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Highway Occupancy Vehicle (HOV) System Analysis Tools – District 8 HOV Facility Performance Analysis

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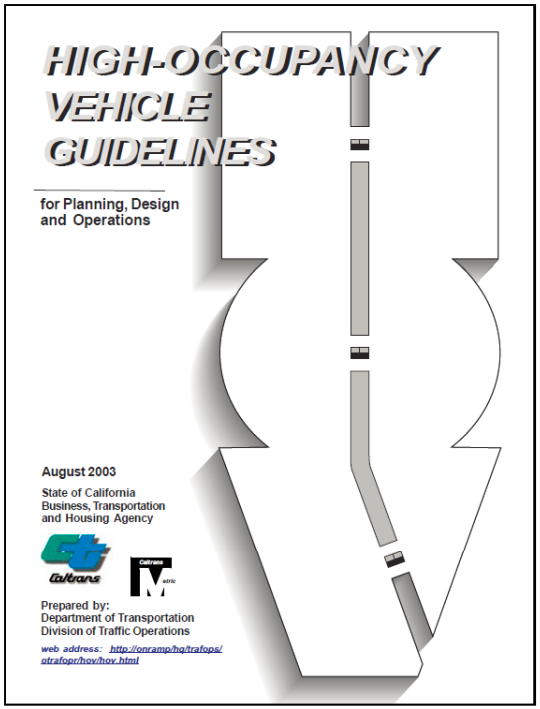
Introduction

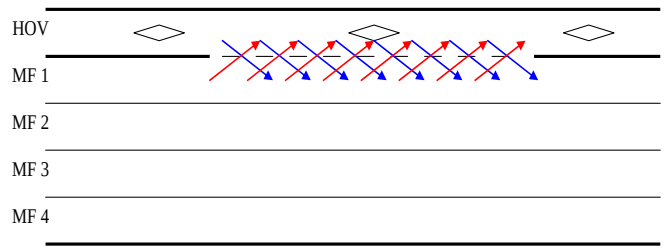
- California has the most extensive managed lane (including HOV lane) system in the U.S.
  - 1,500+ lane miles currently in operation
  - 1,200+ lane miles programmed or proposed
- Caltrans' HOV Guidelines
  - Comprehensive guidelines for planning, design, and operations of HOV facilities
  - Include general policy guidance for selecting the access type of HOV facilities
    - Limited access
    - Continuous access



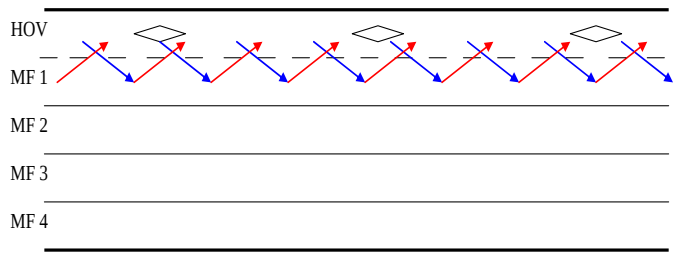
Motivation and Objectives

- Project motivation
  - There has been interest in comparing the performance of the two HOV lane access types.
  - This project focuses on <u>operational</u> performance.
- Research objectives
  - To develop research methodologies for assessing operational performance of HOV facilities
  - To comparatively determine pros and cons of the two HOV lane access types

Limited access HOV lane



Continuous access HOV lane



Note: MF = Mixed-flow

Research Approaches

- Corridor-level analysis
  - Evaluate operational performance of existing HOV facilities in Caltrans District 8 on a corridor-by-corridor basis using field data
- Statistical modeling
  - Conduct regression analysis to estimate the impact of HOV access type on freeway throughput
- Video data analysis
  - Examine lane changing behavior at selected HOV locations using data extracted from video footages
- Simulation study
  - Compare operational performance of the two HOV lane access types using microscopic traffic simulation tool
- Before-and-after study
  - Compare operational performance of SR-60 after the HOV lane conversion from limited access to continuous access

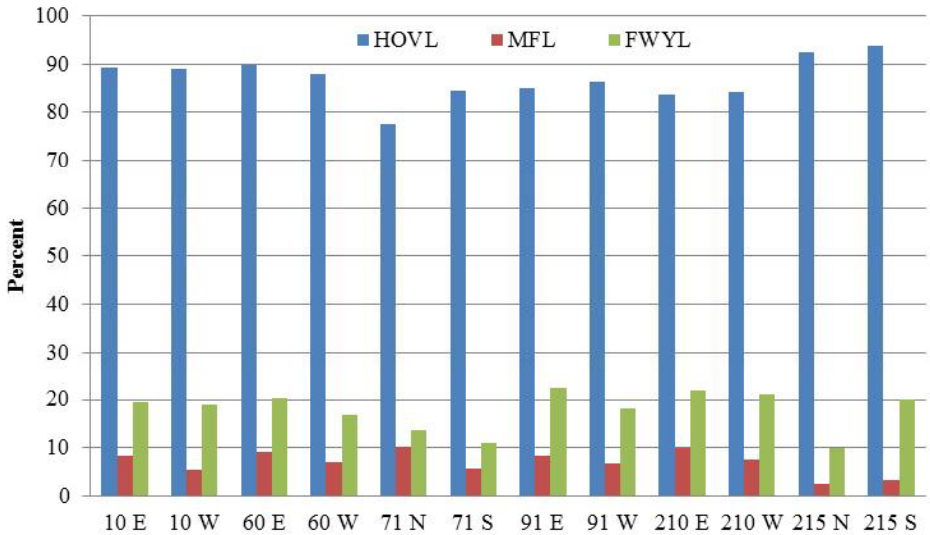
Corridor-Level Analysis (1)

- Methodology
  - Evaluated operational performance of HOV facilities in Caltrans District 8 on a corridor-by-corridor basis
    - Proportion of carpool vehicles
    - Average travel speed during peak hour
    - Etc.
  - Data from PeMS and the 2008 HOV Monitoring Report Statistics
- Pros (+) and cons (-)
  - \+ Implicitly accounts for the impact of traffic demands and bottleneck locations in the study corridors
  - \+ Easy to comprehend by the general public
  - \- Results are corridor-specific.
  - \- Difficult to separate the effect of HOV lane access type from other influencing factors

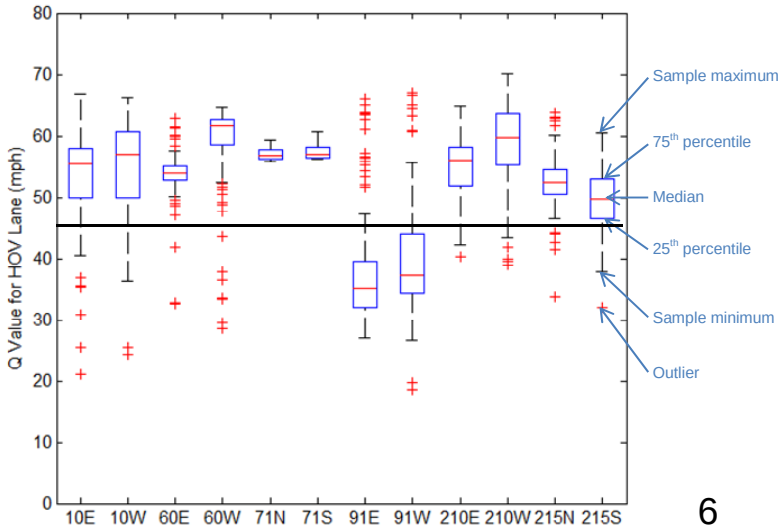
Corridor-Level Analysis (2)

- Key findings
  - Proportion of carpool vehicles in the study corridors ranged from 10% (I-215 N) to 22% (SR-91 E).
  - All HOV facilities in District 8 were able to maintain average travel speed of greater than 45 mph during peak hour, except for the ones on SR-91 (both directions).

Proportion of Carpool Vehicles



Average Travel Speed in HOV Lane



Statistical Modeling (1)

- Methodology
  - Applied several regression techniques to develop relationships between freeway throughput and a number of geometric characteristics, including HOV lane access type
  - Data from PeMS and Highway Safety Information System (HSIS)
- Pros (+) and cons (-)
  - \+ Based on a large amount of real-world data that were systematically collected
  - \+ Able to quantify the effect of HOV lane access type on freeway throughput while controlling for other influencing factors
  - \- Data compilation and processing is time consuming.
  - \- Currently applicable to performance metrics measured at the locations of PeMS' vehicle detector stations

Statistical Modeling (2)

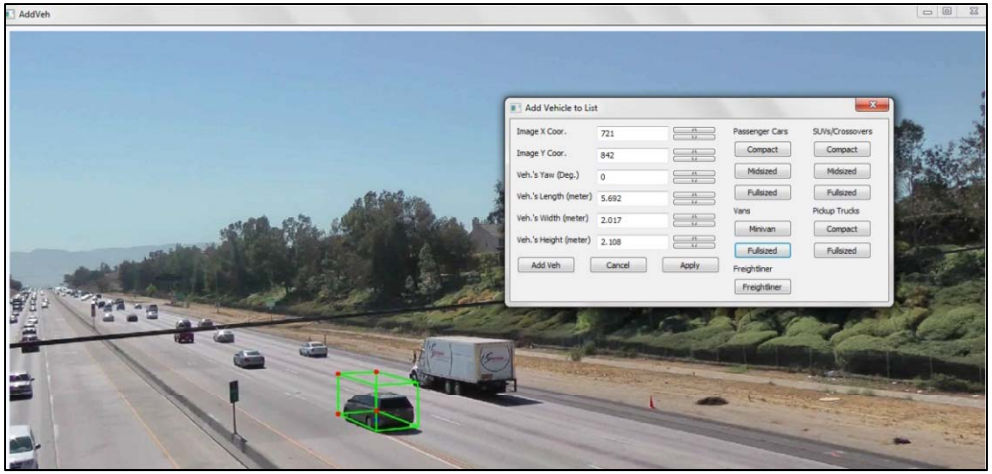
- Key findings
  - HOV lane access type has a statistically significant effect on the maximum throughput of a freeway segment.
  - Freeway with limited access HOV lane would accommodate higher maximum throughput than freeway with continuous access HOV lane, given that everything else being equal.

Model No.	Regression Technique	Maximum Throughput Value	Maximum Throughput Estimation Method	Regression Model Statistically Significant?	HOV Access Type Variable Statistically Significant?	Access Type with Higher Maximum Throughput
1	MLR	Lane Average	Sustainable	Yes	Yes	Limited access
2	MLR	Lane Average	Absolute	Yes	Yes	Limited access
3	MLR	Overall	Sustainable	Yes	Yes	Limited access
4	MLR	Overall	Absolute	Yes	Yes	Limited access
5	Robust MLR	Lane Average	Sustainable	Not applicable	Yes	Limited access
6	Robust MLR	Lane Average	Absolute	Not applicable	Yes	Limited access
7	Robust MLR	Overall	Sustainable	Not applicable	Yes	Limited access
8	Robust MLR	Overall	Absolute	Not applicable	Yes	Limited access

Note: MLR = Multiple linear regression

Video Data Analysis (1)

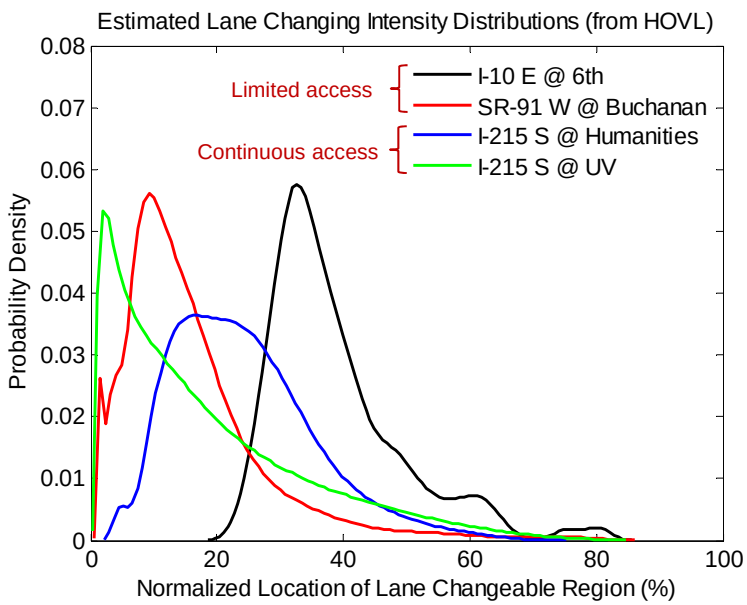
- Methodology
  - Videotaped traffic at selected freeway locations and extracted lane change-related parameters (e.g., number of lane changes, gap at each lane change)

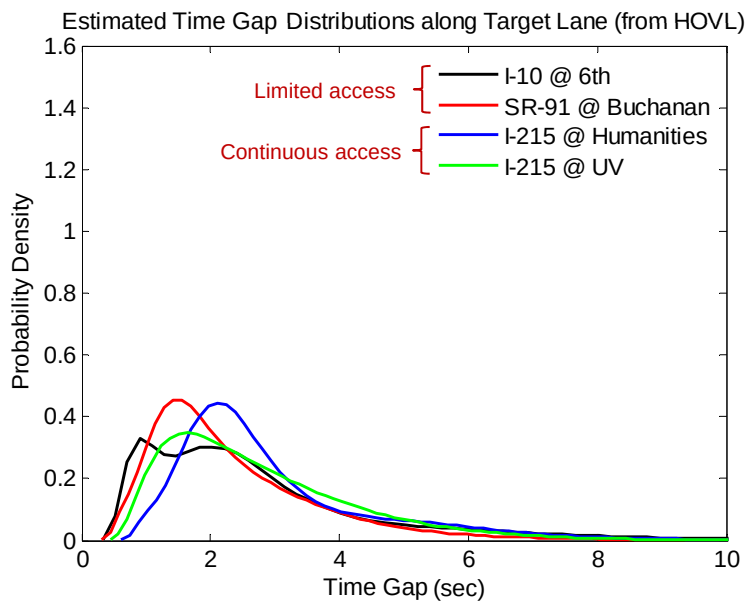


- Pros (+) and cons (-)
  - \+ Provide data that are not measured by conventional traffic data collection methods
  - \+ Allow lane changing behavior to be captured and analyzed
  - \- Difficult and costly to collect and process data
  - \- Limited data collection periods and locations

Video Data Analysis (2)

- Key findings
  - Most lane changes in ingress/egress areas occurred early on within the first half of the areas.
  - Lane changes between HOV lane and the adjacent MF lane in the case of continuous access HOV lane tend to have larger time gap.





Simulation Study (1)

- Methodology
  - Simulated the same freeway network with both HOV lane access types in Paramics simulation tool and compared operational performance

- Pros (+) and cons (-)
  - \+ No other differences (both geometry and travel demand pattern) besides the HOV lane access type that could bias the results
  - \+ Can simulate multiple what-if scenarios
  - \- Results may be site-specific.
  - \- Underlying models in simulation tools may not capture some real-world driving behaviors.

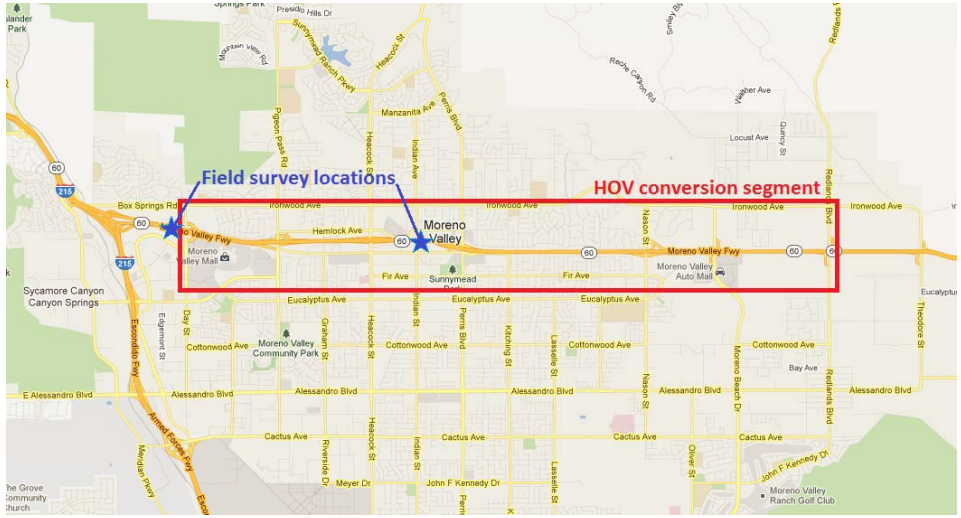
Simulation Study (2)

- Key findings
  - When uncongested (> 50 mph), freeway with limited access or continuous access HOV lane has similar average travel speeds.
  - When mildly congested (35-50 mph), freeway with continuous access HOV lane has higher average travel speeds.

Route	Lane Type	HOV Lane Access Type	Average Travel Speed (mph) on SR-91 E		
			HOVL & MFL Uncongested	HOVL & MFL Mildly Congested	HOVL Uncongested, MFL Mildly Congested
SR-91 E	HOVL	Limited	57.99	46.85	53.65
		Continuous	68.55	60.24	63.16
		% Difference	**18.21%**	**28.58%**	**17.73%**
	MFL	Limited	53.56	45.49	45.09
		Continuous	54.91	48.23	50.02
		% Difference	**2.52%**	**6.02%**	**10.93%**
SR-91 W	HOVL	Limited	75.39	69.83	75.31
		Continuous	76.34	71.31	72.91
		% Difference	**1.26%**	**2.12%**	**-3.19%**
	MFL	Limited	62.70	54.52	55.15
		Continuous	62.68	55.50	55.01
		% Difference	**-0.03%**	**1.80%**	**-0.25%**

Before-and-After Study (1)

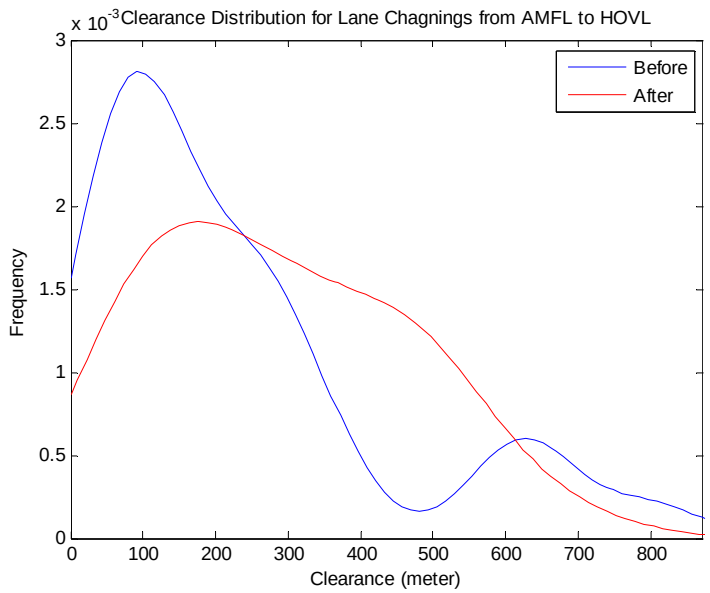
- Methodology
  - Compare performance of SR-60 after the HOV lane conversion
  - Data from PeMS, field surveys, aerial surveys, and public records.

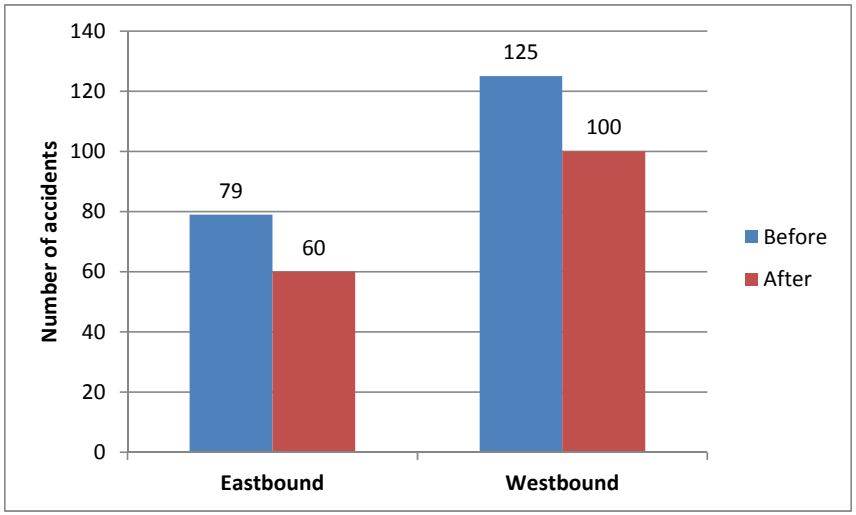


- Pros (+) and cons (-)
  - \+ Real-world data comparison
  - \+ No other geometric differences besides the HOV lane access type that could bias the results
  - \- Different travel demand patterns and fleet characteristics between the before and after periods could bias the results.
  - \- Results may be site-specific.

Before-and-After Study (2)

- Key findings
  - HOV violation rates after the HOV conversion from full-time limited access to part-time continuous access were higher.
  - Lane changes between HOV lane and the adjacent MF lane after the conversion had larger clearance distance.
  - Number of collisions after the conversion decreased.





Conclusions (1)

- HOV facilities in District 8 were operating well.
  - All able to maintain average travel speed of greater than 45 mph during peak hour, except for the ones on SR-91
- HOV facilities on SR-91 experienced the most delays.
  - Westbound during morning peak
  - Eastbound during afternoon peak
  - Part of the delays due to recurrent bottlenecks around the ingress/egress areas along the corridors
- Lane changes between HOV lane and the adjacent MF lane in the case of continuous access HOV lane:
  - Happen more frequently than in the case of limited access one
  - Tend to have larger time gap and clearance distance

Conclusions (2)

- Given that everything else being the same:
  - Freeway with limited access HOV lane would accommodate higher maximum throughput than freeway with continuous access HOV lane.
  - Freeway with continuous access HOV lane would provide higher average travel speed under mild congestion (35-50 mph).
- After the SR-60 HOV conversion from full-time limited access to part-time continuous access:
  - HOV violation rate increased.
  - Lane changes happened more frequently, but were smoother.
  - Number of collisions decreased, especially at one ingress/egress area on eastbound.
  - The general public responded positively.

Recommendations

- Continue to monitor the performance of HOV facilities in District 8, particularly the ones on SR-91
  - HOV eligibility requirement during peak periods may be increased to help alleviate congestion in the SR-91 HOV lanes.
- Combine the advantages of both HOV access types
  - Limited access: better in regulating traffic flow, which results in higher throughput along a short freeway segment
  - Continuous access: better in spreading out lane changes, which allows traffic to maintain higher travel speed along a long freeway section
  - Implement continuous access to achieve relatively higher travel speed along the corridor, but strategically apply buffers to selected freeway segments (e.g., bottlenecks and ramp merges) to accommodate relatively higher throughput on those segments

Acknowledgments

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