the management of all the networks in a corridor.

Develop a toolbox of operational policies, operational strategies, integration requirements and methods, and analysis tools needed to implement effective ICM Systems.
I-880 ICM Corridor, Bay Area (1)

**Freeway**
- 38 miles
- 39 lane-miles of HOV lanes
- Trucks: 11% of AADT

**Arterials**
- 250 traffic signals
- 12 major connectors to I-880

**Transit**
- 700 busses, 109 routes
- Transit signal priority
- BRT

**BART**
- 20 miles of track, 3 lines
- 12 stations
- 150,000 riders
Existing Conditions

- AADT: 120,000 to 275,000 vpd
- 10,000 veh-hrs of daily delay
- At least 30% of delay is non-recurrent
- 10 collisions per day
- 100 incidents per day
Gaps & Needs

1. Insufficient information sharing among different ITS systems
2. Gaps in traveler information for influencing travelers’ decisions and choices
3. Gaps in collaboration for operations and incident responses
4. Gaps in collaboration for event planning
I-880 ICM Strategies (1)

I. Influence Travelers’ Decisions; Traveler Information Strategies

- **Strategy 1**: A corridor-based multimodal ATIS system that supports travelers pre-trip planning
- **Strategy 2**: Promote route shifts between roadways via en-route traveler information devices
- **Strategy 3**: Promote modal shifts from roadways to transit via en-route traveler information devices
- **Strategy 4**: Promote shifts between transit facilities via en-route traveler information devices

II. Facilitate Collaboration Among Agencies

- **Strategy 5**: Coordinated operation between freeways and arterial traffic signals
- **Strategy 6**: Enhance arterial signal timing with advance information about special events at Oakland Coliseum
- **Strategy 7**: TSP for AC Transit buses
II. Facilitate Collaboration Among Agencies (cont.)

- **Strategy 8**: AC Transit adjusts bus operations based on real-time information about highway incidents and special events
- **Strategy 9**: Transit hub connection protection for special events or major incidents
- **Strategy 10**: Port of Oakland advises arriving and departing trucks about port delays and estimated travel times
- **Strategy 11**: Signal preemption for emergency vehicles
- **Strategy 12**: Multi-agency or multi-network incident response

III. Facilitate Collaboration for Event Planning

- **Strategy 13**: Coordinate scheduled maintenance and construction activities among corridor networks
- **Strategy 14**: Guidelines for construction work hours during emergencies
I-15 ICM Corridor, San Diego (1)

- >250,000 vehicles/day
- Multiple bottlenecks
- Congestion in the North segment (AM peak) and in the Mid segment (PM peak)
- I-15 Reversible Lanes have significantly reduced congestion in the South segment
I-15 ICM Corridor, San Diego (2)

Proposed:

- Main Lanes
- Managed Lanes
- Park-and-Ride
- Access Road
- Direct Access Ramps
- BRT Station
I-15 ICM Corridor, San Diego (3)

Operational Strategies

• En-Route Traveler Information
• Pre-Trip Traveler Information
• Signal Priority for Transit
• Freeway Coordinated Ramp Metering
• Signal Coordination on Arterials with Freeway Ramp Metering
• Physical Bus Priority on Arterials
• Increased HOV Occupancy Requirements
• Congestion Pricing on Managed Lanes
ICM AMS Methodology

Regional patterns and mode shift; Transit analysis capability

Traveler information, HOT lanes, congestion pricing and regional diversion patterns

Traffic control strategies such as ramp metering and arterial traffic signal control
ICM AMS: Key Issues

- **Modeling**
  - Traveler information
  - Mode shift and transit
  - Tolling/HOT lanes/congestion pricing
  - Performance measures and benefit-cost

- **Data Requirements**
  - Input data for model application
  - Data for calibration/validation
    - Global vs. local (link specific)
  - Role of data archival systems
  - Data for analysis of alternative scenarios
Managed (HOV/HOT) Lanes (1)

TO 5326/6326 Effectiveness of HOV Lanes
- Field Data on HOV Performance from Caltrans Districts
- Application of FREQ Model to Evaluate Alternative Designs/Occupancy Levels

TO 5315: Effects of Hybrids on HOV Performance
- Demand Estimation: Planning Model Orange County Network
- Operational Impacts: Microsimulation

TO 6301: Capacity of HOV Lanes
- Empirical Study: Analysis of PeMS Data
- Impacts on System Performance
TO 5326/6326: Peak Hour Vehicle Volumes on HOV Lanes, Caltrans District 4 (2003)

Average: 958 Vehicles/Hour

1650 Veh per Hour

800 Veh per Hour

FREEWAY HOV LANE

Average = 6.74 min/_trip
TO 5315: Results

Orange County Test Network

### # Hybrids Statewide
- 35,000 Hybrids
- 50,000 Hybrids
- 75,000 Hybrids
- 100,000 Hybrids

<table>
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<tr>
<th>Scenario</th>
<th>SOV (%)</th>
<th>HOV (%)</th>
<th>Hybrid (%)</th>
<th>HOT (%)</th>
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<td>Base Case</td>
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<td>21.7</td>
<td>4.32</td>
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</table>

Degradation of HOV Lanes: % Operating < 45 mph
This study analyzes peak period traffic data from hundreds of loop detectors over many months (through PeMS) to evaluate the HOV system’s effectiveness.

- HOV lanes are underutilized: 81% of HOV detectors measure flows below 1,400 vph/l during the PM peak hour.
- Many HOV lanes suffer degraded operations: 18 percent of all HOV-miles in the AM peak hour and 32 percent in the PM peak hour have speeds below 45 mph for more than 10 percent of weekdays.
- HOV lanes suffer a 20% capacity penalty: HOV lanes achieve a maximum flow of 1,600 vph/l at 45 mph; in contrast general purpose lanes record maximum flows above 2,000 vph/l at 60 mph.
- HOV lanes offer small travel time savings. However, HOV travel times are more reliable.
- HOV facilities can be useful if there is a significant number of buses or vanpools; as a 2-lane HOV/HOT facility, which eliminates 'snails' (low speed vehicles) and the resulting capacity loss; and, with efficient metering, as a HOV/HOT bypass at the on-ramps.
Managed (HOV/HOT) Lanes (2)

UCB Study on HOV Operations
• Effect of HOVs on Bottleneck Discharge Flows

SR91 Performance Analysis (FHWA)
• Demand Estimation: Planning Model Orange County Network
• Operational Impacts: Microsimulation

PeMS Managed Lane Performance Monitoring Module
• Automation of HOV/Managed Lanes Performance Reporting
• New Measures & Visualizations

TA 77841: Statewide HOV Performance Analysis (NEW)
• Continuous Access vs. Buffer Separated
• Field Data & Simulation Modeling
UC Berkeley Study on HOV Operations

Analysis of field data (video recordings) on I-880 fwy (Tennyson Bottleneck)

Results show that the discharge rate on the fwy mixed lanes is higher following the activation of the HOV lane (smoothing effect)
SR-91 HOT Lane Effectiveness (FHWA Task Order)

Two Express Lanes in each direction in median of the Riverside Freeway/State Route 91 (SR-91) for ten miles. There is a 4- or 5-lane general purpose mainline fwy
SR91: Toll schedule

In FY 2007 operating revenue was $49.8 M; number of toll transponders was 176,818; 14.6 million expressway trips, with 3.1 million (21%) HOV3+ trips

HOV3+ pay 50%, 4-6PM, else free
Superpeak (4-6PM) expressway (HOT) flow 1,400-1,800 vphpl vs. ML flow 900-1,200 vphpl
EB SR91 PM Peak (1)

PM speed at different locations

Superpeak (4-6PM) HOT speed 55+ mph vs. ML speed as low as 10-30 mph
PeMS Managed Lanes Performance Reporting – (In Progress)

- PeMS stores data from loop detectors from all California freeways in a central database at UC Berkeley (2 GB data/day)

- PeMS obtains and stores Highway Patrol’s incident data

- PeMS data sorting and analysis diagnostics reveal trends and important relationships

- PeMS is accessed from anywhere via a standard Internet browser
Current Practices: Performance Reporting

Issues:

1. Reporting takes forever
   • It’s done as a yearly report, takes many months to produce

2. Reported measures don’t completely capture what’s going on
   • Eg: Is the travel time difference constant for the entire day? Or does it vary by time of day?
   • Eg: What if both the HOV and ML facilities are congested? What is travel time difference actually telling you?

3. Can’t compare across facilities
   • Since each district reports different numbers, they can’t be compared
   • It is difficult to answer the question, “Compared to other facilities, are we managing this specific HOV facility properly?”

4. No ability to monitor according to federal standards
   • They aren’t monitoring continuously

5. No linkage from performance results to actions
   • The measures that they are looking at aren’t suggesting any management actions
Managed Facility Maps – Explore

- Standard integration with maps
- Overlaying the status of the facility (active, construction, programmed) with sensors
- Here we’re painting the Census Traffic Counting Stations on the map
- Little popups show the occupancy requirements for the facility
PeMS Managed Lanes Performance Reports (2)

Weekday travel time vs time of day

Flow, Speed vs Time

D7 405S PM

HOV – 761523 (1 lane)

Mainline – 761526 (4 lanes)
Develop operational guidelines for HOV facilities’ configuration

(a) Continuous-access HOV lanes

(b) Buffer-separate HOV lanes
- System & Section Level Performance Measures
- Field Data & Simulation Modeling
- Operational Performance = F (traffic & design characteristics)

### Test Sites

<table>
<thead>
<tr>
<th>HOV type</th>
<th>Corridor</th>
<th>Study boundaries (CA PM)</th>
<th>District</th>
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<tbody>
<tr>
<td>Full-time Continuous-access</td>
<td>SR-22</td>
<td>0-12</td>
<td>12</td>
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<tr>
<td></td>
<td>SR-55</td>
<td>13-18</td>
<td>12</td>
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<tr>
<td>Full-time Buffer-separated</td>
<td>I-105E</td>
<td>1.2-16.9</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>I-105W</td>
<td>2.6-16.8</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>I-210E</td>
<td>24.8-36.4</td>
<td>7</td>
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<tr>
<td></td>
<td>I-405S</td>
<td>12.9-22.2</td>
<td>7</td>
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<tr>
<td></td>
<td>I-5S</td>
<td>7-29</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>I-5N</td>
<td>7-29</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>SR-55N</td>
<td>7-R17.8</td>
<td>12</td>
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<tr>
<td></td>
<td>SR-57S</td>
<td>11.1-R22.6</td>
<td>12</td>
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<tr>
<td>Part-time Continuous-access</td>
<td>I-80E</td>
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<td></td>
<td>I-80W</td>
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<td>4</td>
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<td>SR-101S</td>
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<td></td>
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<td></td>
<td>I-680³</td>
<td>Need to be determined later</td>
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</table>
Active Traffic Management (1)

Definition (FHWA)

...the concept of dynamically managing and controlling traffic demand and available capacity of transportation facilities. By continuously monitoring system performance and related real time data, strategies would be employed based on prevailing and anticipated conditions to optimize the effectiveness, efficiency and safety of the transportation network.
# ATM Strategies and Potential Benefits

<table>
<thead>
<tr>
<th>Active Traffic Management Strategy</th>
<th>Potential Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed harmonization</td>
<td>•</td>
</tr>
<tr>
<td>Temporary shoulder use</td>
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<tr>
<td>Queue warning</td>
<td>• • • • • • •</td>
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<tr>
<td>Dynamic merge control</td>
<td>• • • • • • •</td>
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<tr>
<td>Construction site management</td>
<td>• • • • • • •</td>
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<tr>
<td>Dynamic truck restrictions</td>
<td>• • • • • • •</td>
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<tr>
<td>Dynamic rerouting and traveler information</td>
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<tr>
<td>Dynamic lane markings</td>
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<tr>
<td>Automated speed enforcement</td>
<td>• • • • • • •</td>
</tr>
</tbody>
</table>

- Increased throughput
- Increased capacity
- Decrease in primary incidents
- Decrease in secondary incidents
- Decrease in incident severity
- More uniform speeds
- Decreased headways
- More uniform driver behavior
- Increased trip reliability
- Delay onset of freeway breakdown
- Reduction in traffic noise
- Reduction in emissions
- Reduction in fuel consumption
ATM Strategies - Examples (2)
ATM Strategies – Reported Benefits

Reducing heavy damage accidents up to 30%
Travel time reduction up to 20%
Increasing line capacity up to 25% at least temporarily
High acceptance of variable traffic signs as long as the indicated speed limit seems to be reasonable
Less disturbances through an optimal construction site management
Less congestion in transferring traffic to alternate routes preventively
Macroscopic traffic model: Extended CTM: Coupled with speed dynamics

Real-time congestion onset detection

Predicting uncertainties in drivers’ responses

Real-time capacity estimation and uncertainty prediction

Selection of Preferred Reference Speed (PRS) and Preferred Reference Density (PRD) based on coordinated corridor-wise Extended CTM (Macroscopic) and Fundamental Diagram

Coordinated corridor-wise ramp metering

CACC vehicle operation

Coordinated corridor-wise Speed Limit Advising or Regulation (enforced)

Roadside VMS or to individual vehicle through VII

Macroscopic distance, time aggregated traffic parameter estimation

Traffic Data

Corridor Wide Traffic System