Application of the Traffic Thermostat for the I-30 Managed Lanes in Dallas

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ABSTRACT

Managed lanes have historically experienced an evolution of change in operational policies. Over time, speeds on a managed lane may become degraded due to an oversubscribed demand that cannot be sufficiently met. Operators have strategies they can use to mitigate problems and maintain optimal performance, including changing the occupancy requirement, varying tolls (if the facility is priced), and altering transit service. Assessing the potential impact of operational strategies is a challenge. The traffic thermostat tool was developed as a software-based guide to help with selecting specific strategies projected to impact the metrics for each goal. This paper outlines how the tool was adapted for use on the I-30 managed lanes in Dallas, Texas, a high-occupancy toll lane with reduced toll rates for qualifying carpools. The program goals of travel speed and throughput were selected for the example scenario, with acceptable performance thresholds of 50 mph and 5,700 persons per hour (for the entire facility). Projected speed and throughput values for selected operational fixes were estimated within the tool using the calibrated speed-flow relationship from NCTCOG. Mode shift elasticities were imputed into the model using results from a quantitative travel survey. Overall, the dynamic nature of demand, diversity of user groups, ambiguity with exogenous factors (e.g., regional unemployment, fuel prices) and the need for extensive data on the lanes led to uncertainty and difficulty with prediction capability. However, using the traffic thermostat can show policymakers and others the inherent challenge of performance management for managed lane facilities.
INTRODUCTION

As congestion worsens in the United States, managed lanes (MLs) have become a more frequently used strategy to provide preferential treatment and improve mobility on arterials and freeways. The Federal Highway Administration (FHWA) defines managed lanes as "highway facilities or a set of lanes where operational strategies are proactively implemented and managed in response to changing conditions" (1). Managed lanes usually operate as high-occupancy vehicle (HOV) lanes, high-occupancy toll (HOT) lanes, and express toll lanes (ETLs). HOV lanes provide primary access for transit and carpools, HOT lanes allow single-occupant vehicles (SOVs) that pay a toll (including paid access for HOV2+, depending on the facility), and ETLs generally require all or most travelers to pay a toll.

Each managed lane is operated pertaining to goals for specific corridors, regional networks, or statewide systems. The goals that influence operational policy are usually established by regional planning organizations, state departments of transportation, and the federal government. Common goals for managed lanes include the following:

- Increase person throughput.
- Increase vehicle throughput.
- Maintain free-flow travel speed.
- Ensure travel reliability.
- Increase non-single-occupant mode share.
- Increase revenue generation (for priced facilities).
- Increase use by low- or zero-emission vehicles.

The wide variety of goals leads to a series of operational strategies that can manage demand and regulate operations. These management policies often include the following approaches:

- Permitting or restricting access based on select user groups (e.g., two- or three-person carpools).
- Vehicle eligibility (e.g., low-emission vehicles, electric vehicles, trucks).
- Pricing (e.g., changing the toll price to influence demand).
- Transit (e.g., increased service, incentive/rewards program).
- Ridesharing (e.g., increased number and capacity at park-and-ride lots, toll discounts).
- Separation from general purpose lanes (e.g., limiting the number of intermediate access points to provide preference for long-distance trips).
- Traffic control (e.g., open/closed during select times, use of shoulder, reversible flow).

Frequently, the goals for managed lanes tend to conflict. A common conflict is the desire to increase throughput while maintaining a high level of service/speed. Operators of managed lanes can utilize many techniques to encourage use of their facilities. Two of the most prominent strategies include the altering of occupancy rules (e.g., either two- or three-person carpool requirements) and the use of pricing. However, lowering the occupancy requirement enables more free users to travel on the managed lanes, and those users do not pay tolls that contribute to revenue. One caveat is the phenomenon of lowered effective capacity due to congestion, meaning demand is so great that congestion occurs, speeds become slower, and the highway moves fewer people and vehicles. Consequently, operators must know the associated impacts of
seeking disparate goals and actively manage operational strategies in order to not adversely impact any component significantly.

Historically, managed lanes experienced an evolution of change in operational policies. These changes usually occurred because of altering program goals, fluctuating demand, or statutory compliance. Project sponsors usually plan and build facilities with a clear intent to serve select users based on an established set of rules. However, operational policies often change for managed lanes because of uncertainty in predicting performance and the relative ease to enact policy change compared to roadway reconstruction. These operational policy changes are not made without some difficulty. Raising tolls or restricting access to a user group can be difficult politically. Therefore, it is best to try to predict these policy changes well in advance and let users of the facility know that if the operation of the managed lane drops below an acceptable level, specific policies will change. Thus, the operating agency is giving the public a performance promise, so the public understands that the managed lanes must perform well or changes occur.

An additional complication has been the difficulty in estimating and judging public and traveler reaction. Findings from pre-implementation surveys are limited because travelers are often unfamiliar with managed lane facilities. Past projects have shown that initial operating characteristics can have a great influence on how a facility is accepted and used. Ramp-up periods can last up to the first few years until travelers can get used to how a facility operates (2). Therefore, operators have sought better prediction tools and methods to estimate the impact of various operational strategies and to know when to make an adjustment and what adjustment to make in order to ensure optimal performance.

BACKGROUND

Prior literature and history show difficulties with attempting lifecycle management for managed lanes. The most frequently cited example is an oversubscribed HOV2+ facility with too much demand, slowed speeds, and unreliable conditions. Many of these facilities were built or implemented with federal-aid dollars and are subject to U.S. Code 166, which requires regular monitoring of performance measurement. Generally, federal requirements stipulate that most HOV lanes, including a number of HOT lanes, operate at or above 45 mph for 90 percent of the time within a 180-day period (3). A few managed lanes do not meet—or will soon not meet—this standard. In most cases, project sponsors have considered increasing the occupancy requirement to HOV3+, but the number of existing three-person carpools is relatively small compared to the total capacity. Operators have sought to increase transit service, ridesharing, and vanpools when increasing the occupancy requirement. Project sponsors want to avoid “empty lane syndrome,” where the managed lanes are visibly underutilized and lead to poor public perceptions about the purpose of the managed lane.

Swisher et al. (4) described the inherent difficulty with managing performance given the evolutionary increase in demand. The authors created a graphic that described how projected traffic volume would increase across time by specific user group (e.g., HOV2, HOV3+, bus/transit). At a point in time, the volume would reach a critical operating threshold, or the effective capacity of the managed lane. An operator would have a choice to either accept degraded conditions or restrict access to one of the user groups. If a user group became restricted (e.g., HOV2 not permitted, only HOV3+), then the following years would show a respective decrease in volume. The visual allowed operators to clearly understand how varying levels of demand from disparate user groups influence total managed lane volume. The graphic allowed
project sponsors to easily communicate a complex problem to a non-technical audience, which usually consists of policymakers from regional planning organizations and state legislatures. The visual provided a good framework for understanding but did not estimate the specifics of altering access or implementing certain operational strategies.

The El Monte Busway on the I-10 San Bernardino Freeway was an HOV lane that encountered significant operational problems after changing occupancy requirements from HOV3+ to HOV2+ in 2000. The facility originally opened for operation in 1973 as an exclusive bus-only lane and allowed three-person carpools access in 1976. At the time, operators monitored performance and observed that speed was not degraded due to permitting a greater population of users to travel on the HOV lane. In 1999, the California Legislature passed a bill that permitted two-person carpools to use the El Monte Busway for an 18-month trial period. The legislative intention behind lowering the occupancy requirement was to encourage more carpooling, based on the belief that the lane could handle additional demand. The occupancy change went into effect on January 1, 2000, and media coverage soon after reported significantly decreased travel speeds and increased trip times. During the first six months after the change, peak-period speeds during the morning in the HOV lane were reduced from 65 to 25 mph, and speeds in the adjacent general purpose lane were reduced from 25 to 23 mph. Overall busway vehicle throughput increased, but person throughput was found to decrease. Transit services observed substantial delays. Given the significant decline in service, the California Legislature passed a bill that reinstated the HOV3+ requirement effective July 24, 2000, almost a year before the trial period was initially supposed to end (5).

The HOV-to-HOT lane conversion of the I-85 Express Lanes in Atlanta, Georgia, was a prominent example of an operator having difficulty with managing performance. In 2007, the existing HOV lane on I-85 in Gwinnett and DeKalb Counties encountered heavy demand with congestion occurring during the peak periods. Speeds decreased to 45 mph during the morning peak period and 39 mph during the afternoon, compared to 70 mph during the middle of the day. The regional partners, consisting of the Georgia Department of Transportation, State Road and Tollway Authority (SRTA), and Georgia Regional Transportation Authority, estimated that future HOV demand was highly likely to continue increasing and speeds would worsen. The partners considered increasing the occupancy requirement to HOV3+. However, most the existing travelers were HOV2, and the partners feared that removing all the two-person carpools would lead to significant drops in volume, or empty lane syndrome. In 2008, the regional partners submitted and won a $110 million grant from the U.S. Department of Transportation as part of the Congestion Reduction Demonstration Program. The program enabled the purchase of new tolling equipment, enhanced transit services, and additional park-and-ride lots along the I-85 corridor. The partners moved forward with a plan to implement an HOT3+ lane, allowing toll-paying travelers and additional buses to use the lane in the absence of two-person carpools. The capability of changing the toll rate enabled the managed lane operator to have a greater degree of control than simply permitting access for specific user groups (6).

The I-85 Express Lanes opened in October 2011 and, despite planning and outreach, experienced significant public backlash. Media reports showed images of a relatively empty managed lane, toll rates on overhead signage, and congestion in the adjacent general purpose lanes. Negative comments were directed toward the regional partners, state legislators, and the Governor’s Office (7). SRTA, the agency responsible for managing the toll operations, adjusted the algorithm that set the toll price, and the tolls decreased as a result (8). The governor asked FHWA to lower the occupancy requirement to HOV2+, but FHWA declined the request, citing
the need for more time to see performance (9). A year later, demand for the HOT lane grew to
the point where congestion was observed in the southbound direction during peak morning hours
(6).

4 THE TRAFFIC THERMOSTAT TOOL

The traffic thermostat tool was originally developed as part of a research project for the Texas
Department of Transportation on predetermining performance for priced, or tolled, facilities. The
goal of the project was to manage changes in demand and operational strategies over long
periods of time. Oftentimes, the genesis for supporting a new managed lane was that it would
operate optimally, in other words, ensure a “mobility pledge” with the travelers who use the
facility. Policymakers would choose the goals, affected user groups, and associated operational
strategies in advance. If the facility were to become degraded, the preselected operational
strategies would be enacted to ensure the original goals would be met. Predetermining policy and
operational decisions enables operators to focus more on managing the facility and less on
building support to pass an operational change—often far after degradation has occurred. The
traffic thermostat tool formalizes the process of selecting operational strategies by presenting
information on specific impacts for each strategy. For example, an operator would see the impact
of combining an increase in the occupancy requirement (e.g., from HOV2+ to HOV3+) along
with increased transit service. The goal of the thermostat tool was to provide analytical support
for pursuing operational changes using a sketch-planning simulation tool with rough estimates
(10). The intended users are planners and operators who want to show policymakers the
expected impact and associated tradeoffs of implementing specific policy and operational
changes. If the policymakers accept the changes within the theoretical thermostat framework,
then operators get to make the actual changes for the managed lane.

The traffic thermostat tool was developed to guide planners and operators through a
series of questions that assess how well the lanes are meeting their goals and, if not meeting their
goals, what operational changes might be necessary. The thermostat is embedded with
instructional guidance contained within pop-up boxes. The tool first asks users to select up to
two goals and two measures of effectiveness for each goal. The tool also requires data on the
current number of users on the managed lanes, current toll rates, and any incentives offered to
travel on the managed lanes. In an earlier version of this tool (11), users were asked if the
managed lanes were meeting a designated set of measures. If the lanes were not meeting a set of
criteria (e.g., a specific speed or volume threshold), the tool would present a series of policy
alternatives and ask if changes should occur. If a change was selected, the tool would ask if the
policy resulted in acceptable performance. In all cases, it was up to the user to calculate the
operational performance of the lane (for example, speed and flow) outside of the tool. This was
necessary since all managed lanes are different and it was not possible to develop a program that
could estimate the impact of these operational changes on any facility. This made for a flexible
tool that could be applied to any managed lane but required considerable calculations to
accompany the use of the tool.

I-30 Managed Lanes Test Case

The latest version of the traffic thermostat was modified to be specific for the I-30 managed
lanes in Dallas, Texas—an HOV lane formally operated for 18 miles between Dallas and
Arlington along the I-30 Tom Landry Freeway. The Texas Department of Transportation is
currently in the process of converting the existing HOV lane into an HOT lane. Nine miles of a
reversible HOT lane opened on August 1, 2016, permitting single-occupant vehicles to travel in
the lane for a toll during peak periods. Toll prices will range from $0.43 to $1.14 per mile based
on a fixed, time-of-day schedule for the first six months of operation. The toll amount will be set
according to a dynamic algorithm that adjusts based on seeking a 50 mph travel speed in the
managed lane. Carpools of two or more people can receive a 50 percent toll discount by
registering and recording trips using a mobile application called Drive on TEXpress. The North
Central Texas Council of Governments (NCTCOG) has emphasized the Try Parking It Program
to incentivize carpool/vanpool matching, alternative mode choice, and non-peak travel as part of
the I-30 managed lanes program. This managed lane was chosen since the timing was right to
use the tool to help develop operational policies prior to the opening of the lane. Figure 1 shows
a map of the I-30 managed lanes after all the HOT lane conversion is complete.

![Map of the I-30 Managed Lanes](Source: TxDOT)

**FIGURE 1 Map of the I-30 Managed Lanes (Source: TxDOT).**

**Tool Set-Up and Modifications**

The tool was modified specifically for the I-30 managed lanes. Some calculations were imputed
within the tool for the benefit of the user. For example, the relationship between volume of
vehicles and speed on the lanes could be used to determine the impact of allowed user groups on
travel speed. The ultimate tool could calculate the impact of any operational fix or incentive on
any of the selected goals for a specific managed lane. However, there were many challenges in
creating this tool that could not be overcome. This paper includes a discussion of some of the
challenges faced in the creation of the traffic thermostat for the I-30 managed lanes, the
assumptions used in the tool, the limitations of the tool, and an example of the use of the tool, as well as a discussion of using this tool versus traditional methods for setting operational policies.

The calculations performed by the tool focus on how a specific operational fix or incentive will impact one or many measures of effectiveness. These measures of effectiveness are measures of how well the MLs are achieving program goals. A comprehensive study was completed to determine goals and objectives for the I-30 managed lanes (as shown in Table 1).

The operational fixes and incentives selected for the traffic thermostat include:

- Pricing (changing the toll rate including toll free travel).
- Allowed user groups.
- Increased enforcement.
- Incentives, including:
  - Earn a free trip on the MLs for every ____ number of trips.
  - Earn gifts such as cash or gift cards for every ____ number of trips.
  - Provide a ___ percent discount to local businesses.
  - Earn $5 in credit for every ____ number of trips taken by transit.
  - Provide a transit discount of ___ percent during the peak hours.
  - Offer express bus service to downtown.

The user also has the option to write in any other operational fixes or incentives in a text box marked “other.”

<table>
<thead>
<tr>
<th>TABLE 1 Goals and Measures of Effectiveness for the I-30 MLs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goal</td>
</tr>
<tr>
<td>Safe Travel</td>
</tr>
<tr>
<td>High-Speed Travel</td>
</tr>
<tr>
<td>Reliable Travel</td>
</tr>
<tr>
<td>Provide Choice</td>
</tr>
<tr>
<td>Maximize Throughput</td>
</tr>
</tbody>
</table>

Inherent Limitations

Due to the complexity of modeling, the measures of effectiveness for three of the five goals could not be estimated. These were safe travel, reliable travel, and provide choice. These are clearly very important goals for some managed lanes but also very difficult to estimate. The sophisticated urban planning model developed and used by NCTCOG does not estimate travel time reliability, crashes, or the number of unique individuals using the managed lanes. The model also had difficulty predicting the number of HOVs and SOVs that may use the lane, providing unreasonable results. This limitation was not surprising given the function of a regional model, and this is why traffic and revenue estimates rely on complex models built for a specific roadway—but still frequently incorrectly estimate the number of travelers. Therefore, when using the traffic thermostat, the user will have to calculate any safety, reliability, or choice impacts outside of the tool. Thus, to use this tool on a particular roadway, it is necessary to be
able to model the relationship between traffic volume and any of the goals of that roadway, for example, safety. This is a significant hurdle in the case of many ML goals.

Another important limitation of the tool was that the congestion, or lack of congestion, on the general purpose lanes does not impact the use of the managed lanes. Detailed data could not be confirmed for expected general purpose lane volume (and thus travel speeds on the general purpose lanes) and travelers’ willingness to pay. Therefore, changes in volumes and mode use were based on elasticities of demand with respect to either the toll price or the incentive offered. A value of $-0.3$ was used for the elasticity of demand with respect to the toll, based on the literature. In other words, a 10 percent change in the toll for a group resulted in a 3 percent change in volume, regardless of the change in traffic speeds on the managed lanes or general purpose lanes. Similarly, mode shifts due to incentives were based on the elasticities calculated from a 2014 survey of travelers ($12$).

**Calculation of Speed and Throughput Measures of Effectiveness**

Measures of effectiveness for the other two goals, speed and throughput, were estimated within the tool using the calibrated speed-flow relationship from NCTCOG and numerous assumptions, including:

- No large vehicle factor was applied when calculating the speed of traffic in the lanes. All vehicles were factored the same (motorcycle, SOV, emergency vehicles, buses).
- Real-world opening day tolls for travel on the entire 18-mile length of the MLs were as follows (these tolls are all set by the traffic thermostat user in the software and can be easily changed):
  - Approximately $4$ during the peak for SOVs.
  - Approximately $2$ (half price) for HOV2+ and motorcycles.
  - All vehicles paid the same amount off peak, approximately $2$.
- The relationship between traffic volume and travel speed was provided by the NCTCOG regional model for this section of freeway (see volume-delay function below).
- Enforcement removed half of the violators.
- Elasticities of demand were as follows:
  - Price: $-0.3$. For example, a 10 percent increase in price would result in a 3 percent decrease in volume. This was based on tolling literature.
  - Incentives:
    - Incentives 1 and 3 had fairly high elasticities. Therefore, the changes in traffic volumes due to these incentives were artificially capped so that the change in the number of travelers due to offering these incentives did not become unreasonable. The cap was set equal to the change that would occur if the incentive changed by 100 percent (e.g., for Incentive 3, that would be approximately 13 percent).
- Vehicles were tolled in groups (all vehicle types in a group were tolled together). This is done so the user of the thermostat does not have to answer toll change questions for an extremely large number of vehicle groups:
  - Toll Group 5: Trucks.
  - Toll Group 4: SOVs, low emission, fuel efficient.
Toll Group 3: motorcycles, emergency vehicles, transportation agency vehicles, and low income.

- Toll Group 2: HOV2.
- Toll Group 1: HOV3+ and vanpools.
- Transit and buses were never tolled.

- Occupancy rate for transit and buses was 55-seater bus assumed to be ¾ full = 41 people.
- Average occupancy rates were vanpools = 5 people, HOV3+ = 3.5 people.
- If no time period was chosen, then one peak hour was assumed.
- If a previous value was not chosen for the incentive level, then it was assumed to be 0 (not offered).

**NCTCOG Volume-Delay Function**

The NCTCOG volume-delay function was calculated as follows.

\[
T = T_0 + C_d + S_d + U_d
\]

where:

- \( T \): travel time on loaded link.
- \( T_0 \): free-flow travel time. It was calculated as the link length divided by the speed limit.
- \( C_d \): conical congestion delay.
- \( S_d \): signal delay.
- \( U_d \): unsignalized delay.

\( T_0 \) was a fixed time associated with the link, and it was directly available from the link’s attribute. In this case, it was 2.84. \( S_d \) was signal delay, hence 0 on freeway links. \( U_d \) was 0 as well.

\[
C_d = T_0 (1 + \sqrt{\alpha^2 \left( 1 - \frac{v}{c} + t \right)^2 + \beta^2 - \alpha \left( 1 - \frac{v}{c} + t \right) - \beta - t_v})
\]

\[
C_d = 2.84 (1 + \sqrt{8^2 \left( 1 - \frac{v}{2150} \right)^2 + 1.071^2 - 8 \left( 1 - \frac{v}{2150} \right) - 1.071})
\]

\[
C_d = 2.84 (1 + \sqrt{64 \left( 1 - \frac{v}{2150} \right)^2 + 1.15 + \frac{8v}{2150} - 9.071})
\]

\[
t_v = 1 + \sqrt{\alpha^2 \left( 1 + t \right)^2 + \beta^2 - \alpha \left( 1 + t \right) - \beta = 0}
\]

\[
\beta = \frac{2\alpha - 1}{2\alpha - 2} = \frac{16 - 1}{16 - 2} = 1.071
\]

where:

- \( v \): hourly link volume.
- \( c \): hourly capacity of a link, 9200 for main lane, 2150 for managed lane.
- \( \alpha \): the parameter of conical function, equal to 8 in this case.
t: a constant used to adjust the volume-delay function, and available in link attributes: vdf_shift, −0.15 for main lane, 0 for managed lane.

3 Calculation of Mode Shifts Using Elasticities

The price elasticity of demand for a toll change was assumed to be −0.30 from the literature. The demand elasticities due to incentives were from the survey of travelers surrounding the I-30 corridor (12), as shown in Table 2. Only vehicles traveling on the managed lanes were considered as specific data about lane shifting between the managed and general purpose lanes.

The elasticity formula for a single shift (such as to transit) used for the estimation was:

\[ e = \frac{\% \Delta V}{\% \Delta P} = \frac{V_1 - V_0}{(V_1 + V_0)/2} \]

\[ \% \Delta V = e \times \frac{P_1 - P_0}{(P_1 + P_0)/2} \]

where:

V = volume.

P = price (or incentive value).
1. **TABLE 2 Elasticity Values**

<table>
<thead>
<tr>
<th>Incentive</th>
<th>Mode</th>
<th>Calculated Elasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td>MLDA Inc1</td>
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<tr>
<td></td>
<td>MLDA</td>
<td>0.243</td>
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<tr>
<td></td>
<td>MLCP</td>
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</tr>
<tr>
<td></td>
<td>Transit</td>
<td>-0.050</td>
</tr>
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<td>GPL</td>
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</tr>
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<td></td>
<td>MLDA</td>
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<td>MLCP</td>
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</tr>
<tr>
<td></td>
<td>Transit</td>
<td>33.1</td>
</tr>
</tbody>
</table>

2. For more complicated shifts, such as an incentive ($I = \text{value of incentive}$) that shifts both ML Carpool (MLCP) and ML Drive Alone (MLDA) to other modes:

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*The table contains elasticity values for different incentive modes (MLDA Inc1, MLCP Inc1, etc.) and their calculated elasticities for various modes (GPL, MLDA, MLCP, Transit). Each row represents a specific incentive and mode, with the calculated elasticity provided.*

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*For more complicated shifts, such as an incentive ($I = \text{value of incentive}$) that shifts both ML Carpool (MLCP) and ML Drive Alone (MLDA) to other modes:*
let \( \alpha_1 = (I_1 - I_0) \times e_{MLDA} \) for one of the two elasticities such as MLDA (-0.018)

let \( \alpha_2 = (I_1 - I_0) \times e_{MLDA} \) for the other one of the two elasticities such as MLCP (0.002)

\[
V_1 = V_0 \times \frac{1 + \alpha_1 / 2}{1 - \alpha_1 / 2} \times \frac{1 + \alpha_2 / 2}{1 - \alpha_2 / 2}
\]

### TABLE 3 Incentive Values Shown in the Traveler Survey

<table>
<thead>
<tr>
<th>Incentive</th>
<th>Mode</th>
<th>Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Earn a free trip for every X paid trips on the Express Lanes</td>
<td>MLDA, MLCP</td>
<td>8, 9, 10, 11, 12</td>
</tr>
<tr>
<td>2. Earn gift cards worth $5 for every X peak-hour trips saved by either</td>
<td>MLDA, MLCP, Transit</td>
<td>20, 25, 30, 35</td>
</tr>
<tr>
<td>telecommuting or by not traveling during the peak hours (7–9 a.m. or</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4–6 p.m.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. X% discount offered through select businesses</td>
<td>MLDA, MLCP, Transit</td>
<td>5%, 10%, 15%, 20%, 25%</td>
</tr>
<tr>
<td>4. For every X trips taken by transit, $5 in credits that can be used on</td>
<td>Transit</td>
<td>20, 25, 30, 35</td>
</tr>
<tr>
<td>the Express Lanes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. A transit fare discount of X%</td>
<td>Transit</td>
<td>10%, 20%, 30%</td>
</tr>
<tr>
<td>6. Express bus service from park-and-ride lots to downtown</td>
<td>Transit</td>
<td>N/A</td>
</tr>
</tbody>
</table>

### EXAMPLE SCENARIO

For the I-30 managed lanes, the thermostat had five goals available for users to examine. Three of those goals (safety, unique users, and reliability) required the users to do their own external calculations to determine if that goal had been met. The tool assumed for one hour of the day, 7 a.m. to 8 a.m. The other two goals (speed and throughput) were functional and thus were used in this example run. Those goals, and selected measures of effectiveness (MOEs), were:

- Goal: High Speed Travel, Measure of Effectiveness: Average Speed > 50 mph.
- Goal: Maximize Throughput, Measure of Effectiveness: Person Throughput > 5700.

After choosing the goals, a warning message let the user know that the selected goals may conflict. For example, the increasing the number of travelers could result in lower speeds unless a shift to HOVs occurred at the same time.

After entering those goals and MOEs, the user had to enter the traffic volumes and ranking of user groups (see Figure 2). Volumes for the managed lanes were assumed since there were no accurate projected volumes available. A relatively high figure (5700 people per hour) was chosen to show some congestion that would likely require an operational change. Then, various incentives/disincentives for using the managed lane were entered. For many of these, the opening day value was left blank since they were assumed to not be offered on opening day, but a future value was entered if that incentive was chosen (see Figure 3).
The first iteration resulted in a travel speed that was too low (48 mph), but the speed could be adjusted by raising the SOV toll from $4 to $6. Increasing the toll price resulted in an estimated speed increase to 51 mph. The throughput goal was adjusted after the speed goal was met. At first, the throughput was slightly below the 5700-person goal, so a series of potential operational fixes was pursued. Considering the inclusion of Incentive 1 (a free managed lane trip for a series of paid trips), the throughput increased to 5770 people—above the established minimum. In contrast, a small decrease in throughput was observed if Incentive 5 (a transit discount) was considered. This change was due to a significant increase in transit use (from a very small base number) and very small percentage decreases estimated from other modes (based on large base numbers). The volumes and toll rates resulting from the operational changes are summarized in the final screen of the thermostat toll (see Figure 4).

FIGURE 2 ML user groups with ranking and volume.
FIGURE 3 Operational fixes page.
The biggest challenge in derivation of the traffic thermostat tool centered on maintaining flexibility in the ability to select and modify multiple operational fixes or incentives. This characteristic was particularly difficult when the user selected conflicting goals, such as increased throughput (often requiring additional vehicles) and high-speed travel (generally requiring fewer vehicles).

Another challenge was keeping track of the list of operational fixes and incentives selected by the user and the impact each had on the number and type of vehicles. These changes had to be carried from one operational fix or incentive to another for all measures of effectiveness. If the user were to change their mind and then unselect an operational fix or incentive, the software would have to reevaluate that impact. Since some of the information was stored in cookies, it was found that the software worked best in “incognito” or “private” mode where it did not store information.

Similarly, if the user wanted to try something that was not already included, such as the “other operational fix” option where the user could write in their own fix, then the user would have to estimate the impact of this change outside of the software. This change was not stored in the software. Therefore, any additional modifications to volumes or speeds would not include the change the user made that was outside of the preset operational fixes or incentives and thus would yield incorrect results. Thus, the tool is limited in its flexibility. Future improvements with the application of the tool may be made given refined behavioral response data. A Thermostat with further modifications can provide more suitable information for consideration by planners and operators.
CONCLUSIONS

The traffic thermostat was modified from its original, generic form to one that was specifically calibrated for the I-30 managed lanes. The thermostat allowed users to select from five potential goals for these managed lanes, with two potential measures of effectiveness for each goal. The thermostat was not able to calculate the impact of operational fixes or incentives on MOEs for three of the goals (safe travel, reliable travel, and provide choice). Due to the complexity of modeling travel on managed lanes, estimating the MOEs for these goals would require sophisticated models dedicated to estimating I-30 traffic. Therefore, if the thermostat user selects any of these goals, the user needs to calculate the impact of any operational fixes or incentives on the MOEs outside of the traffic thermostat tool.

The thermostat could estimate the impact of operational fixes or incentives on the MOEs for the other two goals (speed and throughput). This required information from NCTCOG on the speed-flow relationship on the lanes, survey data on I-30 travelers, and numerous assumptions. Thus, for these two goals, planners can use the tool to look at the impact of many operational fixes or incentives on the lanes. They will be led through a series of questions that allow them to adjust the operational fixes or incentives to make best use of the I-30 managed lanes. In this way, the tool is helpful for determining the operational fixes or incentives to be used. However, it does not have the flexibility needed to optimize these operational fixes or incentives over all five goals and 10 MOEs since many of the impacts must be calculated outside of the tool.

This project shows the difficulty in obtaining the necessary data and traffic relationships to estimate the impact of many incentives on ML use and operations. Users need to know how each potential operational change might affect traffic flow on the lane and impact the ML goals. However, the thought process behind this exercise, including goal setting and examining operational scenarios, is valuable. It encourages setting performance standards for the lanes and determining how to meet those standards.

REFERENCES


