Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA/TX-13/5-6396-01-1		

4. Title and Subtitle	5. Report Date
APPLICATION OF A PERFORMANCE MANAGEMENT FRAMEWORK FOR PRICED LANES	April 2013 Published: November 2013
	6. Performing Organization Code
7. Author(s) Ginger Goodin, Mark Burris, Tina Geiselbrecht, and Nick Wood	8. Performing Organization Report No. Report 5-6396-01-1
9. Performing Organization Name and Address Texas A&M Transportation Institute College Station, Texas 77843-3135	10. Work Unit No. (TRAIS) 11. Contract or Grant No. Project 5-6396-01
12. Sponsoring Agency Name and Address Texas Department of Transportation Research and Technology Implementation Office P.O. Box 5080 Austin, Texas 78763-5080	13. Type of Report and Period Covered Technical Report: June 2011–April 2013 14. Sponsoring Agency Code

15. Supplementary Notes

Project performed in cooperation with the Texas Department of Transportation and the Federal Highway Administration.

Project Title: Application of the Traffic Thermostat Framework

URL: http://tti.tamu.edu/documents/5-6396-01-1.pdf

16. Abstract

The Texas Department of Transportation and its agency partners have implemented various forms of lane management and pricing over the past three decades, including high-occupancy vehicle (HOV) lanes, high-occupancy toll lanes, managed lanes, and toll roads. As more of these complex transportation facilities are planned and constructed throughout the state, agencies need to understand how these facilities may operate over time. Ideally, the long-term operations should be based on metrics that are agreed upon in advance. When agencies define what metrics can most effectively and efficiently measure the performance of a facility and outline what thresholds trigger a change in operation, policy makers and the public can anticipate and appreciate how a facility's operation may change over time. This understanding allows the facility operators to focus on the tasks of efficiently operating a smooth transportation network, rather than on how to get the necessary changes approved in a timely manner.

Research Project 0-6396 developed a framework called the Traffic Thermostat, which can help make operating decisions for priced facilities and can guide changes in operational strategies for a facility over time. This implementation project demonstrates how the Traffic Thermostat can be implemented for a specific project, and allowed for adjustments to the framework and implementation process based on results. This pilot focused on the I-30 managed HOV lanes. In addition, the project created a primer and user's manual to assist agencies in using the Traffic Thermostat.

17. Key Words	18. Distribution Statement
Managed Lanes, HOV, HOT, Toll Roads, Pricing, Performance Measures, Performance Management	No restrictions. This document is available to the public through NTIS: National Technical Information Service Alexandria, Virginia http://www.ntis.gov

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	46	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

APPLICATION OF A PERFORMANCE MANAGEMENT FRAMEWORK FOR PRICED LANES

by

Ginger Goodin
Senior Research Engineer
Texas A&M Transportation Institute

Mark Burris, Ph.D.
Associate Research Engineer
Texas A&M Transportation Institute

Tina Geiselbrecht
Associate Research Scientist
Texas A&M Transportation Institute

and

Nick Wood
Associate Transportation Researcher
Texas A&M Transportation Institute

Report 5-6396-01-1
Project 5-6396-01
Project Title: Application of the Traffic Thermostat Framework

Performed in cooperation with the
Texas Department of Transportation
and the
Federal Highway Administration

April 2013
Published: November 2013

TEXAS A&M TRANSPORTATION INSTITUTE
College Station, Texas 77843-3135

DISCLAIMER

This research was performed in cooperation with the Texas Department of Transportation (TxDOT) and the Federal Highway Administration (FHWA). The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of FHWA or TxDOT. This report does not constitute a standard, specification, or regulation.

ACKNOWLEDGMENTS

This project was conducted in cooperation with TxDOT and FHWA. The authors thank Wade Odell, TxDOT for his guidance in the closing months of the project, and for Matt MacGregor and Duncan Stewart for their vision and oversight throughout most of the work effort. The research team also expresses gratitude for the feedback provided by Dan Lamers, Michael Burbank, and Berrien Banks from the North Central Texas Council of Governments (NCTCOG).

The outcome of this implementation project would not have been possible without the input provided by the project's Technical Advisory Committee:

- Chad McKeown, NCTCOG.
- Marian Thompson, NCTCOG.
- Dave Pounds, North Texas Tollway Authority (NTTA).
- Ravi Gundimeda, Dallas Area Rapid Transit (DART).
- Rick Cortez, TxDOT.
- Stephen Endres, TxDOT.
- Tony Hartzel, TxDOT.
- Toney Payberah, TxDOT.

TABLE OF CONTENTS

Page

CHAPTER 1: INTRODUCTION

PROBLEM STATEMENT

Over the past three decades, the Texas Department of Transportation (TxDOT) and its agency partners have implemented many transportation innovations to meet the mobility needs of a growing population and economy. These innovations have included high-occupancy vehicle (HOV) lanes, high-occupancy toll (HOT) lanes, managed lanes (MLs), and toll roads. These types of projects are being considered or implemented in several urban areas of the state. Whenever these projects are considered, agencies must address a range of policy decisions, some of which can be controversial. Moreover, the operating characteristics of a project are likely to change over time, requiring additional policy decisions to adjust operating strategies to match the new operating characteristics.

MLs, HOT lanes, and even HOV lanes are more complex, both from a policy and an operational standpoint, than traditional roads or toll roads. As more of these complex transportation facilities are planned and constructed throughout the state, agencies need to understand and communicate how these facilities may operate over time. The operations should be based on metrics that are agreed upon in advance, ideally before the opening of the facilities. Agencies should also understand and communicate how changes in certain metrics impact the performance of a facility. When agencies define what metrics can most effectively and efficiently measure the performance of a facility and outline what thresholds trigger a change in operation, policy makers and the public can anticipate and appreciate how a facility's operation may change over time. This understanding allows the facility operators to focus on the tasks of efficiently operating a smooth transportation network, rather than on how to get the necessary changes approved in a timely manner.

PURPOSE OF IMPLEMENTATION STUDY

Research Project 0-6396 developed a framework called the Traffic Thermostat, which can help make operating decisions for priced facilities and can guide changes in operational strategies for a facility over time. This implementation project demonstrates how the Traffic Thermostat can be implemented for a specific project, and allowed for adjustments to the framework and implementation process based on results. This pilot focused on the I-30 managed

HOV lanes in the Dallas-Ft. Worth region. In addition, the project created a primer and user's manual to assist agencies in using the Traffic Thermostat. The research team also updated outreach materials developed during the research project.

CHAPTER 2: PROJECT PLANNING AND LITERATURE REVIEW

On August 31, 2011, researchers met with the Regional Managed Lanes Working Group at the North Central Texas Council of Governments (NCTCOG) offices in Arlington, Texas, to describe the implementation project in general and the expected outcomes of the research. At the meeting, researchers presented a summary of the research of Project 0-6396 and described the creation of a Technical Advisory Committee to test the Traffic Thermostat framework on the I-30 corridor, where managed lanes are planned under an Express Lane Demonstration Program (ELDP) agreement with the Federal Highway Administration (FHWA).

Researchers also reviewed a number of documents describing the I-30 project, specifically the potential concept of operations, project-level policies, communication plans, and regional goals. The following documents are included in this review:

- "Business Terms for TxDOT-Sponsored Toll Roads on State Highways," NCTCOG, last modified September 2006.
- FHWA Notice in the *Federal Register*, "Express Lanes Demonstration Program—Performance Goals for the Texas Department of Transportation Express Lanes IH-635/IH-35E and North Tarrant Express Lanes Projects," January 22, 2009, p. 4069.
- Agreement between TxDOT and the North Texas Tollway Authority (NTTA) on excess revenue sharing and the delivery of toll projects, 2006.
- *I-30 Managed HOV Lanes Standard Operating Procedures Manual* (confidential document), TxDOT and Dallas Area Rapid Transit (DART), 2009.
- Express Lanes Demonstration Program application to FHWA, TxDOT, May 2009.
- "Managed Lane Policies," NCTCOG, last modified September 2007.
- Regional Transportation Council (RTC) request of NTTA, NCTCOG, last modified September 2006.
- RTC resolution requesting NTTA compete for toll collection services on TxDOT-related toll roads and managed lanes in north Central Texas, April 2005.
- "IH-30W Value Pricing Project, Pre-HOV and Post-HOV Semiannual Metrics for March 2011," Texas Transportation Institute, May 2011.

This background information was used to test the Traffic Thermostat framework on I-30. Specifically, the information, along with input from the Technical Advisory Committee, helped establish a series of potential goals for the managed lanes, with corresponding measures to assess the operational performance over the life of the project.

CHAPTER 3: TECHNICAL ADVISORY COMMITTEE

The effectiveness of the Traffic Thermostat tool is dependent upon the information that is input into the software. To gather the best data, the research team sought input from all of the agencies involved in planning for the I-30 corridor.

Representatives from these agencies served on the Technical Advisory Committee (TAC). The purpose of the TAC was to provide feedback and concurrence about goals and objectives for the I-30 Tom Landry Freeway corridor from each agency's perspective. Each agency has unique expectations for the facility, and a TAC provides a framework for developing consensus on goals for the project.

Working with the project director, the research team identified TAC participants from each of the following agencies:

- TxDOT Dallas and Fort Worth Districts.
- DART.
- NCTCOG.
- NTTA.

The TAC met for the first time on September 29, 2011, at the NCTCOG offices. At this meeting, the research team presented information about the implementation project. The research team also described the ongoing application of the same methodology to a project in the Austin area. This provided a frame of reference for the TAC and initiated the discussion.

The goal of the kick-off meeting was to familiarize the TAC with the implementation project and ensure the research team's understanding of the I-30 project goals. The research team presented information gained from the RTC adoption of goals for managed lanes projects in the region and from the ELDP application specific to the I-30 project. The TAC discussed whether or not the goals were in agreement.

The TAC later prioritized the goals of the project and the user groups for the facility. The committee also identified performance measures and thresholds appropriate for this project, which were used in the Traffic Thermostat tool.

CHAPTER 4: DEVELOPMENT OF THE TRAFFIC THERMOSTAT PRIMER

A primer outlining the basic goals, performance measures, and associated data elements was developed as supporting documentation to guide the application of the Traffic Thermostat framework to the I-30 Managed Lanes in the Dallas-Fort Worth Region. The primer breaks down the five goals of managing the operation of the facility, ranked by level of significance. Under each goal is a list of measures that can be used to assess the performance of the facility over time, and a short description of the data elements necessary to conduct a valid assessment. Each data element is outlined by mentioning potential techniques for data collection, the infrastructure required to support data collection, and the level of analysis necessary to interpret information. The primer appears in Appendix A.

Communication with the TAC, through in-person collaborative meetings and emails, guided the development of the primer. The research team and the TAC had the following meetings to help develop the primer:

- September 29, 2011: The research team gathered input on the performance goals for the I-30 Managed Lanes. Initial thresholds were suggested along with each goal. For example, defining "…a need to provide a travel speed of at least 50 mph" was a goal that listed a value as a critical threshold. The TAC also identified user groups (e.g., single-occupant vehicles [SOVs], trucks).
- October 28, 2011: The research team gathered input from the previous meeting and emails, and gave the TAC a summary of the feedback received on the goals and user groups. The research team then asked the TAC to rank-order the goals and user groups. The meeting attendees also started discussing the suggested measures for assessing each goal and supporting data elements. Committee members were given a two weeks to provide more detailed feedback.
- November 17, 2011: The research team received the last of the comments on performance goals and user groups from the TAC. Both elements were finalized based on the overall consensus of the committee.

Based on these meetings and feedback from the TAC, the research team developed the primer outlining goals, measures, and data elements during December 2011. In January 2012, they presented a draft copy of the primer to the TAC for review. On February 29, 2012, the research team received the last comment on the draft of the primer, with six members of the TAC submitting feedback on the primer. In March 2012, the research team reviewed the comments and revised the primer.

The primer supports the development of the Traffic Thermostat software tool because it was developed specifically for the I-30 project. This is significant because there are a broad array of generic managed lane measures that could be used within the software tool. The TAC provided important parameters for the software tool. Those parameters were used as a framework to establish a baseline for the performance of the I-30 Managed Lanes in meeting the stated goals of the facility.

CHAPTER 5: APPLICATION OF THE TRAFFIC THERMOSTAT FRAMEWORK

On February 8, 2013, the TAC convened at the NCTCOG offices. Project team member Dr. Mark Burris presented a PowerPoint presentation, explaining the purpose of the Traffic Thermostat software tool and demonstrating how the tool could be used. The user's manual for the Traffic Thermostat, which appears in Appendix B, was also distributed at this meeting.

Throughout the demonstration, the audience asked questions and made suggestions to improve functionality. Suggested improvements were as follows:

- Can the tool be modified to include a toll discount option rather than just free or tolled?
- The text that appears when the tool displays the "lowest priority group" should be modified to show that each group including SOVs should be excluded, not the entire group as a whole.
- Add a symbol on the output screen that clearly shows that tolls were increased.
- Include a warning pop-up when inputs will conflict with each other.

Dr. Burris emphasized that the tool was not an engineering tool but a policy-level tool to walk planners through the decision-making process. Dan Lamers of NCTCOG explained that NCTCOG has a public relations task force that has defined three phases of outreach—pre-opening, operations, and future scenarios. He noted that the tool addresses the future scenarios.

CHAPTER 6: FEEDBACK ON OUTREACH MATERIALS

At this same TAC meeting on February 8, 2013, Tina Geiselbrecht presented outreach products that were developed as part of the original research project. These included a fact sheet, talking points, a press release, and a PowerPoint presentation. She noted that the talking points should include generic information about outcomes. The outreach products are designed to provide policy makers with tools to communicate the concepts of the Traffic Thermostat. The tools are generic in nature, but one suggestion of the TAC was to modify them to provide an example of how they might be used for a project. However, that suggestion could not be accommodated within the scope of this project.

The research team also wanted to share the products with a few policy makers to receive feedback on how effective the tools might be to communicate the Traffic Thermostat. Dan Lamers of NCTCOG provided the roster of the Regional Transportation Council and suggested some members with interest in managed lanes, in particular. In addition, the following message about the implementation project was sent to the RTC members:

> TxDOT has recently sponsored several research projects regarding the planning, implementation, and operation of managed lanes. One study, completed in 2011 and titled Pre-determining Performance Based Operational and Toll Rate Setting Measurers, recommended that managed lane goals and performance measures be set in advance of implementation to ensure the facility is operated and managed effectively to achieve the desired results. The result was the development of a tool to monitor the facility operations and assist in the decision-making process regarding when to adjust operational parameters such as toll rates and auto occupancy. To that end, TxDOT has sponsored a follow-up research project to pilot-test the tool. TxDOT staff have asked their research partner, the Texas A&M Transportation Institute, to refine the tool based on stakeholder input. As an RTC member, you play a significant role in the implementation of managed lanes in the Dallas-Fort Worth area. Since you are a stakeholder, TxDOT and the Texas A&M Transportation Institute would like for some of you to participate in this next phase of the research project. NCTCOG has provided them with the RTC roster, and in the coming weeks you may receive a message from a member of the

> research team to inquire about your potential involvement. Please consider the request relative to your interest in this topic area and your time availability. Note that NCTCOG is not a sponsor of this particular research initiative, but members of our staff have participated in and have provided data to support the project.

Following this message, the outreach products were emailed to the suggested individuals with a request to provide feedback by April 5, 2013. The researchers took the input received and modified the outreach products based on this input.

CHAPTER 7: CONCLUSION

As priced facilities become more prevalent in the state, TxDOT and its regional partners will benefit from approaches that can assist agencies in maintaining the performance of the facilities in a methodical and transparent way. The purpose of the research study was to develop a framework for managing performance based on performance measures and to provide communications products that can be used in applying the framework to priced facilities. In this companion implementation project, the framework was adapted for a particular application to the I-30 corridor in the Dallas-Fort Worth region, with the application largely resulting from a process that engaged multiple regional stakeholders that are involved in developing and operating managed lanes.

In the Dallas-Fort Worth application, the most probable end user of the framework will be the metropolitan planning organization (MPO), which has broad authority for the establishment of tolling and pricing goals for the region and for the projects that are implemented. Upon the completion of the research implementation effort, the MPO staff described the following uses of the framework and products:

- Generate and keep track of priorities should we have a decline in performance, such as lower speeds.
- Implement a thoughtful process and methodical approach to performance management.
- Increase involvement of policy makers in the region regarding operational changes that would need to be made, and help support options when presented to stakeholders.

TxDOT, working with regional partners in metro areas across the state, can apply the framework to collaboratively support and sustain operational policies for priced facilities.

APPENDIX A: TRAFFIC THERMOSTAT PRIMER

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

Primer of the Performance Measures and Related Data Elements

The scope of the primer is to outline the potential data elements that may be necessary to assess the performance of the I-30 Managed Lanes in meeting the stated goals of the facility. Each goal is broken down into suggested performance measures, ranked by order of significance, and assessed by the data elements required to conduct an evaluation. Most of the performance measures use information that is derivative of transportation data elements, such as speed, volume, and travel time. Within each performance measure section, a discussion is provided on the possible data collection methodologies, the infrastructure necessary to collect data, and the analysis procedures to assess the performance. The level of involvement—rated as low, medium, or high involvement—is interpreted as the number of resources necessary to provide specific measures. Where applicable, the I-30 Managed Lanes will be evaluated by tolling zone for the subject areas that can be properly assessed using data derived from the infrastructure. If the intelligent transportation system (ITS) is not capable of providing reliable data on a zone-specific level, the entire corridor will be assessed instead. The ITS infrastructure will have to be reviewed separately to examine whether sufficient coverage exists to support the Traffic Thermostat tool. The measures will be assessed on a continual basis—iteratively as relevant data become available—to adjust the operating conditions and design features of the facility.

The tolling zones as described for evaluation are identified from the latest set of plans for the I-30 corridor:

- Ballpark Way to North Belt Line Road.
- North Belt Line Road to MacArthur Boulevard.
- MacArthur Boulevard to Walton Walker Boulevard.
- Walton Walker Boulevard to North Westmoreland Road.
- North Westmoreland Road to Sylvan Avenue.

Goal #1: The I-30 Managed Lanes need to provide an average travel speed of at least 50 mph.

The performance measures under this goal are:

1. Travel speed.
2. Travel time.
3. Travel time index.
4. Travel density.
5. Travel delay.

Travel Speed

Target: The managed lanes need to operate at an average travel speed of at least 50 mph in all of the major segments.

Average travel speed is a measure of the distance traveled per unit of time that is experienced by users. The Express Lanes Demonstration Program (ELDP) agreement signed by the Texas Department of Transportation (TxDOT) and the Federal Highway Administration (FHWA) outlines a minimum travel speed goal of 50 mph for the I-30 Managed Lanes. If the speed is degraded from 50 mph, the operating parameters of the facility will change and should result in higher travel speeds, regardless of the difference in magnitude. The agreement also establishes a framework for TxDOT to periodically report speeds to FHWA that are aggregated by AM peak, off-peak, and PM peak time periods. Currently, the monthly average vehicle speed in the I-30 managed/high-occupancy-vehicle (HOV) lane exceeds 60 mph, based on year 2010 data.

Required Basic Data Elements: Speed
Data Collection (Low to High Involvement): Collecting and archiving data from Wavetronix and video camera detection sensors (e.g., Autoscope SOLO) are standard practices performed at the DalTrans Traffic Management Center, which is operated by TxDOT. Lane-specific information on speed and volume is gathered from the Wavetronix sensors operated by DalTrans. Data can be aggregated into 5- or 15-minute average summaries or be continuous.

Infrastructure (Low to High Involvement): The devices used to measure travel speed (either observed at a single location or along a trajectory—limitations appear below) can be:

- Portable traffic counters.
- Portable side or overhead counters.
- Permanently installed inductive loops (with a connected recorder collecting data).
- Instrumented vehicles.

Collecting data using an instrumented vehicle equipped with a global positioning system (GPS) may require more involvement because of the high sample size required to validate significantly reliable statistics, which would necessitate a large budget due to in-house data collection. Third-party GPS data may be purchased at a reduced cost when compared to supporting in-house data collection processes.

TxDOT may already have enough detectors located along the I-30 corridor to observe speeds for the five tolling segments, given the functionality and capability of the detectors. Other traffic management centers (TMCs) in Texas are considering Wavetronix or Bluetooth®-based sensors to collect speed information.

The locations to install detector infrastructure supporting speed-based performance measures can be tiered into the following three approaches, ordered by level of investment:

- Minimum: One detector is used for an entire corridor that is not affected by bottlenecks and does not have operational issues. The location also cannot be near any access or ingress/egress areas where the detector may misread vehicles transitioning on and off the highway.
- Preferred: Multiple locations that are not near any ingress/egress point, bottleneck, or area with operational issues (e.g., segment with a high volume of merging vehicles). For the I-30 corridor, this could be one or two sensors—depending on whether there are one or two managed lanes in the segment—for every tolling zone in each direction (for a potential total of 10 or 20 locations).
- Optimum: Speed sensors located every ½ or ¼ mile using inductive loops or some other type of detector product.

Analysis (Medium Involvement): The level of analysis will depend on the type of technology used to collect speed data. Sensor data collected at spot locations may reliably observe speed, but stationary sensors cannot ascertain average corridor performance along a trajectory—only at single points. GPS data are capable of communicating performance at instances for a path of travel, but the interpretation of data may require a significant post-processing effort to assess the data.

Travel Time

Target: The 95th percentile peak-period travel times in the managed lanes need to be no more than 8 minutes (for 7.5 miles of travel) in the eastbound direction and 13 minutes (for 12.1 miles of travel) in the westbound direction.

Travel time is a measure of the time needed to traverse from one point of the system to another. The ELDP between TxDOT and FHWA requires TxDOT to provide periodic reports on the travel time differential between the general purpose lanes and managed lanes, aggregated by daily averages, AM peak, and PM peak time periods. The 95th percentile travel time was selected because it is representative of the slowest day in a month. The average travel time on the I-30 HOV lane was 7.4 minutes for the 7.5 miles in the eastbound direction and 11.8 minutes for the 12.1 miles in the westbound direction (based on year 2010 data).

Required Basic Data Elements: Travel Time

Data Collection (Low to Medium Involvement): Potential methodologies for collecting travel time data include:

- Average travel time using manual observation techniques (e.g., technician with stopwatch) or GPS equipment.
- Bluetooth readers to match observations.
- License plate recognition technology to match plates.
- Transponder tag reads from a toll collection system.

The time frames for data collection can either be aggregated into 5- or 15-minute averages, or be provided as a continuous dataset.

Infrastructure (Low to Medium Involvement): Using a floating car methodology (recording the start and stop times of a vehicle passing through a corridor) does not require the installation of extensive technology. However, the floating car method is intensive in manpower. Automatic license plate readers and Bluetooth sensors can add costs to data collection due to the installation of new equipment.

The locations to install infrastructure supporting time-based performance measures can be tiered into the following three approaches, ordered by level of investment:

- Minimum: Short-term manual data collection studies performed by corridor.
- Preferred: Studies done by corridor with added intermediate waypoints. For the I-30 corridor, this could potentially be at the termini of the tolling zones (as indicated in the introduction).
- Optimum: Studies performed by corridor, but multiple start and endpoints are added to correspond directly to ingress/egress points.

Analysis (Low Involvement): The analysis of travel time data should be relatively straightforward, but some post-processing may be required to grasp a complete composite of the corridor if data are collected for a number of different segments. Travel times in both the managed and general purpose lanes must be measured if a comparison is to be generated between the two lane groups. Gathering travel time data for the general purpose lane may be difficult because the lanes do not commonly have electronic toll collection (ETC) equipment.

Travel Time Index

Target: The travel time index in the managed lanes will need to be less than 1.05.

The travel time index (TTI) is a comparison of the peak-period travel time to free-flow travel time, represented as the ratio between the two values. The travel time index is a holistic measure of individual segment performance that incorporates both recurrent and non-recurrent congestion into a calculation to assess how much additional time is added onto a trip, relative to congestion-free travel. In short, the calculation of the travel time index can be viewed in the following equation:

For a specific road section and time period:

$$\underset{\text{(no units)}}{\text{Travel time index}} = \frac{\text{Average travel time (minutes)}}{\text{Free-flow time (minutes)}}$$

The average travel time in the managed/HOV lane during the year 2010 was essentially the same as the free-flow travel time, indicating a TTI of approximately 1.00.

Required Basic Data Elements: Travel Time and Volume

Data Collection (Low Involvement): The data collection methodology is dependent upon basic travel time and corresponding volume data that are collected during peak travel periods. The methodology for collecting volume data is similar to collecting travel time information.

Infrastructure (Low Involvement): For the volume component of the travel time measure, some potential types of infrastructure include:

- Portable traffic counters.
- Portable side or overhead counters.
- Permanently installed inductive loops (with a connected recorder collecting data).
- Instrumented vehicles.

The use of temporary, or portable, counters will limit the potential data collection points needed to produce a valid measure. Many ingress and egress points along a corridor with few data collection points may also result in erroneous volume data, due to poor placement of the vehicle detector.

The locations to install infrastructure supporting volume-based performance measures can be tiered into the minimum, preferred, and optimum approaches—the same hierarchy as the basic speed performance measure.

Analysis (Medium Involvement): A travel time index that incorporates corridor-level performance has to account for different volumes within individual segments—by weighting individual segments by the vehicle miles traveled (VMT). VMT is not directly measurable from a facility but can be calculated by assessing volume data along with static roadway and link length information. The travel time index can be measured either by tolling zone (as indicated in the introduction) or for the entire length of the corridor).

Any travel time data element that is dependent upon observations based on a single point, such as a permanently installed counter, has to consider conditions that may continuously exist along the corridor. A process can be undertaken, using assumptions (such as extrapolating spot speeds along the distance of a segment), to render stationary data for trajectory-based corridor performance. However, these steps may limit the accuracy of the reported travel time values.

Travel Density

Target: The travel density in the managed lanes needs to be less than 26 passenger cars per mile of lane-highway (pc/mi/ln).

According to the 2010 *Highway Capacity Manual* (HCM), travel density is a measure to assess level of service for basic, weaving, merging, and diverging freeway segments. The units for expressing travel density are expressed as lengths of passenger car equivalents occupied by a vehicle within a mile of a lane for a freeway segment. Weighting of values is done to interpret the level of service for an entire facility. The threshold between level of service C and D is defined as 26 pc/mi/ln.

Data Collection (Medium Involvement): Travel density can be calculated from the field using volume and speed data. The HCM does not currently outline a field measurement procedure for assessing density. An approximation of density can be made using imputed data elements representing the demand flow rate, geometric characteristics, heavy-vehicle composition, capacity, and other elements.

Infrastructure (Medium Involvement): Volume can potentially be measured:

- Manually using temporary pneumatic counters (continuous counts may be difficult to compile because pneumatic tubes may not last long within active lanes of traffic).
- With embedded sensors within an integrated ITS network.

Speed can be approximated using similar techniques. Conducting spot speed studies is preferential to using embedded sensors because sensors have to rely on more error-prone assumptions due to static placement.

Analysis (Low Involvement): Calculation of density is a function of speed and volume, based on the fundamental relationship of traffic flow theory, which defines density as the quotient of volume by speed ($d = v/s$). Since travel density is a unit of cars per lane-mile of highway, travel density can be measured by tolling zone.

Travel Delay

Target: The travel delay in the managed lane needs to have less than 40 vehicle-hours of delay per day (based on a travel time observed via the floating car method) of operation, compared to the general purpose lanes.

Travel delay is defined as the amount of lost time experienced by users of a system multiplied by the number of users. Delay can be aggregated by lane group (general purpose or HOV) and time period. The units for measure are given as vehicle-hours. Currently, there is no delay experienced during the AM peak period in the eastbound direction, but approximately 45 vehicle-hours of delay was experienced, on average, in the westbound direction during PM peak-period operation (based on year 2010 data using an average volume of 1,250 vehicles and a travel time difference, using the floating car method, of 2.2 minutes between the HOV and general purpose lanes).

Required Basic Data Elements: Travel Time and Volume

Data Collection (Low Involvement): The data collection methodology is dependent upon basic travel time and speed data that are typically collected by TMCs.

Infrastructure (Low Involvement): No additional infrastructure is needed beyond what is required for travel time and volume data.

Analysis (Medium Involvement): Data extrapolation on basic travel time and volume data elements needs to be done to translate basic single-location data to corridor-based measures. Travel delay can be measured by the length of the entire corridor since it is commonly viewed as a macro-level statistic. A good estimate of travel delay would use the travel times as measured by the floating car method, factored by the volume of the facility to calculate performance along a vehicle path.

Goal #2: The I-30 Managed Lanes need to provide more reliable travel than the general purpose lanes, as measured by speed and time.

The performance measures under this goal are:

1. Buffer index.
2. Planning time index.
3. Days per month below speed threshold.

Buffer Index

Target: The managed lanes need to have a buffer index of 5 percent or less.

The buffer index (BI) is a measure of travel reliability that can account for the variations with the distribution of travel times due to non-recurrent congestion. Traffic incidents, crashes, and the weather are all causes of non-recurrent congestion. The BI is equivalent to the extra time travelers must add to their average travel time when planning trips. Specifically, the BI is defined as the ratio of the difference between the 95th percentile and average travel times to the average travel time. The ELDP agreement stipulates that TxDOT has to report the buffer index for the I-30 Managed Lanes, as aggregated by weekday AM peak, off-peak, and PM peak time periods. In summary, the computation of the BI can be explained in the following equation:

For a specific road section and time period:

$$\text{Buffer index } (\%) = \frac{\begin{matrix}95^{th} \text{ percentile travel time} \\ \text{(minutes)}\end{matrix} - \begin{matrix}\text{Average travel time} \\ \text{(minutes)}\end{matrix}}{\text{Average travel time (minutes)}}$$

Required Basic Data Elements: Travel Time and Volume

Data Collection (Medium Involvement): The BI is primarily reliant on the travel time data element as an input parameter. Data for reliability measures can be captured through four primary techniques:

- Direct observations from continuous vehicle probes.
- Estimation from point-based detectors.
- Floating car runs.
- Estimated computer simulation.

To interpret BI as a corridor-based measure, volume data should be incorporated to weight the travel times by frequency of use. A continuous dataset is preferential to gather a large enough sample size, transcending time periods, to produce statistically valid measures. For example, gathering data from a continuously operated TMC with embedded sensors would be preferential to conducting numerous floating vehicle travel time runs to establish a large, significantly valid dataset for analysis.

Infrastructure (Medium Involvement): No additional infrastructure is needed beyond what is required for travel time and volume data.

Analysis (Medium Involvement): Calculating the BI will require some intermediate data analysis because the format of the data will likely be more detailed than what is needed for calculation. Probe data will need to be associated with roadway links and aggregated by specified time periods. Point-based detector data require link-based travel times to be estimated for each time period of analysis. Quality assurance is also an important step to ensure data validity. The buffer index can be measured by the length of the entire corridor to capture trip-based statistics.

Planning Time Index

Target: The managed lanes need to have a planning time index of 1.05 or less.

The planning time index (PTI) represents how much total time a traveler should allow for ensuring on-time arrival, as opposed to additional time represented from the BI. The PTI is useful because it can be compared to the travel time index. The difference between the PTI and the travel time index is the use of the 95^{th} percentile travel time as opposed to the average travel time. The PTI is usually greater than the BI because the PTI is influenced more by non-recurrent congestion. Data can be aggregated by peak hour, peak time period, and daily time period. The formal equation to compute the PTI is:

For a specific route/trip and time period:

$$\underset{\text{(no units)}}{\text{Planning time index}} = \frac{95^{th}\text{ percentile travel time}}{\text{Free-flow travel time}}$$

Required Basic Data Elements: Travel Time and Volume

Data Collection (Medium Involvement): Data collection procedures are similar to those used for the buffer index.

Infrastructure (Medium Involvement): Infrastructure requirements are similar to those used for the buffer index.

Analysis (Medium Involvement): Analysis procedures are similar to those used for the buffer index. Once the distribution of travel times is established for a segment, corridor, or system, the PTI equation can be applied. The planning time index can be measured by the length of the entire corridor to capture trip-based statistics.

Days per Month below Speed Threshold

Target: The average speed in the managed lanes should not fall below 50 mph for a time period of greater than 15 minutes. The speed threshold should not be breached for more than one 15-minute instance during an entire month of operation.

The concept of assessing the number of days per month operating below a set speed threshold is meant to capture a measure of travel reliability that is more readily understood by the traveling public. It can be easier to grasp the notion of days of unsatisfactory performance, as opposed to a dimensionless buffer or planning time index.

Required Basic Data Elements: Speed
Data Collection (Medium Involvement): The data collection effort would require collecting continuous travel speeds over a longitudinal time period.
Infrastructure (Medium Involvement): The use of spot speed studies may not require intensive infrastructure, but the approach may not yield a large dataset that can have observations during all time periods. Preferably, embedded sensors in the facility can continuously capture and catalog speed data.

Analysis (Low Involvement): The analysis of data would necessitate the averaging of speed by 5- or 15-minute intervals for all the days of operation in a month. This measure can be captured by considering data aggregated by tolling zone to evaluate where degradation exists in the corridor.

Goal #3: The I-30 Managed Lanes need to provide choices for travelers.

The performance measures under this goal are:

1. Public perception of user choice.
2. Number of unique users.
3. Number of HOVs in the managed lanes.
4. Occupancy ratio.

Public Perception of User Choice

Target: A majority of users affirm that various travel options are available to them through answering a public opinion survey. The potential question posed could be: "Do you feel that the I-30 Managed Lanes are an acceptable travel choice for you?"
Measuring user satisfaction can be a good method to assess acceptability among members of the general public. In the context of managed lanes, the perception of personal freedom (or choice) can be viewed as the ease to switch between different modes of the transportation system—whether it be traveling in an SOV, HOV, or transit vehicle. This measure can capture the attitudes of users from all modes of transportation.

Data Collection (Low to Medium Involvement): Attitudinal surveys given iteratively assess the overall awareness, acceptance, and satisfaction of a facility. The specific instruments used to gather information may include:

- Focus groups.
- Telephone surveys.
- Mail-back driver surveys.
- Onboard surveys (potentially at park-and-ride lots).
- Web-based surveys.

Infrastructure (Low to Medium Involvement): The costs to support data collection for public perception-based measures can range from a unit cost of $4 per web-based survey to $7,000 for conducting a single focus group session.

Analysis (Medium Involvement): Conducting focus groups can enable analysts to understand different user reactions with an in-depth investigation of specific market segments. Analyzing focus group data can potentially be a time-consuming exercise with interpreting feedback that may be vague, not directly specific, or not absolute. However, analyzing aggregated web-based data is fairly simple but may not provide data that can support statistically significant conclusions. A web-based survey may also be prone to being skewed due to the presence of repeat participants.

Number of Unique Users

Target: The number of unique users in the managed lane needs to be greater than an average of 3,800 users per weekday. This threshold is determined by discounting the multiple trips made by home-based, journey-to-work travelers in the region, which is presently 56 percent of all volume on major highways in the Dallas-Fort Worth Region (from the 2005 Dallas-Fort Worth External Survey, done by the Texas A&M Transportation Institute).

A good measure of a facility that can provide user choice is one that can aptly serve a diverse number of user groups. The number of unique users is a non-traditional measure used to assess the variety, or uniqueness, of the demographic served by a transportation system. This measure is different from the total volume of persons and vehicles because the value does not double-count occurrences that are due to the same individuals or parties taking multiple trips in the same day or time period. Since the concept of user choice is a bit nebulous, data collection and analysis may be a bit harder to define than traditional measures. It is suggested to base the threshold using the person throughput value, and to discount journey-to-work trips that give an additional weighting factor to commuter households in overall volume counts. An assumption can be made that most households that complete multiple, same-day trips are conducting, on average, at least two trips on the same facility. Additional study can help to refine the process by incorporating observed information from travel surveys. An assumption of two trips per commuter household can be used in the absence of detailed information. The methodology to determine the threshold for the number of unique users can also be expressed in an equation, such as:

T_{avg} = *Average number of work-related trips made per household by home-based commuters*

PT = Person throughput (people per hour)

CT = Percent of home-based trips conducted by commuters (%)

$$\text{Number of unique users} = PT * \left(1 - \frac{CT}{T_{avg}}\right)$$

Note: To more precisely capture the number of unique users, a similar procedure should be performed to discount multiple, same-day trips made by intraregional businesses and commercial delivery fleets. Additional survey data from these travel uses would also be required.

Data Collection (High Involvement): Potential data elements used to measure the number of unique users may include:

- License plate tags.
- Number of transit riders.
- Vehicle occupancy counts.
- Volume data from automatic counters.

Infrastructure (High Involvement): The infrastructure used to gather license plate tags is extremely complex and could potentially require many hours of manpower to collect data. Automatic license plate readers (ALPRs) are a possible solution to autonomously gather and catalog license tags, but the equipment is prone to error and misreading characters, resulting in an erroneous dataset. For example, operators in many toll offices have to manually check plate characters after a vehicle is tagged as a violator by ALPR before an official violation is issued. The number of transit riders can be collected by assessing the ridership logs from transit vehicles and aggregating the number of boardings per run. Coordinating vehicle occupancy counts requires significant manpower to staff observers on the side of the road, during set time periods, and attempting to record a sample of the number of passengers from observed vehicles.

Analysis (High Involvement): Interpreting the data for analysis would likely be fairly complex, due to the association of different data elements. This measure can be assessed by the length of the entire corridor to capture macro-level traveler characteristics.

Number of HOVs in the Managed Lanes

Target: The average daily number of HOVs in the managed lanes needs to be at least 2,900 for an average week, excluding major holidays. The threshold represents a 15 percent increase over current HOV volume.

The number of HOVs that are traveling in the managed lane is a measure of how successful carpooling initiatives are in the corridor. A good indication of user choice may be the use of alternative travel modes, other than single-occupant vehicles (SOVs), assessed by volume of non-SOV modes. If the HOV volume is lower than the threshold, additional incentives (potentially monetary prizes through an awards program) may be implemented to increase ridesharing in the corridor. Based on year 2010 data, the daily average volume of HOVs on the I-30 corridor was 2,532 vehicles.

Data Collection (Medium to High Involvement): Data collection of HOVs currently relies on periodic vehicle occupancy counts to determine which passenger vehicles are SOVs or HOVs. Once the facility is converted to a high-occupancy toll (HOT) lane, then tolling equipment with a back-end office that can handle user-declaring statuses could potentially collect data autonomously. However, it is strongly suggested that manual occupancy counts be used to verify data from the tolling system. Manual occupancy counts are iteratively being conducted on I-30.

Infrastructure (Medium to High Involvement): Facilities that are non-tolled have to rely on manual occupancy counts, and facilities that are tolled have the capability to electronically detect vehicles. Manual counts require individuals to be placed on the side of the road to record the number of passengers observed inside the vehicles. Electronic toll equipment, placed iteratively along the corridor, can record the number of tags that are declared through the system. For a system that does not incorporate self-declaring switchable transponders, a process can be implemented whereby users can call in or interact via a web portal (and potentially through a mobile application) to give their occupancy status before a trip on the facility is conducted. An autonomous tolling infrastructure requires a user-declaration process to measure volume from specific user groups (e.g., SOV versus HOV), or else manual counts will be required to record information. Manual occupancy counts are costly to collect, but if HOV volumes can be derived from the tolling infrastructure, then the data collection cost for solely counting HOVs may be less. Before an HOV-to-HOT lane conversion, basic volume data can be used to determine baseline HOV usage, and vehicle occupancy counts can be used to account for noncompliance rates.

Analysis (Low to Medium Involvement): The level of analysis is low because only averaging and aggregating are required once the data collection process is complete. Toll account status (whether the vehicle is currently in toll or non-toll mode) and toll account type (toll paying, transit vehicle, or toll exempt) are two required variables that need to be present in order to conduct an analysis. This number of HOVs can be assessed by the length of the entire corridor to capture macro-level traveler characteristics. Verification of any data from the tolling system should be done with manual vehicle occupancy counts.

Occupancy Ratio

Target: The occupancy ratio in the managed lanes needs to be greater than 2.20, based on a monthly average.

The occupancy ratio is a measure of travel mode use that is inclusive of total persons and vehicles traveling in the managed lane and displayed as a ratio of persons to vehicles. The vehicle part of the ratio is comprehensive of all travel modes, including SOVs, HOVs, transit services, vanpools, and motorcycles. However, there are currently no significant transit services that operate on the I-30 managed/HOV lanes. Measuring the occupancy ratio is currently being done on the managed/HOV lanes in the Dallas-Fort Worth region. Based on year 2010 data, the monthly average occupancy ratio was 2.08 for the existing HOV lanes on the I-30 Tom Landry corridor.

Data Collection (High Involvement): Data collection is dependent upon the ability to count the number of people and vehicles traveling on the managed lane. The only common source to collect vehicle person occupancy data is from manual observation. No commercially available equipment or third parties currently provide data. Factors that can complicate the collection of vehicle occupancy data include window tinting, sun angles, twilight hours, vehicle height, vehicle speed, occlusion, and ability to see passengers in the back seat.

Infrastructure (High Involvement): The number of vehicles can be counted using automatic traffic recorders or detection equipment as part of an ITS infrastructure, similar to how basic volume data elements are collected.

The locations to install infrastructure supporting vehicle-occupancy-based performance measures can be tiered into the following three approaches, ordered by level of investment:

- Minimum: Data collected at the main entry point.
- Preferred: Data collected at additional ingress/egress points.
- Optimum: Data collected at all ingress/egress points.

Vehicle occupancy data can be collected manually either during peak periods (minimal approach), for multiple time periods (preferred approach), or during a constant 24-hour cycle (optimum approach).

Analysis (Low Involvement): Analysis of the occupancy ratio is a fairly straightforward process with some intermediate steps of data aggregation to calculate daily values and monthly averages. This measure can be assessed by the length of the entire corridor to capture macro-level traveler characteristics.

Goal #4: The I-30 Managed Lanes need to maximize person throughput throughout the corridor.

The performance measures under this goal are:

1. Person throughput.

Person Throughput

Target: The person throughput in the managed lanes needs to be more than an average of 6,100 per day. The threshold represents a 15 percent increase over current person throughput values.

Person throughput is a measure of performance that assesses, as a whole, the number of people served by a facility or a system regardless of particular travel mode used. The measure is commonly calculated by conducting manual vehicle classification and corresponding occupancy counts to gather a sample of the number of passengers per vehicle mode (since knowing the number of all the passengers within a vehicle is limited by currently applied technology) and multiplying that figure by the number of vehicles by detected mode. People riding transit are usually counted by factoring the number of detected transit vehicles by the average ridership per route, typically given in an operations report. The monthly average of the person throughput for the I-30 managed/HOV lane was 5,274 people in year 2010.

Data Collection (High Involvement): Data collection is dependent upon the ability to count the number of people and vehicles traveling through a corridor. The only common source to collect vehicle person occupancy data is from manual observation. No commercially available equipment or third parties currently provide data. Factors that can complicate the collection of vehicle occupancy data include window tinting, sun angles, twilight hours, vehicle height, vehicle speed, occlusion, and ability to see passengers in the back seat.

Infrastructure (High Involvement): Vehicle classification and corresponding occupancy counts are necessary to measure person throughput for a facility, which would include program support of time for physical observers to record observations. Periodic observations can be made during peak time periods of different days within the same week or month. Additional data collection can be performed to capture a 24-hour continuous operation cycle. Information on vanpools can be summated from operation reports, whether using monthly or quarterly aggregated data. Gathering basic vehicle detection information would be the same as collecting other vehicle-occupancy-based data elements.

Analysis (Medium Involvement): The analysis to compute a person throughput measure would be centered on the process of factoring vehicle occupancy counts by designated mode (e.g., SOV, HOV, vanpool, or transit) by the volume detected for each mode. This measure can be assessed by the length of the entire corridor to capture macro-level traveler characteristics.

Goal #5: The I-30 Managed Lanes need to ensure safety and security in the managed and general purpose lanes.

The performance measures under this goal are:

1. Number of crashes.
2. Crash rate.
3. Incident clearance time.

Number of Crashes

Target: The number of injury crashes in the corridor needs to be less than 80 crashes per year.

The number of crashes is a measure used to assess, on a basic level, the performance of a facility as it pertains to ensuring the safety of users.

Data Collection (Low Involvement): Potential sources for the number of crashes data element include the manual aggregation of incident records, automation of incident center and crash record systems, and the purchase of third-party information. The typical methods of gathering data are manual reports and incident records from a TMC. Costs to collect data are primarily based on the manpower used to determine appropriate records, and to extract and compile information. Crash data can be obtained from TxDOT by filing an online request to have TxDOT staff query the Crash Records Information System (CRIS) system for certain variables. Individual crash records are reported in the CRIS system, including information on county and city of crash location, date, time, severity, nearest intersection, type of object struck, and weather conditions. A summary of the type and format of data available from CRIS can found within a presentation made by North Central Texas Council of Governments (NCTCOG) staff in July 2010 (http://www.nctcog.org/trans/safety/CRIS.pdf). The page to request CRIS data from TxDOT can be found at http://www.dot.state.tx.us/drivers_vehicles/crash_records/data.htm.

Infrastructure (Low Involvement): No major physical infrastructure requirements are needed to collect the number of crashes.

Analysis (Low Involvement): The steps to determine the number of crashes from a facility include:

1. Query the TxDOT CRIS dataset to get the number of raw events recorded for a given time period.
2. Create a geodatabase using latitude and longitude coordinates.
3. Import the dataset into ArcGIS.
4. Select the highway network for analysis based on a roadway buffer of 100 feet.
5. Export the records with coordinates that fall within each buffer zone.

The sum of the number of records by zone is the number of crashes for a given segment of a highway facility. A similar process to extract and use TxDOT CRIS was given in an NCTCOG presentation made in September 2011 (http://www.nctcog.org/trans/safety/CrashRateDevProcess_092311.pdf). This measure can be captured by considering either the entire corridor or the tolling zone.

Crash Rate

Target: The injury crash rate in the corridor needs to be less than 20 incidents per 100 million VMT.
The crash rate is a derivative of the frequency of injury crashes that takes into account the vehicle volume (or use) traveling on that facility. Commonly, the crash rate is expressed as the number of injury crashes occurring for every 100 million VMT. Under inclement conditions (i.e., an ice storm), the managed lanes would receive the same preferential treatment as the general purpose lanes.

Data Collection (Low Involvement): The data collection process to gather information pertaining to the crash rate measure includes two basic data elements: the number of injury crashes and VMT. The number of injury crashes can be collected from physical incident records, a traffic management center, or a third-party vendor. Vehicle volume can be collected by using portable traffic counters, permanently installed inducted loops, or side-mounted sensors (e.g., Bluetooth technology). Specifically for I-30, crash data can be found by querying the TxDOT CRIS dataset.

Infrastructure (Low Involvement): No additional physical infrastructure is needed beyond what is needed to collect volume data.

Analysis (Medium Involvement): The process used to compute the injury crash rate, using VMT and the number of crashes as the input variables, can be described from the equation:

*Crashes * 100,000,000 / (365 * VMT)*

The value of VMT is defined as the product of annual average daily traffic and highway length segment. Therefore, this measure is best viewed for an entire highway corridor, as opposed to a specific tolling zone.

Incident Clearance Time

Target: The average incident clearance time in the corridor needs to be less than 20 minutes for property-damage-only incidents and 40 minutes for incidents with reported injuries (excluding fatalities). The incident clearance time is defined as the amount of time from when an incident for an inoperable vehicle (or debris) is first reported until the vehicle is removed from the scene and traffic is permitted to flow freely. Fatalities are excluded from the clearance time calculation because police officers need the appropriate amount of time to cordon the lane and report a fatal incident.

Data Collection (Medium Involvement): Sources of data to determine the incident clearance time include manual aggregation of incident records (for start and end time variables), reporting from an automated function of a TMC, and purchased reports from a third-party vendor. The costs to collect and validate data are dependent upon the amount of manpower used to determine the appropriate records for analysis and to extract information. Certain incident records may be erroneous or lacking significant detail, potentially requiring more time for validation.

Infrastructure (Low Involvement): No major physical infrastructure is required.

Analysis (Medium Involvement): Analysis is primarily dependent upon the ability to quantify key variables (the start and end time per individual incident) from the incident reports into a single dataset. Crash rates can also be shown by vehicle class and time period. Special data aggregation can be done to show performance under certain operating rules (e.g., time period for 50 percent discount for HOV-2). This measure can be captured by considering either the entire corridor or the tolling zone.

Summary of the Level of Involvement by Performance Measure

Performance Measure	Level of Involvement		
	Data Collection	Infrastructure	Analysis
Goal #1: The I-30 Managed Lanes need to provide an average travel speed of at least 50 mph.			
Travel Speed	Low to High	Low to High	Medium
Travel Time	Low to Medium	Low to Medium	Low
Travel Time Index	Low	Low	Medium
Travel Density	Medium	Medium	Low
Travel Delay	Low	Low	Medium
Goal #2: The I-30 Managed Lanes need to provide more reliable travel than the general purpose lanes, as measured by speed and time.			
Buffer Index	Medium	Medium	Medium
Planning Time Index	Medium	Medium	Medium
Days per Month below Speed Threshold	Medium	Medium	Low
Goal #3: The I-30 Managed Lanes need to provide choices for travelers.			
Public Perception of User Choice	Low to Medium	Low to Medium	Medium
Number of Unique Users	High	High	High
Number of HOVs in the Managed Lanes	Medium to High	Medium to High	Low to Medium
Occupancy Ratio	High	High	Low
Goal #4: The I-30 Managed Lanes need to maximize person throughput throughout the corridor.			
Person Throughput	High	High	Medium
Goal #5: The I-30 Managed Lanes need to ensure safety and security in the managed and general purpose lanes.			
Number of Crashes	Low	Low	Low
Crash Rate	Low	Low	Medium
Incident Clearance Time	Medium	Low	Medium

APPENDIX B: TRAFFIC THERMOSTAT USER'S MANUAL

Use of the Traffic Thermostat Decision Tool

The traffic thermostat decision tool is built to help guide the user through a logical, step-wise process of examining potential changes to the managed lane/toll facility. The user will need to gather a great deal of information prior to making good use of this tool. The information needed to make the best use of this tool includes:

1. How is the facility currently operating? In the case of planning a future facility, this would be how it is expected to operate upon opening. Issues include:
   a) What user groups, if any, are allowed on the facility toll free? Which are allowed if they pay a toll? What are the toll levels—do they vary, or are they the same for all user groups? Which user groups are never allowed?
   b) What are the operational characteristics, including average travel speeds, travel time reliability, crash rates, toll revenue, and person movement on the lane?
   c) What are the design characteristics, including number of lanes, number and location of entry/exit points, and enforcement locations?
2. What are the primary (one or two) goals of the facility?
3. How do you plan to measure the lane's ability to meet the goals? What constitutes successfully meeting the goals?
4. What potential changes are possible on this facility to improve performance of the facility? How much will implementing any/all of these changes impact the operation of the facility?
5. Which user groups will be the first to be tolled or removed from the lane? In essence, which user groups will get the most preferential treatment, and which will get no preferential treatment?

Once the user has collected the information outlined above, he or she will be able to examine multiple policy options for the facility. These options will be focused on ensuring the facility meets its operational objectives based on the goals set by policy makers. The tool is available online at http://thermostat-dev.tti.tamu.edu/. This user's manual steps the user through the process of using this tool.

Screen 1: Initial Facility Type

In the first screen (see Figure 1) the user must indicate the user's name, the name of the roadway, and the current (or planned opening day) type of facility. Based on answers provided in subsequent screens, the facility type may change, but at this point information on how the facility is currently operating is required. There is also an option to browse and upload a project file. For all screens, click Next once you are ready to continue. On subsequent screens there is also the option to hit Back to change your answers on the previous screen.

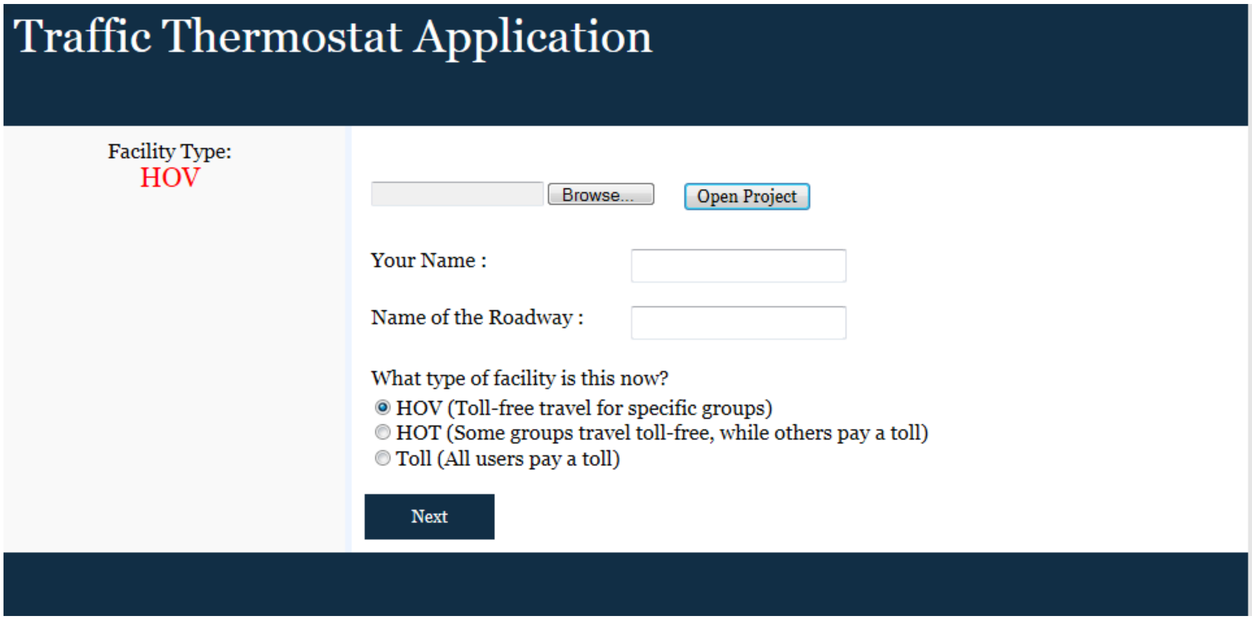

Figure 1. Opening Screen—Choose Facility Type.

Screen 2: Facility Goals

In the second screen (see Figure 2) the user must select one or two primary goals of the facility. At first glance this would appear difficult because all goals are likely important. Keep in mind that the selection of primary goals will then lead to setting specific measures of effectiveness (**Screen 3**) that, if not met, force a change in the operations of the facility. Keeping this in mind may help select the appropriate goals. Alternatively, the user could run the tool multiple times, selecting different goals each time. After running these multiple scenarios, the user would have multiple outputs detailing the operational changes required to obtain many different goals and to achieve different measures of effectiveness.

The tool is built to warn the user when the goals may be conflicting. Unfortunately, many goals have the potential to conflict with other goals, and the user must keep these in mind. For example, it is possible that safe travel, high-speed travel, and reliable travel could all conflict with optimized revenue. Optimizing revenue might call for lowering tolls to increase demand to a point where demand might have a slight negative impact on safe travel, high-speed travel, and reliable travel. The user of the software is reminded to consider this when selecting goals and objectives.

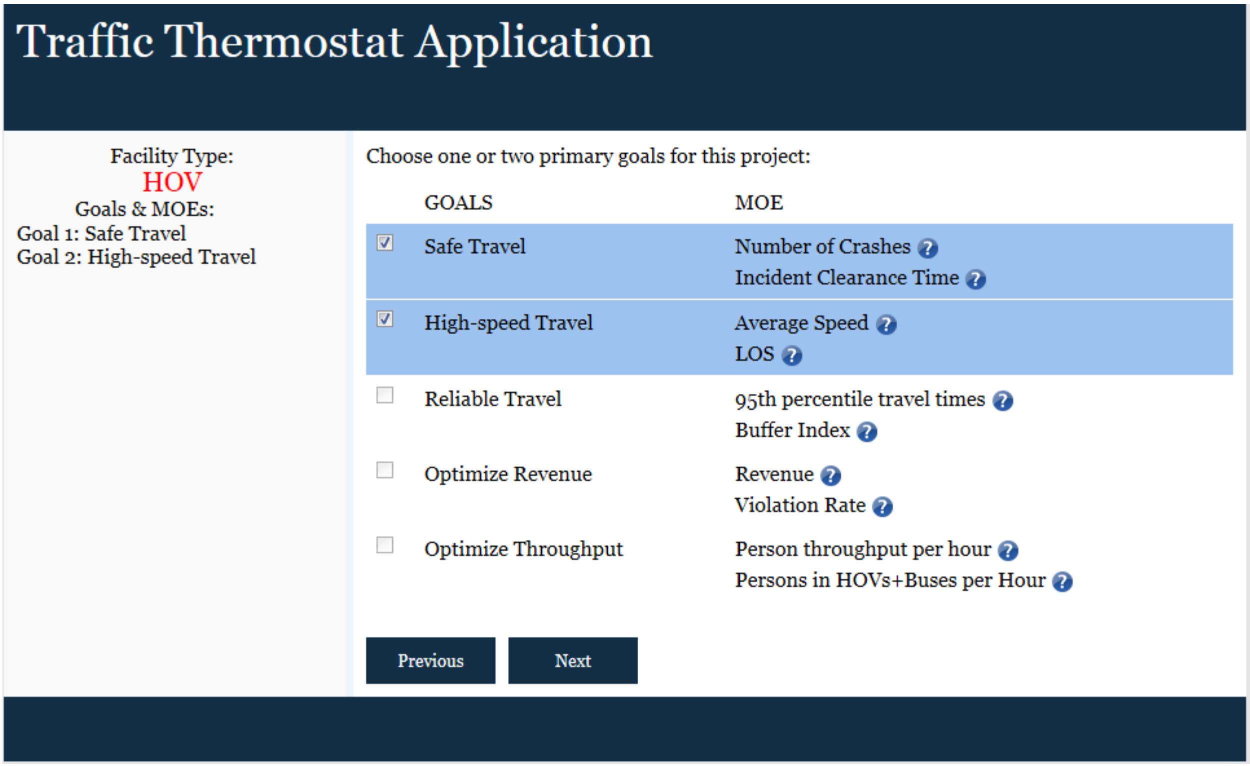

Figure 2. Choose Facility Goals.

Screen 3: Measures of Effectiveness

Based on the goals selected in Screen 2, the user must now choose how progress toward these goals will be measured. Each goal has two measures of effectiveness (MOEs) associated with it. The user can select one or both MOEs for either the peak time(s) or the peak and off-peak period(s) (see Figure 3). The user must define for him- or herself the time of day of the peak and off-peak periods since they are facility specific.

Each MOE needs a minimum acceptable value associated with that MOE. If this minimum acceptable value is not met, then operational or pricing fixes (Screen 5) will be necessary. Some help in selecting the appropriate MOE is provided to the user when the mouse is moved over the question mark (?).

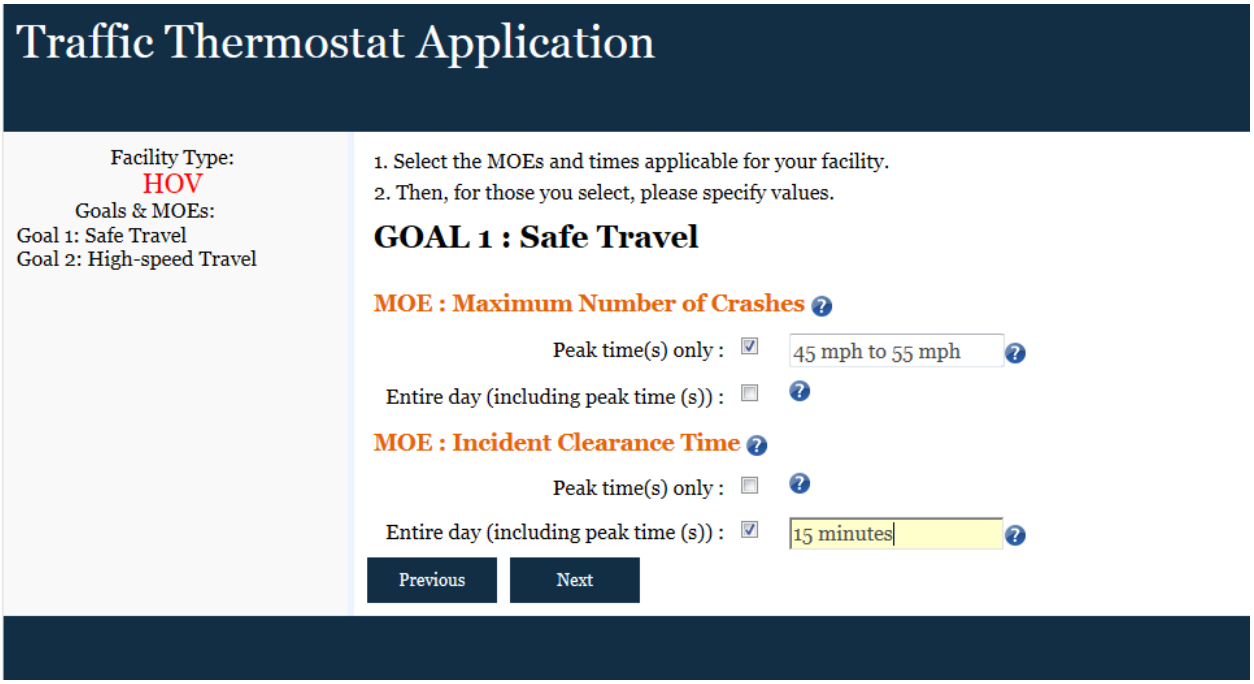

Figure 3. Enter Measures of Effectiveness.

Each MOE is facility specific and left up to the user to define. For example, *Number of Crashes* could be:

- The total number of all crashes on the entire facility (MLs and general purpose lanes [GPLs]) in a year).
- The total number of fatal crashes on the entire facility (MLs and GPLs) in a year.
- The number of severe crashes on the MLs only in a year.
- The crash rate per million vehicle miles traveled.
- Any other definition appropriate for this facility.

Screen 4: User Groups

Next, the user will be asked about the various user groups that may or may not be allowed to use the lane(s). To begin, enter the current (or planned opening day) status of each user group. If they are not allowed, then select "currently not allowed," and the software then knows that the group is not currently allowed on the lane (e.g., trucks in Figure 4). Then rank-order each user group based on its given priority level on the facility. A user group priority of 1 is the highest (i.e., transit) and thus would always have use of the lane. Lower priority user groups (2 and higher) would be priced or removed from the lane in order to achieve necessary performance objectives set by the user in Screen 3. Some groups may be of equal priority. In that case they would be given the same rank and treated identically. Groups that are never allowed on the facility are given a rank of 0 (e.g., trucks in Figure 4).

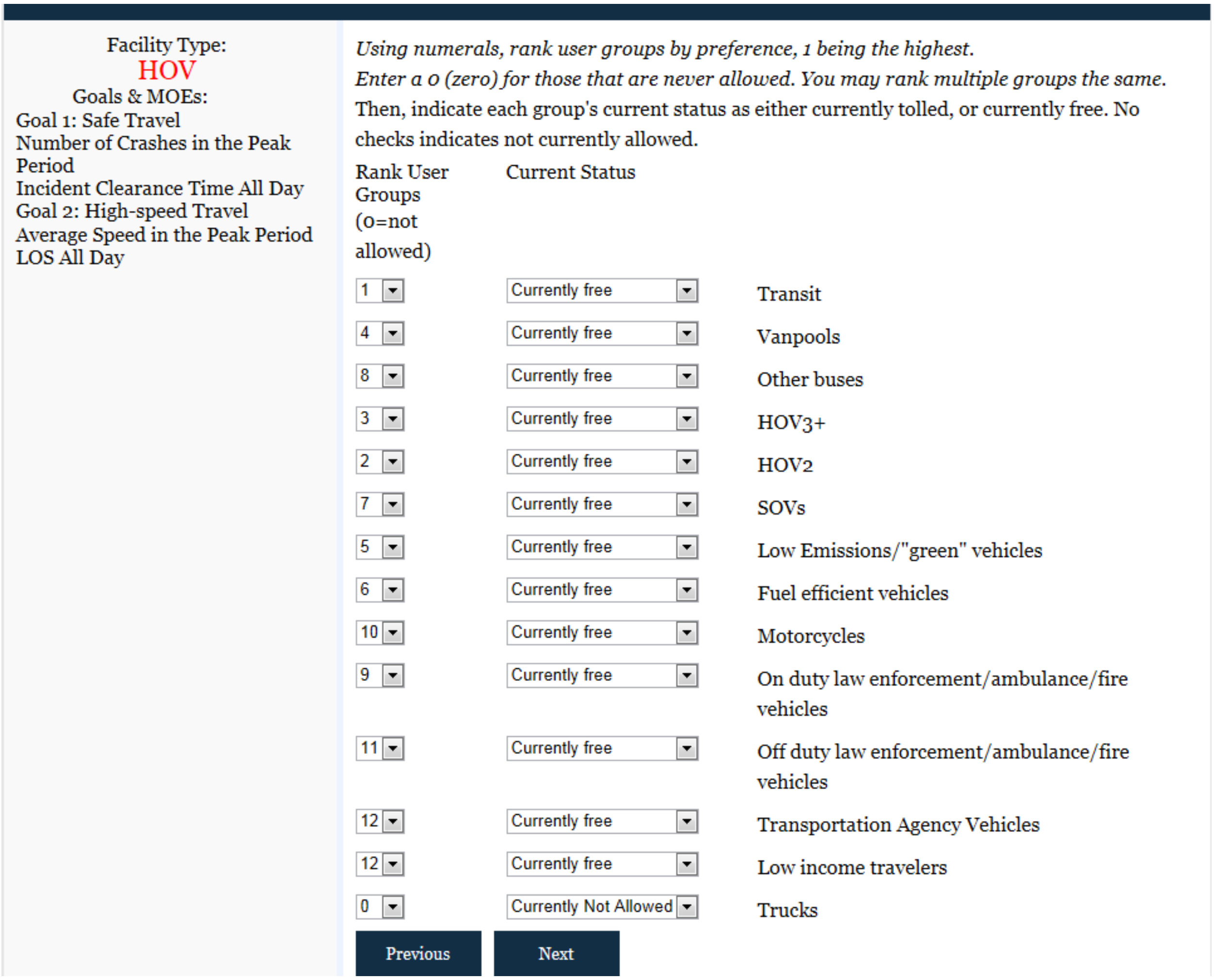

Figure 4. Select User Groups.

Screen 5: Operational and Pricing Fixes

The next screen (see Figure 5) offers the user 10 potential items to change in order for the facility to meet the MOEs detailed in Screen 3. Additionally, the user can enter one or two additional potential fixes for this facility. In the event the facility fails to meet any of its goals, the user will be shown the selected potential fixes as measures to improve performance.

The tool does not know the exact extent of the size of the fix or what impact any of these fixes may have on the lane. For example, "increase enforcement" may mean adding one or a dozen enforcement officers, new equipment, or automated enforcement. Its impact may range from negligible to a significant improvement in the operations of the facility. Since this is site specific, it is left to the user to define what is meant by the fix (such as "increase enforcement") and determine/estimate what impact it may have.

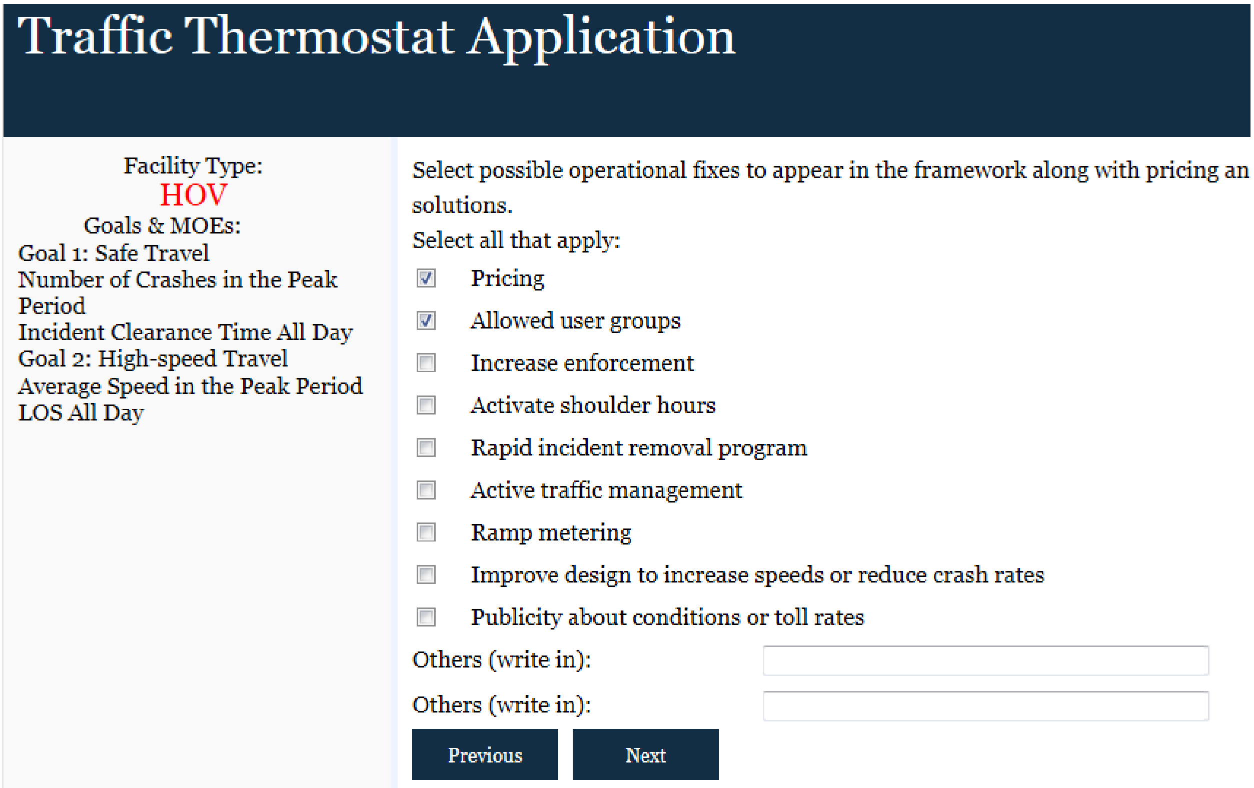

Figure 5. Potential Operational and Pricing Fixes.

The fix "activate shoulder hours" is for a facility that has peak-period charging only and during the off-peak period everyone is allowed use of the lane. In the case of the shoulder becoming congested, then restrictions must be extended beyond the peak period and into the shoulder hours.

Proceeding through the Decision Tool

With these inputs the tool now guides the user through the decision/choices that are needed for the facility (see Figure 6). A good starting point would be when the facility is meeting all of its performance objectives (or MOEs). In this case the user can proceed through each subsequent screen and answer "yes" when asked, "With regards to this MOE and value, is the present situation satisfactory?" The end result will then be to make no changes to the facility.

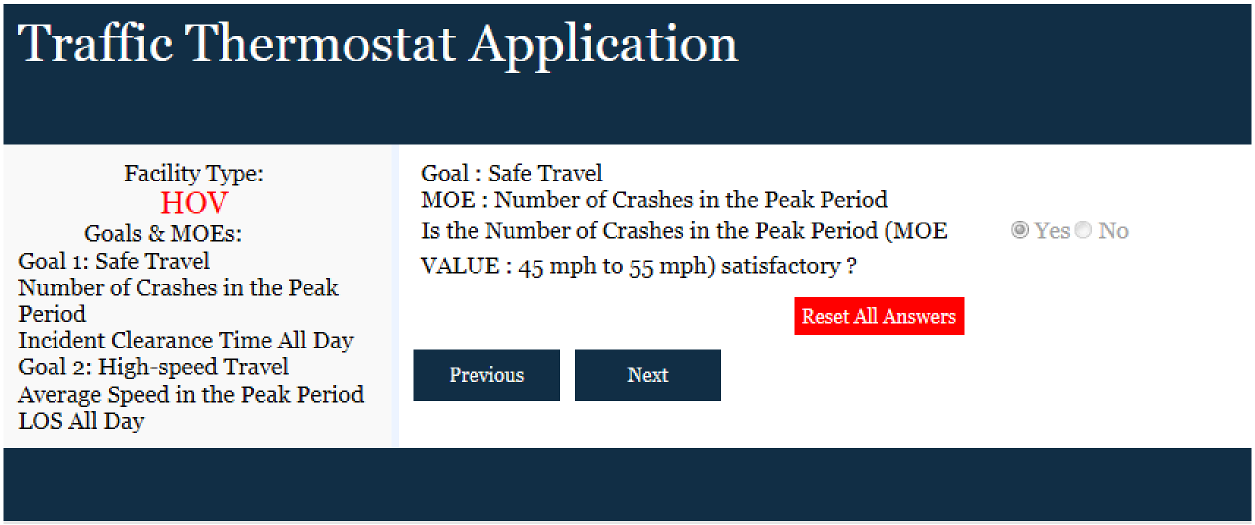

Figure 6. Decision Framework.

Next the user might examine the facility assuming a future date and increased traffic volumes. During this scenario the facility may no longer meet the minimum MOEs, and operational or pricing fixes must be chosen. This second run then represents required changes in the facility as it matures over time. The user might run this future scenario several times, each time trying different operational fixes. Each output from each run then represents a potential policy option that can be presented to decision makers. In this way a governing board is shown a variety of options and can select the preferred one. That provides operational guidance, based on performance measures, for years to come.

The output includes a detailed list of the user groups, MOEs, and selected operational fixes (see Figure 7). This can be printed or saved. Additionally, the project itself can be saved by selecting Save Project.

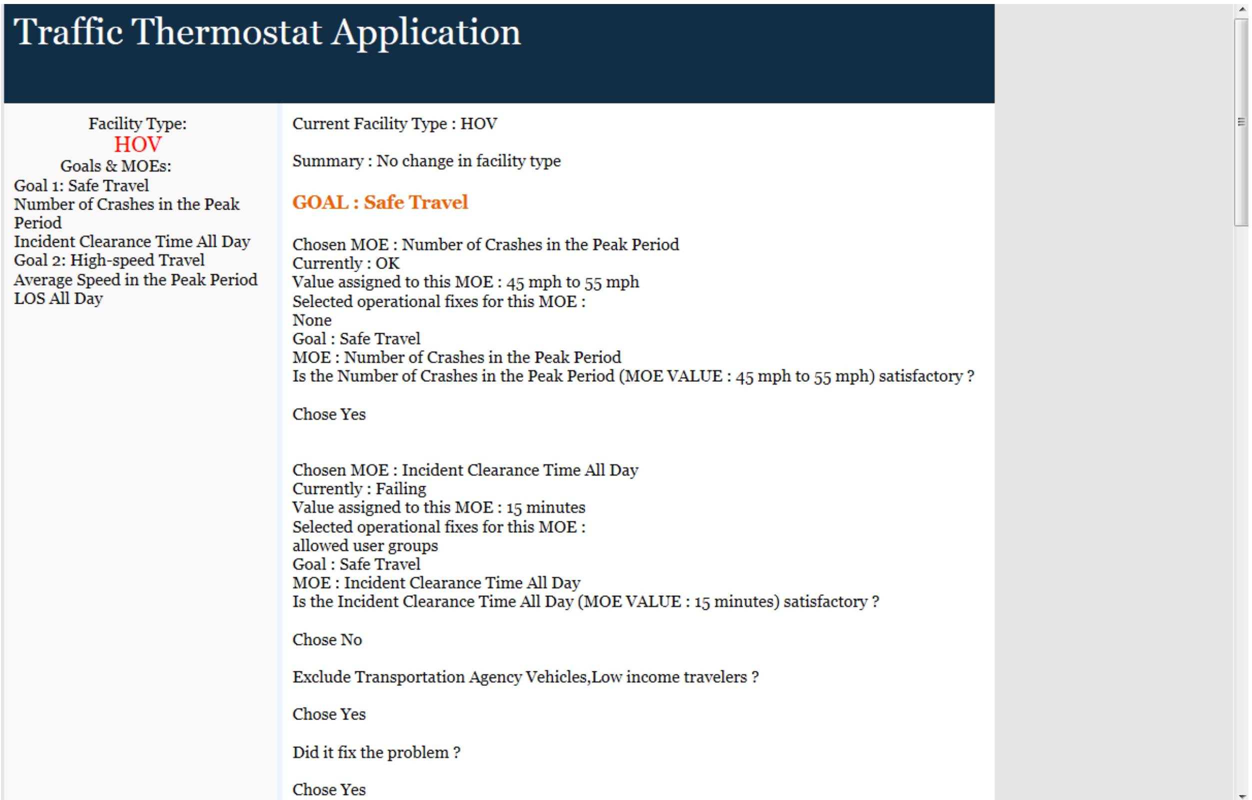

Figure 7. Text Output.