

# Impacts of Dynamic Pricing on Managed Lane Operations

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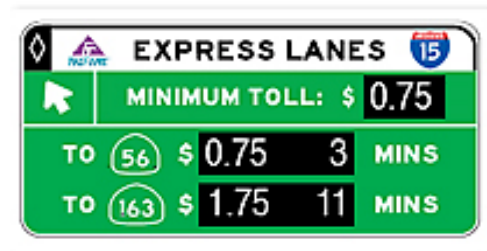
Florida Department of Transportation

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# Background

- Managed Lane Projects
  - 95 Express, Miami, FL
  - I-15 Express Lane, San Diego, CA
  - I-394 Express Lanes, Minneapolis, MN
  - 91 Express Lanes, Orange County, CA
- Pricing Schemes
  - Time of day
  - Dynamic



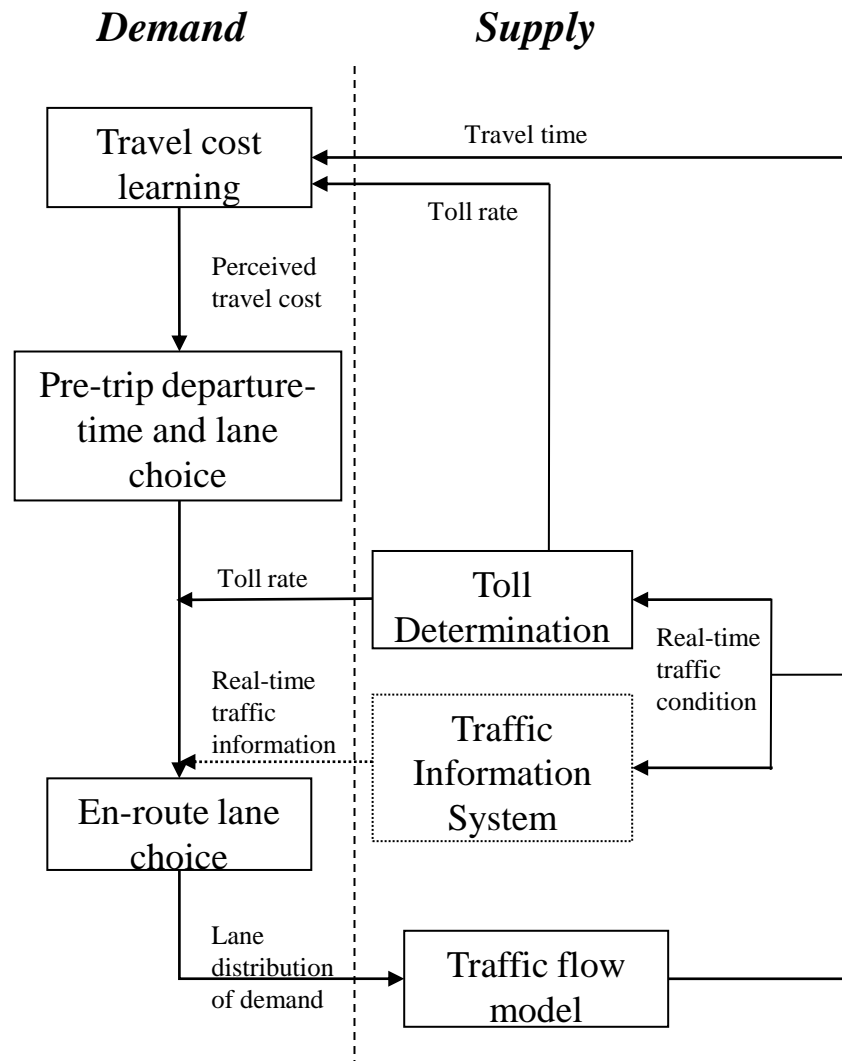
# Objective

- Develop an simulation model to analyze travelers' behaviors in a managed lane system in response to different tolling schemes and traffic conditions.
- Answer the following questions:
  - Does managed lane system exhibit hysteresis-like behavior under dynamic pricing?
  - Does dynamic tolling necessarily perform better than static or time-of-day (TOD) tolling?

# Behavior Based Simulation Model

- Requirements
  - Capture users' departure time and lane choice decisions.
  - Represent traffic dynamics based on user behaviors.
  - Be able to apply different toll determination schemes.

# Model Framework



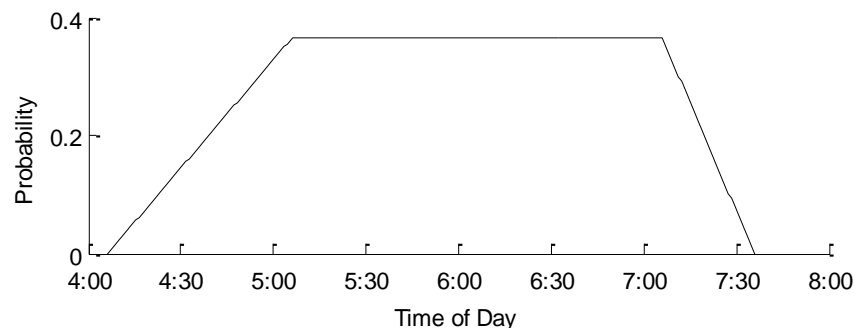
# Model Configuration

- I-95 Express is used as a test bed in the simulation model
  - 7 miles long
  - 6 lanes
    - 2 express lanes and  
4 general purpose lanes
  - Dynamic pricing
    - Toll rate calculated based on the traffic density on the express lanes



# Model Configuration

- Free-flow speed: 70mph
- Capacity (stochastic):
  - Express Lane: Weibull distribution, (7, 2000)
  - GP Lane: Weibull distribution, (11, 2100)
- Simulation horizon: 4 hour peak period
- User preferred arrival time:



# Model Configuration

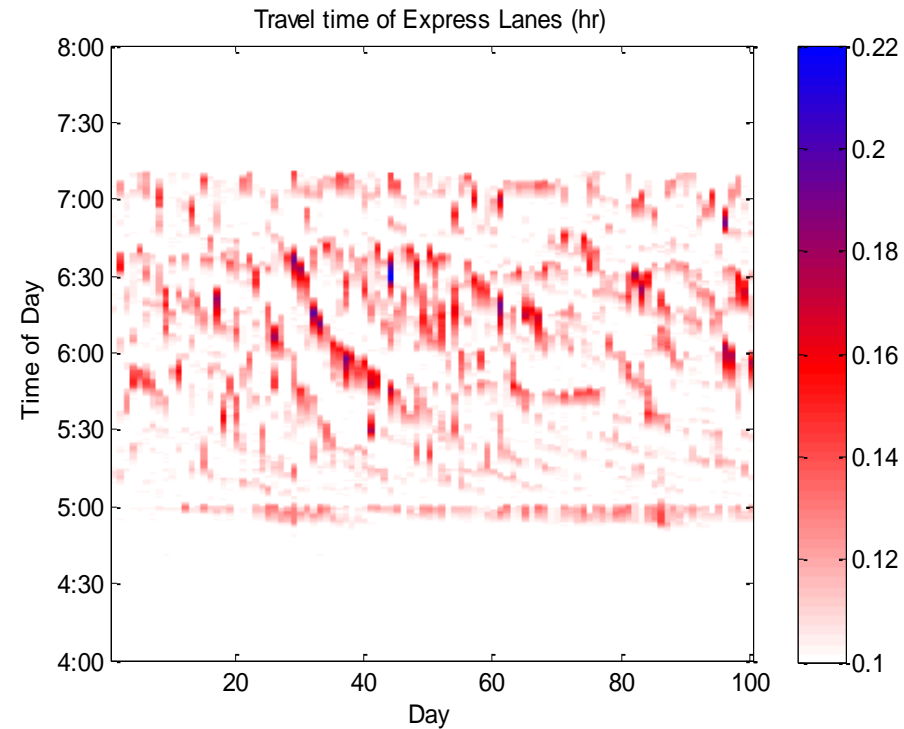
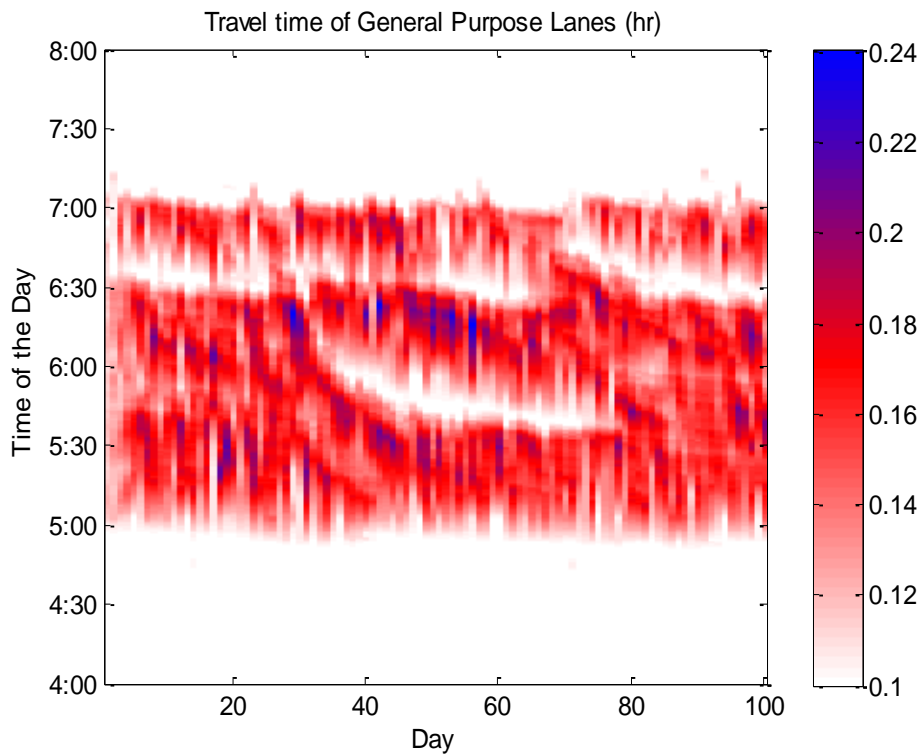
- User classes
  - Class 1: users with toll exempt vehicles.
  - Class 2: users not equipped with SunPass.
  - Class 3: users who are able to pay to access HOT lanes.
  - Class 4: the users who will make a choice on which car to drive: one is a SunPass-equipped vehicle and the other are not.

# Simulation Results

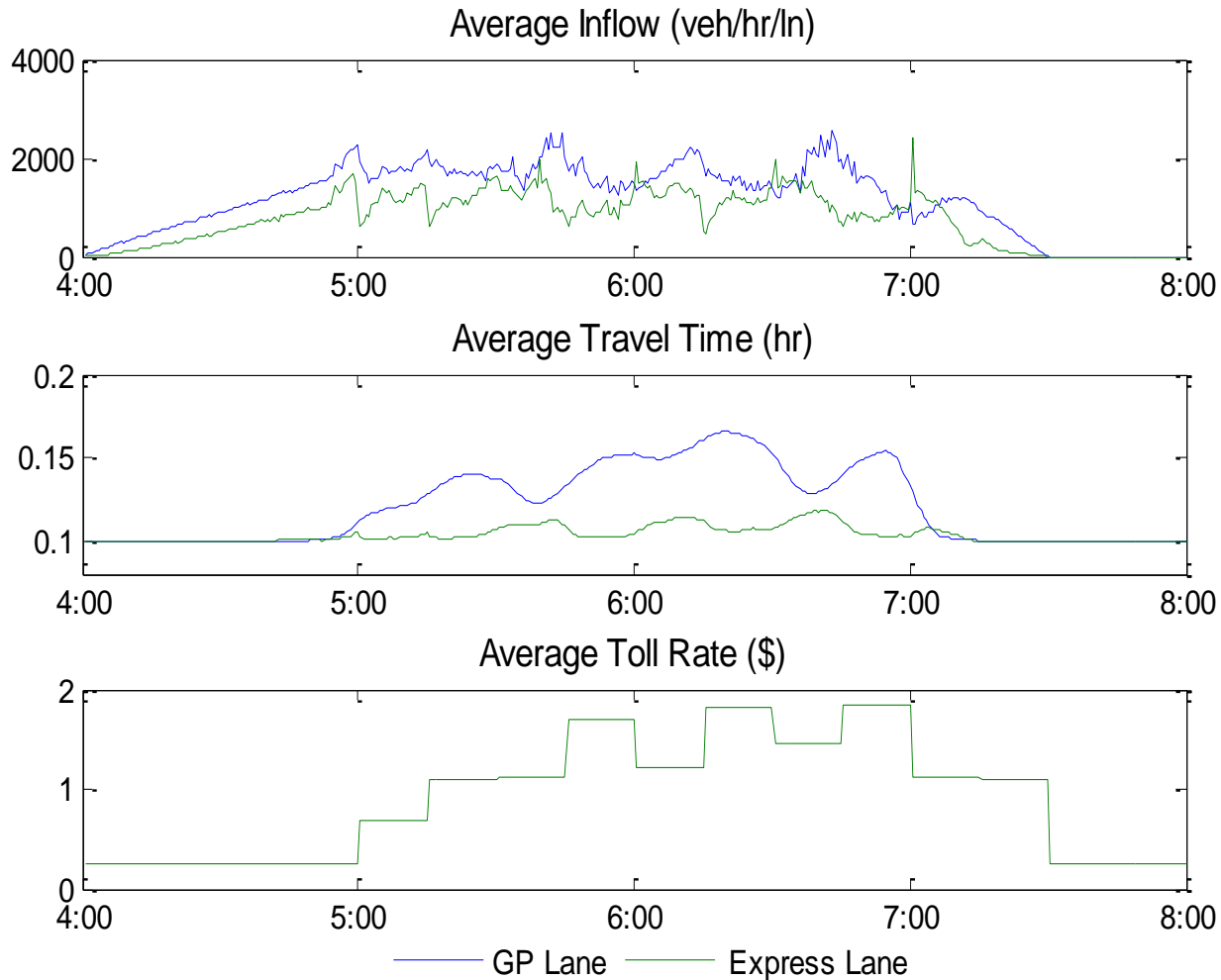
- Comparison of three scenarios
  - Base demand with real-time information provision
  - High demand with 40% demand increase
  - Base demand without real-time information provision

# Base Demand Scenario

- Travel Time

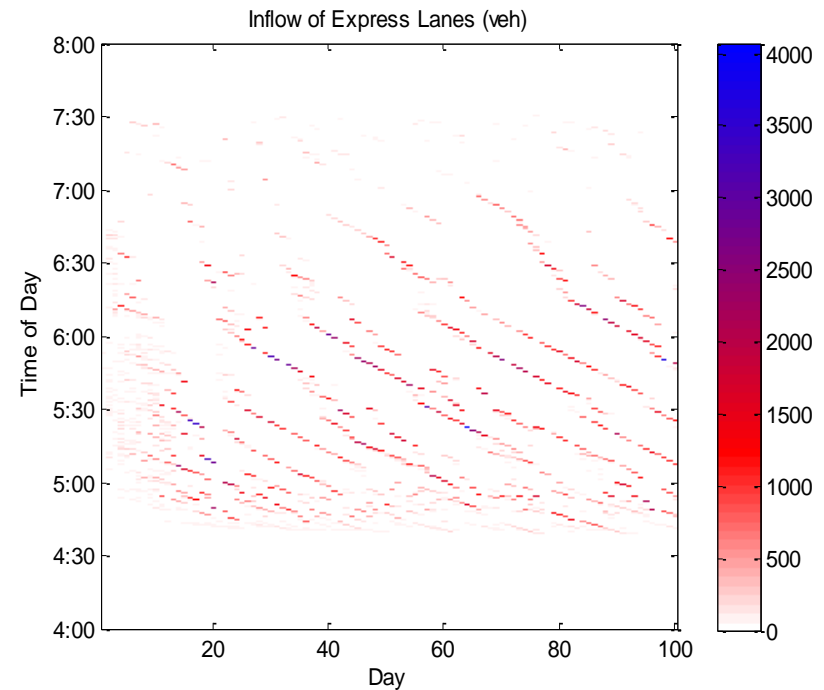
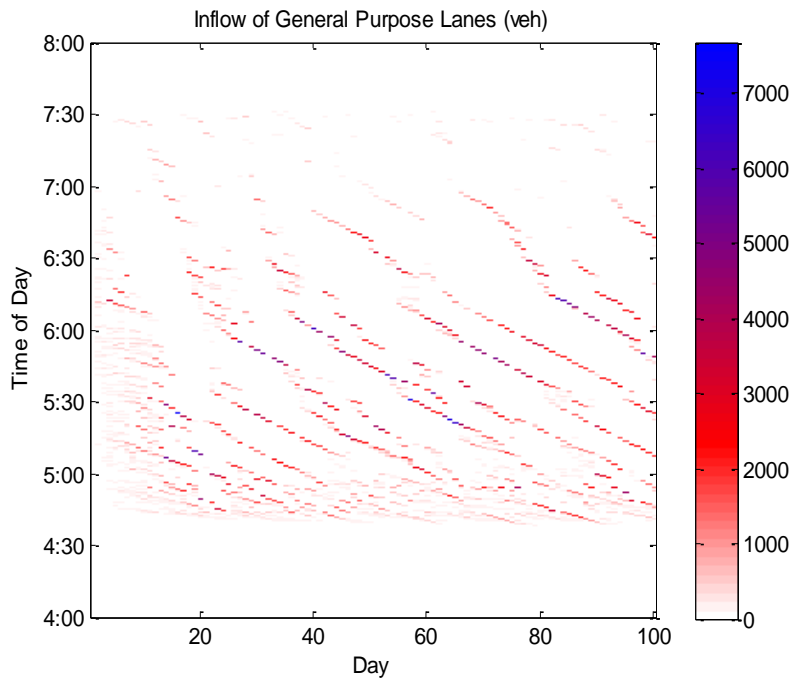


# Base Demand Scenario



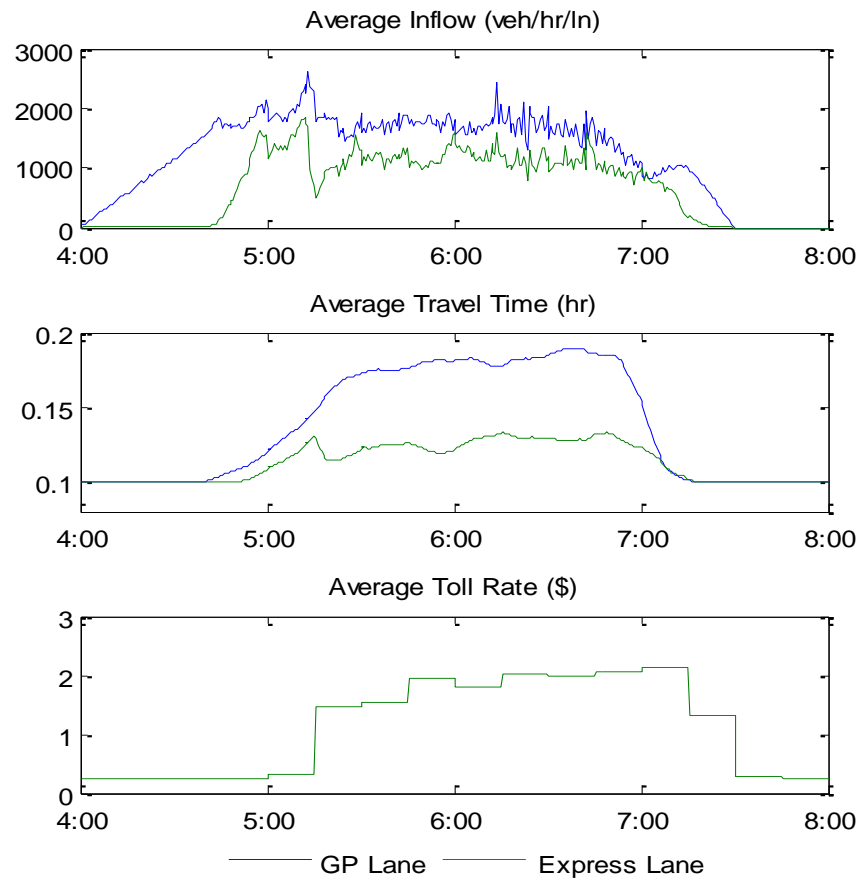
# High Demand Scenario

- Total demand increased by 40%.



# The Impact of Information Provision

- Results without real-time traffic information



# Findings

- In the base scenario, the demand distribution and the resulting travel times are in a relatively stable state and the system achieves a certain degree of equilibrium.
- When the demand is high, the system exhibits hysteresis-like behavior, i.e., travelers periodically shift their departure times and lane choices on a day-to-day basis.

# Findings

- The tolling algorithm for I-95 Express is able to manage travel demand and maintain a superior level of service on the HOT lanes. However, when the traffic condition on the GP lanes becomes severe, the effectiveness of the current tolling algorithm is limited.

# Findings

- The provision of real-time traffic information helps travelers with their decision makings on the choices of departure time and lane, and is able to substantially reduce traffic congestion in the experiments we conducted for the I-95 corridor.

# Analyzing TOD and Static Tolling vs Dynamic Tolling

- Does dynamic tolling necessarily perform better than static or time-of-day (TOD) tolling?
- Whether or not the benefits from dynamic tolling justify the additional cost for its implementation?

# Analysis

- Determined the static and TOD tolling plans, which achieve similar performance as dynamic tolling.
- Performance measures include
  - Avg. speed of express lanes
  - Avg. speed of general purpose lanes
  - Percent time that the express lanes are operated above 45 mph
- Considered nominal demand of 28000 veh for 4 hour peak period.

# Simulation Results

Table 1 Selected static and TOD tolling plan for the nominal demand

Static Toll (\$)	Time-of-day Toll (\$)	Time of Day
2.50	0.25	4:00 - 5:00 PM
	2.75	5:00 - 6:00 PM
	3.25	6:00 - 7:00 PM
	0.75	7:00 - 8:00 PM

Table 2 Performance measures of different tolling approaches under the nominal demand

Tolling Plan	Total Demand (veh)	Avg SpeedEL (mph)	Avg SpeedGP (mph)	Operating SpeedEL > 45 mph (Percent)
Dynamic Tolling	28,000	50.48	40.50	72.80
TOD Tolling		50.26	40.50	72.89
Static Tolling		50.38	40.68	74.19

# Simulation Results (cont'd)

Table 3 Comparison of three tolling approaches under different future demand scenarios

<b>Tolling Plan</b>	<b>Demand Scenario (Change from Current Demand)</b>	<b>Total Demand (veh)</b>	<b>Avg SpeedEL (mph)</b>	<b>Avg SpeedGP (mph)</b>	<b>Operating SpeedEL &gt; 45 mph (Percent)</b>
Dynamic Tolling	2% Increase	28,560	47.88	38.22	68.35
TOD Tolling			47.28	40.01	64.96
Static Tolling			45.36	38.61	63.04
Dynamic Tolling	5% Increase	29,400	46.20	37.11	62.91
TOD Tolling			40.59	36.75	50.49
Static Tolling			41.30	36.36	55.97
Dynamic Tolling	5% Decrease	26,600	63.89	52.87	96.55
TOD Tolling			65.96	48.63	99.35
Static Tolling			64.56	49.74	97.66

# Findings

- When travel demand is predictable, TOD or even static tolling can perform as well as dynamic tolling, provided that the toll profiles are optimized against the demand level.

## Findings (cont'd)

- However, since dynamic tolling is adaptive to different level of traffic demand and condition, its performance is more robust and stable.
- In contrast, the performance of the static and TOD tolling plans may deteriorate substantially if there is an increase in travel demand.

# Future Work

- Further simulation experiments will be done with different demand scenarios and demand patterns.
- A cost-benefit analysis will be conducted to investigate that whether or not the benefits from dynamic tolling justify the additional cost of its implementation.

Thank you!