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16. Abstract

This report describes research sponsored by the Texas Department of Transportation (TxDOT) to develop a decision-support tool to aid in evaluating key issues related to converting a high-occupancy vehicle (HOV) lane to a high-occupancy/toll (HOT) lane. The tool includes three broad categories of factors to consider, including facility considerations, performance considerations, and institutional considerations. Facility considerations, such as design, operations, and enforcement, which have been shown to be critical factors, can present insurmountable obstacles to the implementation of HOT lanes. Performance considerations and goals allow the user to estimate the likely levels of usage and person-movement, factors that always bear significantly on HOT lane development decisions. Institutional considerations are also addressed, as factors of interagency cooperation and legal limitations are historically important for HOV lane and HOT lane decisions.

Finally, the research incorporates simple trade-off tools to allow TxDOT and local entities to assemble all relevant factors into an analysis to aid decision makers in evaluating the available options. The analysis tool was developed in Visual Basic.NET®. The program is called the High-Occupancy/Toll STrategic Analysis Rating Tool (HOT START), and it is designed to be easily tailored to local needs. The report also provides an application of the tool to a hypothetical freeway. Many state departments of transportation (DOTs) are facing the difficult task of performing assessments of potential HOV lane to HOT lane conversions, and this report describes a practical tool that can assist with such analysis.

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EVALUATING CRITERIA FOR ADAPTING HOV LANES TO HOT LANES: DEVELOPMENT AND APPLICATION OF HOT START SOFTWARE TOOL

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DISCLAIMER

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 views or policies of the Texas Department of Transportation (TxDOT) or the Federal Highway Administration (FHWA). This report does not constitute a standard, specification, or regulation. The engineer in charge of this project was William R. Stockton (P.E. #41188).

The United States Government and the State of Texas do not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the object of this report.

ACKNOWLEDGMENTS

This document represents the investigative and analysis phase of a research project involving the design, development, and testing of a tool used to assist in analyzing the suitability of the conversion of an established or planned HOV lane to a HOT lane.

The authors appreciate the ongoing assistance and guidance of the project director, David Rodgers of the Houston District of the Texas Department of Transportation (TxDOT), as well as that of the program coordinator, Sally Wegmann, also of the Houston District. Also making valuable contributions and providing insight into the decision-making processes were Diana Vargas and others in the Turnpike Authority Division, Elvia Cardinal from the Houston District, Matt MacGregor and Stephen Endres from the Dallas District, and Flor Sanchez from the Traffic Operations Division. Wade Odell of the Research and Technology Implementation Office was exceptional in his support and direction for the project. Stephen Ranft of the Arlington Office of Texas Transportation Institute shared his considerable experience with HOV lanes and with the decision-making process in the Dallas-Fort Worth area.

Special thanks are also due to the various people who have graciously contributed time and effort in providing test data and constructive feedback and review of the project, the software, and all associated official documents relating to this effort.

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LIST OF ACRONYMS AND ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
AVI	Automatic Vehicle Identification
CCTV	Closed Circuit Television
CMS	Changeable Message Sign
DART	Dallas Area Rapid Transit
ETC	Electronic Toll Collection
FHWA	Federal Highway Administration
GPL	General-Purpose Lane
HOT START	High-Occupancy/Toll STrategic Analysis Tool
HOT	High-Occupancy/Toll
HOV	High-Occupancy Vehicle
ITS	Intelligent Transportation Systems
LOS	Level-of-Service
METRO	Metropolitan Transit Authority, Harris County, Texas
ML	Mainlane
MOEs	Measures of Effectiveness
MPOs	Metropolitan Planning Organizations
NCHRP	National Cooperative Highway Research Program
MUTCD	Manual on Uniform Traffic Control Devices
O-D	Origin-Destination
PCPHPL	Passenger car per hour per lane
SOVs	Single-Occupancy Vehicles
TTI	Texas Transportation Institute
TxDOT	Texas Department of Transportation
VPHPL	Vehicles per hour per lane

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

High-occupancy/toll (HOT) lanes offer drivers the option of traveling on a high-occupancy vehicle (HOV) lane for a toll, when they would normally not meet the occupancy requirements of the lane. These characteristics have led to the growing perception that HOT lanes offer both substantial revenue opportunities and a solution to popular concern about underused HOV lanes.

There are only five existing projects where HOV lanes have been converted to HOT lanes, and the www.valuepricing.org Internet site lists numerous cities that are in various stages of implementation (*1*). Transportation departments and transit authorities are aware that there are complexities and costs associated with converting HOV lanes to HOT lanes and operating HOT lanes, but the exact nature and magnitude of these issues are generally unknown.

The complexities and costs associated with converting HOV lanes to HOT lanes necessitate detailed evaluations of such projects. Further, each project is case specific, and the importance/relevance of the numerous factors that must be considered in an HOV lane to HOT lane conversion vary from one project to the next. Though detailed analysis of the factors is necessary prior to dedicating financial resources to such a significant transportation improvement, there is a need for a sketch-planning tool that can evaluate the multiple factors (quantitative and qualitative) involved in implementing a conversion project.

This research project evolved from more than two decades of experience with HOV lanes in Texas. The Texas Transportation Institute (TTI) has teamed with the Texas Department of Transportation (TxDOT) and the transit authorities in Houston and Dallas to perform ongoing, comprehensive evaluations of existing and proposed HOV lanes and HOT lanes since 1979. This research project captures the benefits of this extensive experience in a manner that is applicable not only to Texas projects, but readily applicable to HOV lane to HOT lane conversions everywhere.

1.2 PURPOSE AND SCOPE

This report describes the research effort to develop a much-needed sketch-planning tool for assessing HOV lane to HOT lane conversion projects—the next challenge in the evolution of HOV facilities. The identification of key issues and incorporating them into an evaluation tool is an exercise that is anticipated to be of benefit to the myriad of regions considering the conversion of an HOV lane to a HOT lane.

When developing the tool, the research team initially prepared a list of the most likely goals behind the conversion of an HOV lane to a HOT lane. These goals included:

- increase corridor mobility,
- generate revenue,
- improve air quality,

- provide travel options, and
- ensure public acceptance.

Increase Corridor Mobility

One goal of the conversion of an HOV lane to a HOT lane is based upon improved mobility in the corridor. Typically, improved corridor mobility can be the result of improvements in roadway supply components (e.g., added capacity) and/or demand components (e.g., shifts in volume by mode, altering hours of operation). Typical performance measures for increased corridor mobility include speed and travel time measures for all modes using the facility. These measures inherently include the effect of supply and demand components along the roadway as these components directly affect the operation of the corridor. Not only are average travel times of interest, but there is also an interest in ensuring that there is a significant and reliable travel-time savings along the HOT facility compared to the general-purpose lanes. Therefore, the travel-time savings and travel-time reliability are important corridor mobility measures. Finally, another important aspect of increased corridor mobility is the person-movement of the corridor.

Generate Revenue

At a minimum, the HOT lane should generate sufficient revenues to pay for the additional expense of converting it from an HOV lane and for any additional operation and maintenance expenses above those of the HOV lane. A HOT lane that cannot cover these incremental costs may not have the patronage to be successful and will be even more difficult to convince local decision makers to implement (and should not be implemented if net societal benefits, including items such as travel-time savings, do not exceed net societal costs).

Improve Air Quality

Environmental improvements are a goal of HOV lane conversion to HOT lane projects, especially in non-attainment areas. Seeking public and political approval for transportation projects that will cause more harm to the environment may be challenging. There are also financial reasons, such as air quality credits, for considering environmental improvements as a goal. As a traffic control measure, one of the reasons HOV lanes are created is to reduce harmful impacts to the environment associated with congestion, especially when encouraging the use of mass transit systems. As such, federal funding is often granted to metropolitan planning organizations (MPOs) for construction of their HOV lane. If conversion to a HOT lane reverses or lessens these environmental benefits, money could be owed back to the granting institution.

Provide Travel Options

One goal of conversion is to provide travelers high speed or superior service travel options in the event that they need to bypass congestion occasionally or on a regular basis.

Increase Public Acceptance

The goal of public acceptance is to create an environment of acceptance and/or promotion of a HOT lane concept. This acceptance is demonstrated by ongoing political support of a project across administrations and may even include championing projects or expanding project applications. Public acceptance should be measured by ascertaining the satisfaction with the project by both users and non-users of the facility.

The results of this research are intended for application to existing or proposed HOV lanes, which assumes that the responsible agency has already determined that an HOV lane is appropriate. This tool is not intended for use in evaluating whether an HOV lane is warranted or whether a toll lane is warranted.

1.3 APPROACH

Researchers developed a list of the primary measures of effectiveness (MOEs) of these goals and issues/elements that would prevent attaining each goal. These measures fall into three main categories:

1. Identify, analyze, and quantify the *facility considerations* in a potential conversion of an HOV lane to a HOT lane. This objective includes those design, operations, and enforcement features or characteristics that would be essential and/or desirable for a successful HOT lane operation.
2. Identify, analyze, and quantify the *performance considerations* associated with a conversion of an HOV lane to a HOT lane. This objective includes how to best measure and predict the potential for a conversion project to accomplish the goals of the transportation agencies and communities involved in the project. These goals might include increasing person-movement, reducing congestion, generating revenue, providing travel options, and/or achieving other performance goals.
3. Identify, analyze, and quantify the *institutional considerations* in evaluating the appropriateness of converting an HOV lane to a HOT lane. This objective includes factors such as public acceptance, revenue use, interagency cooperation, and media relations.

In addition to the above categories, it was necessary to develop an appropriate mechanism (analytical tool) to allow public agencies to evaluate the *trade-offs* within and among the project objectives listed above. It is unlikely that any potential HOV lane project represents an ideal combination of features, demands, and characteristics to assure success as a HOT lane. Satisfying this objective allows the analyst to assess the relative significance of trade-offs among facility, performance, and institutional objectives and considerations in reaching decisions about the most appropriate decision. The result of developing this analytical tool is the High-Occupancy/Toll STrategic Analysis Rating Tool (HOT START) software program.

CHAPTER 2

LITERATURE REVIEW

2.1 HISTORY OF HOV LANES

For over 30 years, HOV facilities have been a part of urban transportation planning. Many of the early HOV lanes developed in response to specific issues and limitations in congested freeway corridors. Most HOV projects are aimed at improving the people-moving capacity of these corridors. The objective is to restrict certain highway lanes to exclusive use by multi-occupant vehicles, thereby encouraging carpooling, vanpooling, and transit bus ridership *(2, 3, 4, 5)*. The result is a familiar sight – congested traffic in the general-purpose highway lanes while vehicles travel near the speed limit in the parallel HOV lane(s) *(5)*.

Two projects, the bus-only lane on Shirley Highway (I-395) in Northern Virginia outside Washington, D.C., in 1969, and the contraflow bus lane on the approach to New York-New Jersey's Lincoln Tunnel in 1970, were the first freeway facility HOV lanes in the country. Although HOV facilities started showing up in the 1970s, the rate of implementation did not pick up until the mid-1980s, when a significant increase in HOV facility projects could be seen across the country. This growth can still be seen today.

Throughout their history, like any new system, HOV facilities have drawn fire from critics, as well as praise from supporters *(5)*. Not all HOV projects have been successful at meeting the desired objectives, while others have been highly successful and continue to meet common objectives, such as: increase the average number of persons per vehicle, preserve the people-moving capacity of a corridor, improve bus operations, and enhance mobility options for travelers *(4)*.

Recently, a select few HOV facilities have converted to HOT lanes due to HOV volumes that are significantly lower than the capacity of the HOV lanes. Many experts continue to promote HOV facilities as one way to deal with increasing levels of traffic congestion in major metropolitan areas. This debate has resulted in a large number of research studies on HOV lanes. The National Cooperative Highway Research Program (NCHRP) and the Federal Highway Administration (FHWA) are the key supporters of research *(6, 7, 8, 9)*. State departments of transportation, including Texas (TxDOT) and California also support HOV lane research. Through monitoring and evaluation of the HOV facilities, along with innovative research, the future of HOV facilities can be anticipated *(5)*.

2.2 FACILITY TYPES

There are four common types of HOV lanes: reversible-flow, two-way, concurrent, and contraflow (see Figure 2-1).

Reversible-flow HOV lanes are permanent facilities that carry traffic one direction in the morning and the opposite direction in the evening. These facilities have one or more lanes and are applicable when there is an unequal traffic distribution, which commonly occurs in an urban area with outlying suburbs, where most people commute to employment areas in the morning and return home in the evening *(5 ,10)*.

Reversible-Flow

Two-Way Flow

Concurrent Flow

Contraflow

Figure 2-1. Types of HOV Lane Facilities.

Two-way HOV facilities provide a lane or multiple lanes in either direction during the peak flow or for full-time use. These facilities commonly occur in areas where the traffic distribution is approximately equal in both directions, even during the morning and evening peaks. Both two-way and reversible-flow facilities are often separated by barrier from the general lanes, with controlled access points *(6, 10)*.

Concurrent-flow HOV lanes run the same direction as the adjacent general-use lanes and are typically separated by a buffer, usually consisting of pavement markings. Ingress and egress points along the HOV lane may be more frequent than with the previous two types of facilities *(2, 6)*.

Contraflow HOV lanes allow a lane to be “borrowed” from the off-peak direction and made accessible to the peak direction. Movable traffic barriers separate these facilities from oncoming traffic. These facilities are found where low traffic demand in the off-peak direction allows for a lane reduction in capacity *(2, 6)*.

2.3 BENEFITS OF HOV LANES

HOV lanes provide a cost-effective travel choice, which can include the following objectives: increases the number of passengers per vehicle, preserves the person movement capacity of the roadway and enhances bus transit operation. These lanes provide the individual with a potential cost savings in the form of reduced travel-time. HOV lanes do not force the driver to make changes but rather encourages them to do so *(6, 11)*.

TTI has developed a tool for making decisions relating to HOV lanes. Report 1353-1 presents *The ABC's of HOV – The Texas Experience*, which was developed in cooperation with the US Department of Transportation and the FHWA, and was sponsored by TxDOT. This report mentions one particular benefit of HOV lanes that has been experienced in Texas: "Carpooling has declined nationally by an average of 30 percent in the past two decades. Yet on Texas freeway corridors with mature HOV lanes, there has been an increase in carpooling of 100 percent or greater during the same time period"*(4)*.

2.4 CURRENT STATUS OF HOV LANES

As of 2003, there were 130 HOV facilities on freeways and in separate rights-of-way in 23 metropolitan areas in North America *(11)*. These facilities account for approximately 2000 centerline miles of HOV lanes. Major HOV systems operate in Houston and Dallas, Texas; Seattle, Washington; the Los Angeles and Orange County area and the San Francisco Bay region in California; the Newark, New Jersey, and New York City area; and the Northern Virginia, Washington, D.C., and Maryland region. Other facilities are in various stages of planning, design, and construction *(5)*. A summary of the nation's HOV lane systems, including costs, volumes, operational changes and many other statistics of the respective HOV systems, can be found in Fuhs and Obenberger's report *(7)*.

As of June 2002, there was a listing of approximately 2500 HOV lane miles that were in various stages of proposal or under construction in the nation *(5)*. The majority of these lane miles are located in California (1000), Georgia (400), and Texas (300). In Texas, the additional HOV lane miles add to existing facilities in Dallas and Houston, as well as introduce HOV lanes to Austin and San Antonio.

Many of the proposed lane miles are on long-range proposals, some as far off as the year 2025. Others are simply in an assessment study and may never be included in a short-range or long-range transportation plan *(5)*.

2.4.1 Houston Area HOV Lanes

Houston's Metropolitan Transit Authority of Harris County, Texas (METRO), in a joint effort with TxDOT, operates the area's 104.2 mile HOV lane system. Figure 2-2 shows the Houston area HOV lanes, and Table 2-1 summarizes the current status of the lanes. The system facilitates approximately 118,000 person trips each weekday, which corresponds to about 36,400 vehicle trips. The average operating speed is approximately 50-55 mph, which saves the average commuter 12 to 22 minutes per trip. The Houston area HOV lanes move morning rush-hour traffic toward downtown, Monday thru Friday. The lanes reverse and move rush-hour traffic away from downtown during the evening rush hours *(3)*.

The Houston area HOV lanes have been the focus of many studies and overall have been found to successfully meet project goals. The I-10W lanes have already been designated a 3+ occupancy facility during rush hours and have actually been converted to a HOT facility. US 290 has also been designated a 3+ occupancy during the morning rush hours and is a HOT lane during that period. In addition to I-10W and US 290, there are other HOV facilities in the area being assessed for conversion to HOT lanes.

Table 2-1. Status of the Houston HOV Lane System, October 2004.

HOV Facility	Date First Phase Opened	Miles in Operation	Ultimate System Miles	Vehicles Allowed to Use HOV Lane	Hours of Weekday Operation[1]
Katy (I-10W)	October 1984	13.1	15.3	3+ vehicles from 6:45 to 8:00 a.m., 5:00 to 6:00 p.m.; 2+ during other operating hours	5 a.m. to 12 p.m. inbound 1 p.m. to 8 p.m. outbound
North (I-45N)	November 1984	19.3	19.9	2+ vehicles	5 a.m. to 11 a.m. inbound 2 p.m. to 8 p.m. outbound
Gulf (I-45S)	May 1988	15.0	17.7	2+ vehicles	5 a.m. to 11 a.m. inbound 2 p.m. to 8 p.m. outbound
Northwest (US 290)	August 1988	15.5	15.5	3+ vehicles from 6:45 to 8:00 a.m.; 2+ vehicles during other operating hours	5 a.m. to 11 a.m. inbound 2 p.m. to 8 p.m. outbound
Southwest (US 59S)[2]	January 1993	13.5	15.6	2+ vehicles	5 a.m. to 11 a.m. inbound 2 p.m. to 8 p.m. outbound
Eastex (US 59N)	March 1999	19.9	20.2	2+ vehicles	5 a.m. to 11 a.m. inbound 2 p.m. to 8 p.m. outbound
Total		96.3	104.2		

[1] Katy (I-10W) is open Saturday, 5:00 a.m. – 8 p.m. for outbound traffic and Sunday, 5:00 a.m. – 8:00 p.m. for inbound traffic.
[2] A 2.1-mile addition to the Southwest HOV lane is under construction *(3)*.

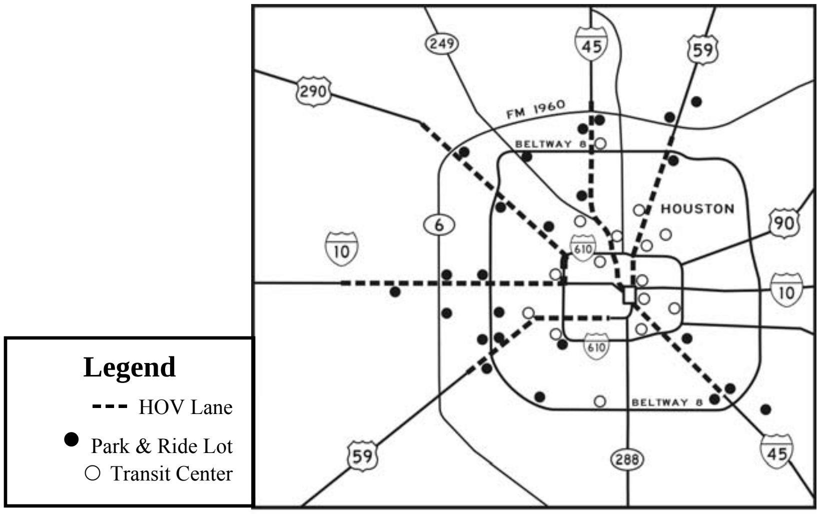


Figure 2-2. Houston's HOV Lane System.

2.4.2 Dallas Area HOV Lanes

Dallas Area Rapid Transit (DART), as a joint effort with TxDOT, operates the area's HOV lane system. Currently, the system consists of 54.2 lane-miles of the proposed 89-mile HOV network. Figure 2-3 shows the Dallas area HOV lanes, and Table 2-2 summarizes the current status of the lanes. The system currently facilitates approximately 100,000 person trips each weekday. The DART website (www.dart.org) states that the speed in the HOV lanes is often twice as fast as the general-use lanes *(12)*.

Project 7-4961 looked at the HOV lanes in Dallas during the years of 1997-1999 with a goal of investigating the operational effectiveness of the lanes. Researchers found that all three HOV lane projects in the Dallas area were cost-effective and had attained, or were projected to attain, a benefit/cost ratio of greater than 1.0 within the first six years of operation. Additionally, each HOV lane generated a substantial number of carpools, increased the person movement in the corridor, and increased the occupancy rate in the corridor – without negatively impacting the operation of the adjacent freeway main lanes *(13)*.

Table 2-2. Status of the Dallas High-Occupancy Vehicle Lane System, October 2004.

HOV Facility	Date First Phase Opened	Miles in Operation	Ultimate System Miles	Vehicles Allowed to Use HOV Lane	Hours of Weekday Operation
I-35E	September 1996	5.6 miles NB 7.3 miles SB	26 miles	2+ vehicles	24 hours
I-635	March 1997	6.7 miles EB 6.2 miles WB	23 miles	2+ vehicles	24 hours
I-30	September 1991	5.2 miles EB 5.2 miles WB	18 miles	2+ vehicles	6 a.m. to 9 a.m. inbound 3:30 p.m. to 7 p.m. outbound
I-35E/US 67	US 67 – March 2000 I-35E – March 2002	2.5 miles NB 2.5 miles SB 6.5 miles NB 6.5 miles SB	11 miles 11 miles	2+ vehicles	US 67 south of Loop 12 is 24 hours; the rest is 6 a.m. to 9 a.m. inbound 3:30 p.m. to 7 p.m. outbound
Total		54.2 lane-miles	89 miles		

Additional lanes that are either under construction or have been proposed:

US 75 north of I-635 (reversible lane)
I-635, connecting to US 75 north
I-30 between Loop 12 and Downtown (reversible lane)
I-35E north of I-635 (reversible lane replaces concurrent flow lanes)
SH 183 between DFW Airport and Stemmons (dual reversible lanes)
Loop 12/I-35 east side up to I-635 (dual reversible lanes)
SH 161 and I-635 between SH 183 and Stemmons

Figure 2-3. Dallas' HOV Proposed and Existing HOV Lanes.

2.4.3 Other Texas HOV Lanes

In addition to the operational HOV lanes in Houston and Dallas, HOV lane facilities are in the planning stages in the San Antonio and Austin areas. Loop 1, US 183, and I-35 in Austin are being considered for reversible lane facilities, and I-35 in San Antonio is under study to receive HOV lanes *(5)*.

2.5 VOLUME AND CAPACITY OF HOV LANES

There are many factors that will affect actual capacity, such as: lane widths, shoulder clearances, number of lanes per direction, types of vehicles allowed on facility, and the frequency of ingress and egress points. Table 2-3 lists some key volumes based on the methods of calculating capacities and levels-of-service (LOSs) in the 2000 *Highway Capacity Manual (HMC)* *(14)*.

Table 2-3. Approximate HOV Lane Volumes Based on 2000 HCM Methods.

Lanes per Direction	Conditions	Capacity	Maintain LOS C
1	Base	1700	---
1	Restricted	1700	---
2	Base	2350	1750
2	Restricted	2300	1550

Volumes are reported in passenger car per hour per lane (pcphpl).

Most agencies believe it is important to avoid the "empty lane syndrome," which occurs when users of the adjacent congested general-use lanes see the almost empty HOV lane and feel it is being underutilized. To avoid this, a minimum volume goal for the first year of operation of the HOV lane should be 700 to 1000 vehicles per hour per lane (vphpl) *(15)*. Table 2-4 summarizes the flow volumes of select HOV facilities *(8, 16)*.

Table 2-4. Typical HOV Lane Volumes.

HOV Facility	Facility Type	Location	Weekday Peak-Hour Volume	Weekday Off- Peak Volume
Eastex (US 59N)	1 Lane, Reversible	Houston	280 (2003)	98 (2003)
North (I-45N)	1 Lane, Reversible	Houston	1405 (2003)	544 (2003)
Gulf (I-45S)	1 Lane, Reversible	Houston	1457 (2003)	376 (2003)
I-35E (SRLT)	1 Lane, Reversible	Dallas	1221 (2002)	187 (2002)
I-30 (ERLT)	1 Lane, Reversible	Dallas	1427 (2002)	364 (2002)

Volumes are vphpl.

The Houston HOV Lane Operation Summary, March 2003, showed a range of 1273 to 1457 vehicles per hour per lane for AM peak-hour volumes for the majority of the HOV lanes. Volume on the Eastex HOV lane (US 59N) was only 280 vehicles per hour per lane. Excluding the Eastex, the range of person movement was from 4077 to 5736 persons per hour per lane. The volumes for the evening rush hour were less than the morning rush hour *(7)*.

Figure 2-4 is taken from *The ABC's of HOV – The Texas Experience*. It shows the significant person volume moved during the morning peak period occurs on the HOV lanes. A critical factor in sustaining the volumes of person movement in HOV lanes is the inclusion of transit bus services. Bus passengers account for an average of 30 percent of peak period HOV lane travelers in Texas *(4)*.

Predicting the demand for HOV lanes is a critical factor in the decision-making process. Currently, planning agencies use a variety of tools to assess HOV demand. These tools include, but are not limited to: macroscopic simulation models such as FREQ, and microscopic simulation models such as FRESIM. All of the agencies involved in HOV demand use regional travel demand models as part of their analysis, which include TRANPLAN, MINUTP, EMME/2, and UTPS or UTPS-based models *(17)*.

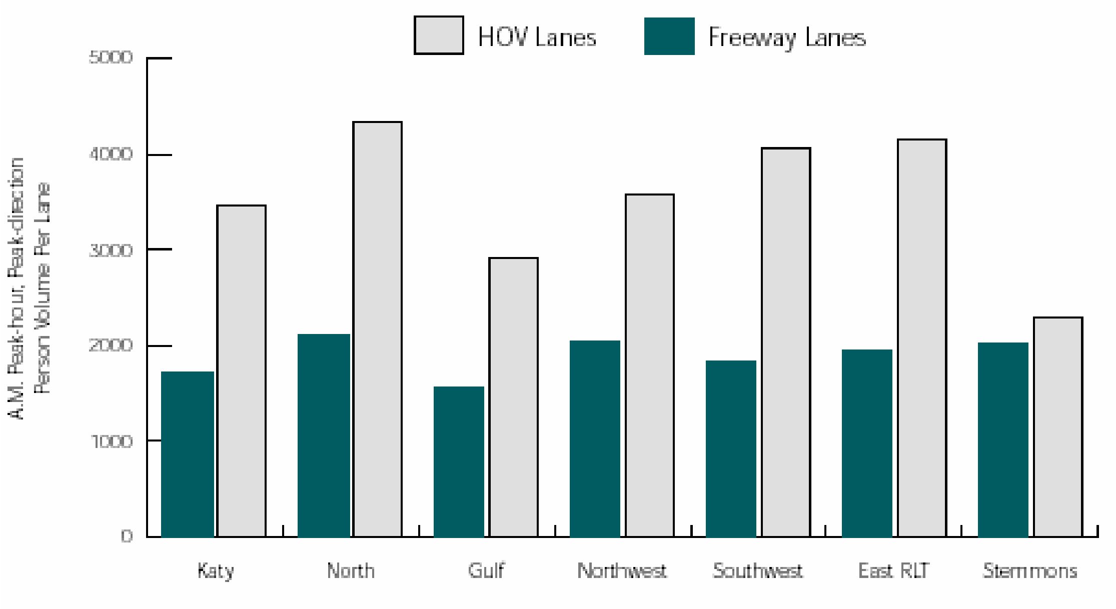


Figure 2-4. Person Movement on Texas HOV Lanes.

Once the demand for HOV lanes has been estimated, Figure 2-5 represents a graphical tool for anticipating the life cycle of an HOV facility. Whenever an HOV lane is established or the occupancy requirements increase, there is typically a time period when the volume to capacity ratio is low, which leads to the "empty lane syndrome" that is perceived by the public traveling in the more congested general-use lanes. Figure 2-6 represents the life cycle of an HOV facility that utilizes this extra capacity through the inclusion of lower occupancy vehicles that is regulated by a toll *(18)*.

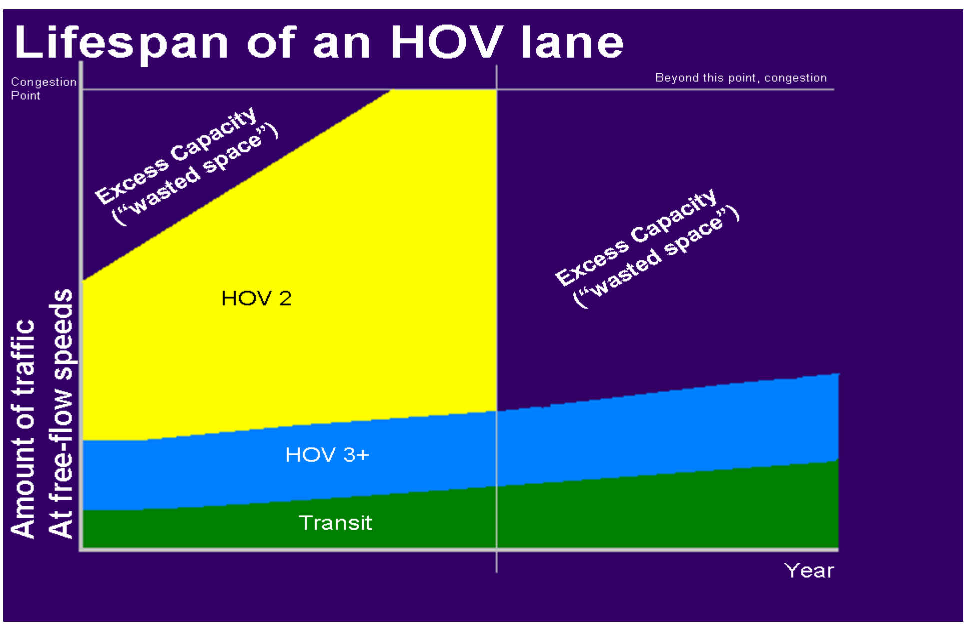
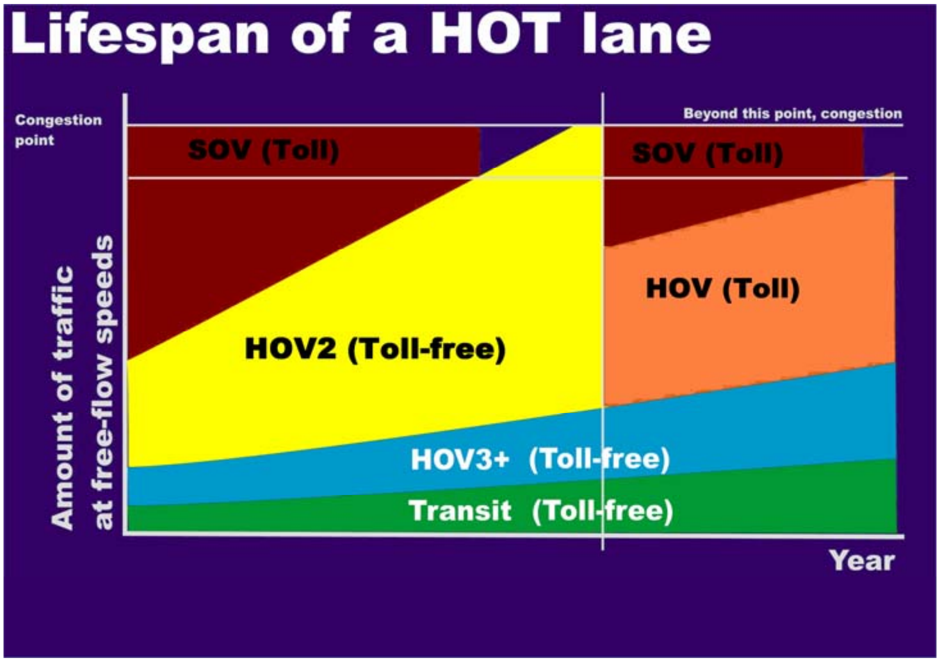


Figure 2-5. The Lifespan of an HOV Facility *(18).*



* SOV = single-occupancy vehicle

Figure 2-6. The Lifespan of a Managed HOV Lane *(18)*.

2.6 PERFORMANCE OF HOV LANES

The success of HOV facilities is dependent on the integration and balancing of design, operation, and enforcement needs to ensure the facility objectives are satisfied. The analogy would be to a three-legged stool with each leg representing one of these elements. Without sufficient "strength" (i.e., proper consideration) in each of these "legs," the potential success of the HOV lanes can be compromised. In addition, HOV success requires the involvement and support of various federal, state, and local agencies. A positive and aggressive public awareness campaign is also paramount to this process. Some HOV facilities have been reclassified as general-use lanes due to negative public reaction as a result of the HOV facilities not meeting the project objectives. To aid in this task, Research Project 0-4160 has resulted in reports that assist in developing position papers on managed lanes that are aimed at policy makers *(19)* and the media *(20)*.

NCHRP Report 414 *(6)* provides a comprehensive approach to planning, designing, operating, monitoring, and evaluating HOV lanes, and it serves as a foundation for the American Association of State Highway and Transportation Officials' (AASHTO's) "Guide for High-Occupancy Vehicle (HOV) Facilities" *(15)*. In addition to these steps, the institutional aspect of the HOV facility must also be addressed. Existing legislation must be evaluated for sufficiency and new legislation enacted if the existing is found to be deficient. As a follow up to the legislation, enforcement of the facility is imperative as illegal use of the facility can raise the volumes above capacity, thereby eliminating the benefits of the facility *(21)*.

TTI Research Report 1353-6 identifies certain conditions that help make HOV lanes successful. These conditions fall into several categories, including: congestion levels, travel patterns, current bus and carpool volumes, travel-time savings, trip reliability, trip distance, and support facilities and services. Just because one condition is not met in one of these categories does not necessarily mean that an HOV lane will be unsuccessful. All of these factors need to be considered as a whole, with the specific project objectives in mind *(2)*.

Much research has been, and is being, conducted on the performance of existing HOV lanes. Ongoing studies of the Houston and Dallas area HOV systems were an original part of the project, anticipated as performance monitoring studies. In addition, FHWA is leading efforts to develop an HOV Pooled-Funds Study, which allows state transportation departments and local transportation agencies to pool funding for developing, conducting, and publishing research on HOV and managed lanes. Currently, Georgia, California, New York, Tennessee, New Jersey, Virginia, Massachusetts, Maryland, Washington, and Minnesota are participating *(22)*.

In general, many HOV lanes have performed well and achieved their desired objectives. Some have worked so well that although they were at one point HOV2+ lanes, they have been forced to change to HOV3+ lanes during peak traffic flow. These facilities include I-10 and US 290 in Houston, and I-10 in Los Angeles. Other HOV facilities started out as HOV3+ and have maintained this designation. These facilities include SR 4, SR 80, SR 160, SR 680, and I-80 in California, the New Jersey Turnpike and I-95 in New Jersey; and H-1 in Hawaii. States such as California and Texas are planning to add extensively to their HOV networks due to the success of the current HOV lanes that are in place *(5)*.

2.7 REMOVAL OF HOV LANES

Some HOV lanes, such as on I-80 and I-287 in New Jersey, were reclassified as general-use lanes, usually due to negative public opinion as a result of the HOV lanes not achieving their desired objectives. These specific HOV lanes were only open for a total of 11 months before they were reclassified. During the initial HOV lane openings in 1994, the news media was generally favorable. As the HOV lane segments were added, press coverage became less supportive and eventually turned critical after the completed lanes opened in 1998. As a result of the negative media in 1998, the New Jersey Department of Transportation initiated a review of the HOV lanes. They found that only one of the three main objectives – promote carpooling, maintain use levels, and reduce or at least maintain the present level of congestion in the corridor – was met. This objective was to maintain the use levels on I-80. As a result, the HOV lanes were reclassified *(9)*.

Overall, including I-80 and I-287 in New Jersey, six HOV lane facilities have been terminated since 1976. The other facilities were the Santa Monica Freeway and US 101 in California, the Banfield Expressway in Oregon, and the Dulles Toll Road in Virginia *(7, 9)*.

2.8 OPTIMIZING HOV LANE USE THROUGH ROAD PRICING

One method of congestion management is pricing. By charging travelers for use of roadways, transportation professionals can help to mitigate traffic congestion while simultaneously generating revenues. Charging for road use has been around for many years in the form of toll roads; most charged a flat toll throughout the day for access to the facility, and many still do. Toll authorities can set the single toll amount to a level that ensures a certain level-of-service throughout the day. However, this method may not make the most efficient use of the roadway if travel-time incentive is not enough during off-peak hours to pay the toll that works well during the peak period.

Common sense dictates that for a user to be willing to pay for a service, then he/she must benefit in some way from it. For toll facility users, this benefit is most likely travel-time savings. Often, a toll facility will offer a faster trip than an adjacent or nearby route. Drivers can choose to use the toll facility if the travel-time savings are enough to warrant paying the requisite toll.

One relatively new form of road pricing is value pricing, which changes the amount charged for road use based on demand. On a typical roadway, a flat toll would not be the optimal toll throughout the day. During off-peak periods (with less time savings), it may be too high for drivers to benefit from paying it. Conversely, during times of peak demand, the toll may not be high enough to maintain adequate level-of-service on the facility. Value pricing offers a solution to this problem by increasing the toll during periods of peak demand and reducing it during off-peak times *(23)*.

Recently, value pricing has been used to manage traffic demand in highly congested areas. One example of this is London's congestion pricing scheme. Under the pricing scheme, drivers who travel to the city center during the business day must pay an £8 toll (approximately $14.25 US). The project has thus far been a success, reducing the amount of traffic during the week by 20 percent *(24)*.

The creation of a suitable pricing scheme requires an understanding of the value that travelers place on travel-time savings. The value of travel-time savings is measured by estimating drivers' value of time. Value of time describes how much monetary value drivers place on their travel time. This value is typically estimated in dollars per hour. It can be measured by revealed or stated preference survey, or by observing travelers' route choices *(25)*. For instance, if a driver pays a $1 toll to use a toll facility rather than an adjacent route and saves 10 minutes on his trip, then that traveler had a travel-time value of at least $6 per hour. By analyzing values of time, toll authorities can increase or reduce the toll amount to manage demand for the toll road. Research estimates the value of time in the range of 20 percent to 50 percent of the driver's wage rate *(26, 27)*. However, drivers also place a value on travel-time reliability. Research indicates that confidence in trip length and arrival time is valued highly by travelers *(28, 29)*.

The effect that a toll has on traffic demand is measured using travel-demand elasticity. Travel-demand elasticity is defined as the percent change in demand divided by the percent change in price. Essentially, it is a value that can be used to estimate the change in travel demand after a toll increase or decrease. Travel-demand elasticity is negative, indicating an inverse relationship between toll price and travel demand. Toll price, though, is not the only component of travel-demand elasticity. Fuel costs, maintenance costs, insurance, and other costs associated with driving also contribute to elasticity. However, research has shown that the toll price component of elasticity is greater for variable tolls than for flat-rate tolls *(30)*. Variable tolls are used to compensate for changes in the value travel-time savings. When travel times change, the value of the time savings is altered, and a change in toll price is necessary to maintain the desired demand for the facility. In cases where travel-time savings does not change, travel-demand elasticities can accurately predict the effect of a change in toll level on demand.

2.9 HIGH-OCCUPANCY/TOLL LANES

The result of a combination of value-pricing strategies and HOV lanes is the HOT lane. HOT lanes are a form of managed lanes that combine the benefits of both HOV lanes and value pricing by maintaining an occupancy requirement for free travel while simultaneously allowing those who do not meet the occupancy requirement to pay a toll for access to the facility. FHWA's AGuide for HOT Lane Development *(31)* outlines three primary benefits of HOT lane implementation:

- expanded mobility options in congested urban areas,
- new source of revenue that can be used to improve transportation system, and
- improvement of HOV efficiency.

HOT lanes provide shorter and more reliable travel times when compared to the general-purpose lanes *(32)*. The addition of value pricing to an HOV lane allows for better utilization of the facility in addition to increased revenues. Tolls on a HOT lane can be adjusted to make use of excess capacity while retaining a high level-of-service. HOT lanes may be priced in two ways, based on a fixed schedule or dynamically. Fixed tolls are determined by a toll schedule that varies the toll based on the time of day, such as SR 91, I-10, and US 290. With dynamic pricing, however, charges are based on current demand for the facility, such as I-15. Dynamic pricing allows the tolls to be changed to more accurately reflect the fluctuations in traffic demand.

There are no definitive design standards for HOT lanes. There are only four operational HOT facilities in the United States, and they have noticeably different characteristics. Among the four facilities, the number of lanes varies between one and four, and the number of entry and exit points varies as well. Additionally, three of the four facilities are reversible, while the other operates continuously in two directions. Two common characteristics among the four, though, are barrier separation and the use of electronic toll collection technology to collect charges.

2.10 CURRENTLY OPERATING HOT LANES

There are currently only four HOT lanes in operation in the United States, located in California and Texas. These four projects are located in the following corridors:

- SR 91 near Los Angeles, California;
- I-15 in San Diego, California;
- I-10 in Houston, Texas;
- US 290 in Houston, Texas, and
- I-394 in Minneapolis, Minnesota.

2.10.1 SR 91 Express Lanes

The SR 91 express lanes were the first application of HOT lanes in the U.S. The express lanes are four managed lanes in the median of SR 91, a heavily congested freeway in Orange County, California. The lanes cover 10 miles between SR 55 and the Orange/Riverside county line. They were constructed by the California Private Transportation Company, which opened and operated the facility beginning in 1995 *(33)*. Since January 2003, however, the facility has been operated by the Orange County Transportation Authority.

When the express lanes first opened, a flat toll was charged for travel during each of the morning and afternoon peak periods, but in 1997 a variable-pricing scheme was introduced that varied the toll amount throughout the day. The pricing schedule is fixed based on the time of day and is updated periodically to maintain adequate levels-of-service on the lanes. Figure 2-7 is an example of the toll schedules on SR 91. The tolls on SR 91 are collected with electronic toll collection technology; all vehicles using the lanes are required to have a FasTrak transponder. Currently, use of the lanes is free for HOV3+ vehicles at all times with one exception. Between the hours of 4:00 PM and 6:00 PM, Monday through Friday, HOV 3+ vehicles must pay 50 percent of the toll *(34)*.

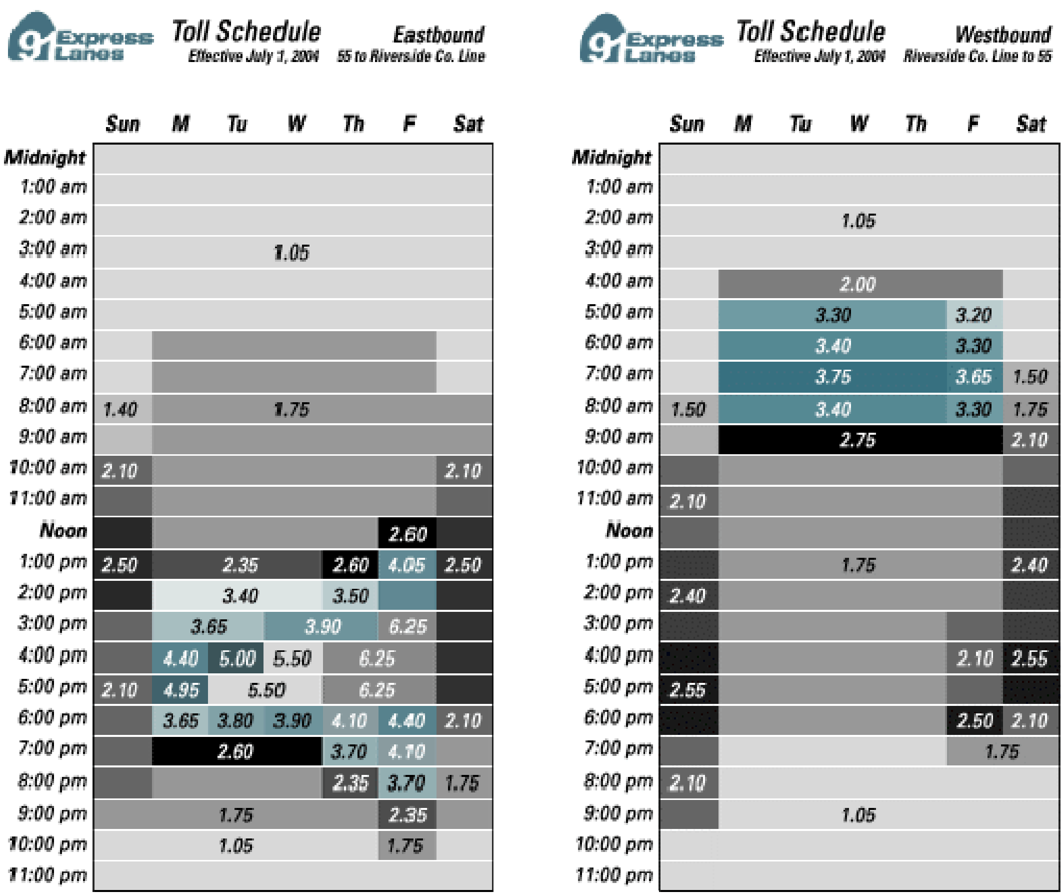


Figure 2-7. Toll Schedules for SR 91 Express Lanes.

2.10.2 I-15 FasTrak Lanes

The I-15 FasTrak lanes consist of two reversible lanes in the median of I-15 north of San Diego, California. The lanes operate southbound toward San Diego in the morning and northbound in the afternoon and evening. The I-15 project opened in 1996, during which drivers paid a monthly fee for unlimited use of the lanes. In 1998, pricing was changed to a variable per-trip fee based on current traffic on the lanes *(35)*. Variable message signs located at the entrance and exit points of the facility notify travelers of the current toll. Toll schedules (see Figure 2-8) outline the maximum toll during different times of the day. Typically, the tolls range from $0.50 to $4.00 per trip, but during periods of extremely heavy congestion the toll can increase to as much as $8.00. The varying toll allows the FasTrak lanes to maintain the level-of-service C that is required by law. Tolls are only paid by SOVs, and HOV2+ vehicles travel free of charge throughout the day *(36)*.

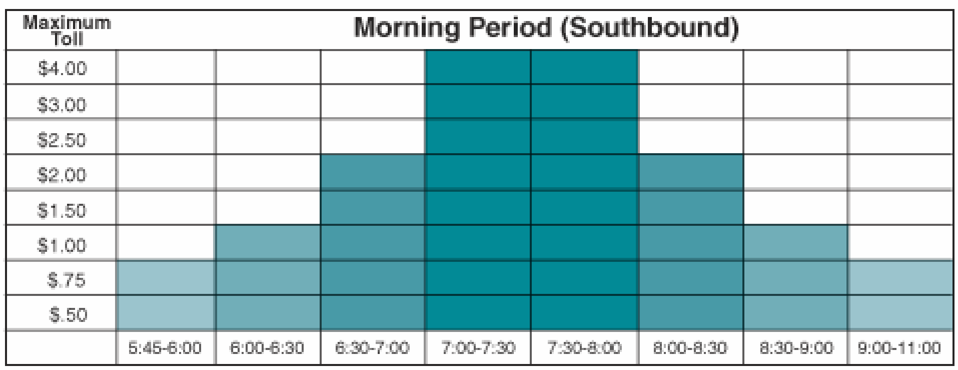


Figure 2-8. Toll Schedule for I-15.

2.10.3 I-10 (Katy Freeway)

The Katy Freeway (I-10) is located west of Houston, Texas, and accommodates a large amount of daily commuter traffic (see Figure 2-2). In 1984, a single-lane, barrier-separated HOV lane was opened in the median of the freeway. Use of the HOV lane was initially restricted to transit and registered vanpools, but underutilization of the lane led to the allowance of HOV2+ vehicles in 1986. Over time, the volumes increased on the HOV lane, and in 1988 the occupancy requirement was changed to 3+ in the peak periods to maintain adequate level-of-service. However, this increase led to underutilization of the lane during the peak period *(13)*.

In 1998, in response to the underutilization, METRO and TxDOT began operation of the QuickRide program, which allows 2-person carpools to use the HOV lane during the peak period for a $2 toll. Participants are required to sign up for a QuickRide account, pay a $2.50 monthly fee, and affix a transponder to their windshield along with a hangtag that indicates their enrollment in the program. Tolls for HOV2 vehicles are charged from 6:45 AM to 8:00 AM in the morning and from 5:00 PM to 6:00 PM in the evening.

2.10.4 US 290 (Northwest Freeway)

Similar to the Katy Freeway, the Northwest Freeway (US 290) contains a single-lane, reversible, barrier-separated HOV lane in its median. The lane is open in the southeast direction in the morning and the northwest direction in the afternoon. Following the success of the QuickRide program on the Katy Freeway, METRO added HOV2 buy-in on the Northwest Freeway in 2000. The QuickRide program operates on the Northwest Freeway during the morning peak period from 6:45 AM to 8:00 AM Monday through Friday. The afternoon peak is not part of QuickRide and allows HOV2 vehicles access to the lane for free.

One major difference between the HOT lane facilities in California and those in Houston is SOV allowance. Both SR 91 and I-15 allow SOVs to buy in the lane. However, at this time, SOVs are not allowed on I-10 and US 290 in Houston. Additionally, HOV2 vehicles can travel for free on I-15 but must pay the toll during peak periods at the other three facilities.

(Note: This literature review was prepared at the beginning of the project in preparation for the research effort. Since that time, the Minneapolis I-39 HOT lane conversion has been implemented.)

2.11 COMPARISON OF HOT LANE USERS AND NON-USERS

In March 2003, a survey was conducted to analyze the socioeconomic and trip characteristics of QuickRide users. Analysis of the survey data revealed significant differences in the trip purpose and socioeconomic characteristics of QuickRide users when compared to the other modes. QuickRide users were significantly more likely to be making school trips than other modes. They were also more likely to have a post graduate degree and have a household income greater than $100,000 per year. Additionally, they were significantly less likely to be male, be between the age of 25 and 34, or live alone.

The results gained from the survey seem to suggest that some of the primary users of the QuickRide program are parents taking their children to school. However, it is important to note the unique access requirements of the QuickRide program. SOVs are not allowed on the Houston HOV lanes for any toll amount. The admittance of SOVs would most likely change the socioeconomic characteristics of QuickRide users significantly.

2.12 HOT LANE INSTITUTIONAL CONSIDERATIONS

The institutional arrangements of a HOT lane project define the scope and the operation of the project. In addition to traditional agency coordination, case studies have shown that a recommended practice is to include as many potentially affected stakeholders as possible and to include them as early in the planning process as possible. Other parties to include are:

- transit agencies,
- regional transportation authorities,
- toll agencies,
- law enforcement personnel,

- court personnel,
- environmental groups,
- special interest groups, and
- citizens *(37)*.

In the case of existing HOV lanes that are to be converted to HOT lanes, some of the institutional arrangements may already be in place. For example, a transit authority may already operate an HOV lane on a department of transportation facility.

One of the first requirements is the legal authority to collect tolls on a facility. At the federal level, the authority is granted through the Value Pricing Program if implemented on an Interstate highway. An application must be made and specific authority granted through the program. Texas state law allows for the collection of tolls by the department of transportation, a regional toll authority, a county transportation authority, or a regional mobility authority. Additionally, some transit authorities, such as METRO, have authority to assess tolls on its facilities *(10)*.

The implementation of a HOT lane can be delayed or even halted by a number of institutional issues.

CHAPTER 3

METHODOLOGY AND PROCEDURE

3.1 RESEARCH ANALYSIS PROCEDURE

The researchers, in consultation with TxDOT personnel, developed a lengthy list of factors that have been identified throughout the documented research as having had some demonstrated or suspected degree of impact on the HOV lane to HOT lane conversion. Researchers consolidated that list to those factors that could have a meaningful bearing on the decision to convert.

Once the key factors were identified, described, and bounded, the research focused on how to incorporate these relevant factors into an analysis of the whole set that was logical, comprehensive, and explainable. That process took into account three dimensions for each factor:

- Weight—how significant or important is this factor relative to the goals of conversion?
- Score—how well does this factor compare to a desirable or minimum standard?
- Interaction—how does this factor interact with other factors and how can that be captured quantitatively?

Each of these dimensions required comprehensive development, which is described in further detail elsewhere in this report *(38)*.

With the large number of factors and detailed guidance associated with each, a hard copy workbook was not very practical, so the TTI team developed a software tool that accomplishes two tasks.

- It guides the user through logical steps in the development of an assessment.
- It performs all of the record keeping and calculations automatically.

This model was envisioned from the outset of the project and has been developed in parallel with the technical details. A flowchart of the research activities is included as Figure 3-1.

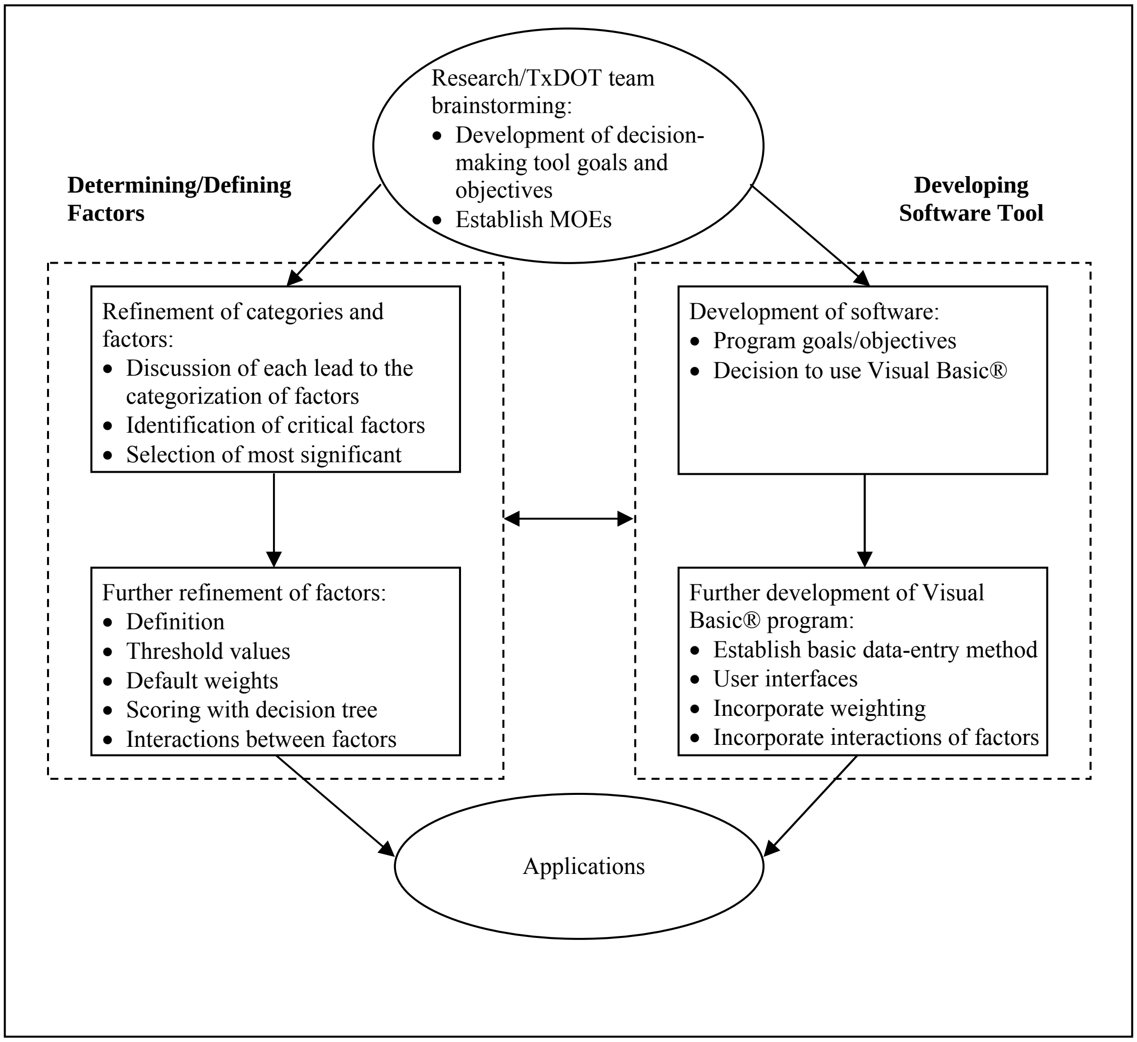


Figure 3-1. Flowchart of Research Activities to Develop HOV Lane to HOT Lane Conversion Tool.

Figure 3-2 illustrates the analytical process. The "analyst" is assumed to be a staff person in a transportation organization who has access to routine design, operations, and performance information. Using that routine design, operations, and performance information, along with links embedded in the software program, the analyst prepares the analysis of the facility and performance categories, and prepares the input data for the institutional category of factors. While the analyst may conduct part of the institutional analysis, the final elements are likely left to a senior management individual who may be more aware of the political sensitivities and interagency cooperation issues. In the case of TxDOT, this individual is assumed to be the district engineer, the ranking staff person over a geographic region of several counties, though the duties could certainly be delegated.

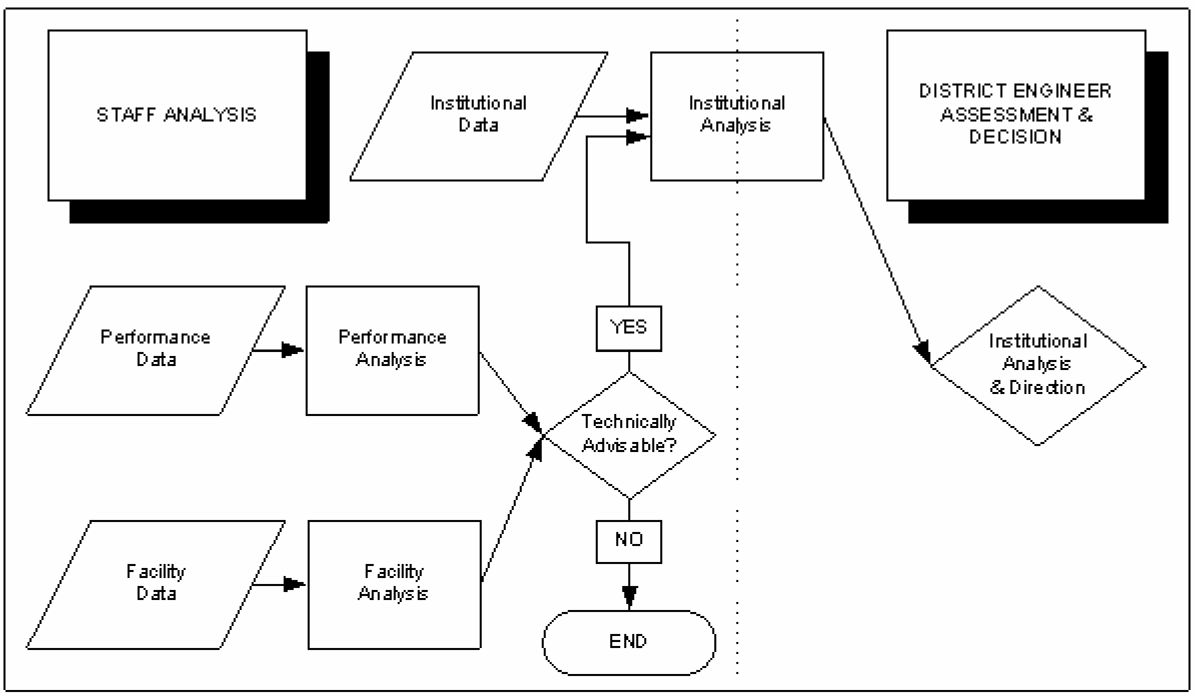


Figure 3-2. Decision Flowchart for Converting HOV Lanes to HOT Lanes.

CHAPTER 4

OVERVIEW OF THE MODEL

4.1 OVERVIEW OF THE MODEL

The HOT START software is a Microsoft Windows-based program that is built upon the Visual Basic.NET® platform (Microsoft Corporation, Redmond, Washington). The software guides the analyst through the process of evaluating an HOV facility for possible conversion to a HOT facility in a four-step process, following the guidelines discussed in this report.

Step 1. Assign factor weights.
Step 2. Score factors.
Step 3. Calculate scores.
Step 4. Interpret results.

The software provides the full functionality of a Microsoft Windows-based program, including the ability to save, load, print, and copy, as well as provide access to various help functions. The software also ensures a mathematically accurate analysis by automating the interactions between various factors, as well as leading the analyst through a series of steps/questions to obtain the correct score value for a given factor. For various factors, additional links are provided to documents, websites, and phone numbers that will further help the analyst answer questions that will result in determining the appropriate score.

4.1.1 Corridor/Community Information Requirements

To ease the data-entry process, routine information about the design, operations, and performance of an HOV lane should be collected prior to using the HOT START program. Table 4-1 provides a list of necessary resources. Tables 4-2 through 4-4 provide data collection forms for facility, performance, and institutional considerations, respectively. They contain a more detailed explanation of each factor through a series of questions. The second column lists the main resources needed to answer the questions prompted by HOT START. The numbers in this column refer to the resources listed in Table 4-1. The “Corresponding Scoring Decision Tree Table” column lists the figure in Appendix B that illustrates the scoring process for that factor. The “HOT START Questions” column is the information HOT START needs to determine the score, while the “Answer Choices” column shows the form of the answer the user must enter into the program. Section 4.3.3, *Scoring Each Factor*, explains more details about the scoring step.

Table 4-1. HOT START Resources Needed.

Resource Number	Type	Description
1	Report	"Guide for High-occupancy Vehicle (HOV) Facilities." American Association of State Highway and Transportation Officials. Washington, D.C., 2004. *(38)*
2	Report	Perez, B., and G. Sciara. "A Guide for HOT Lane Development." FHWA-OP-03-009FHWA, Federal Highway Administration, Washington, D.C., 2003.
3	Report	Cothron, A.S, D.A. Skowronek, and B.T. Kuhn, "Enforcement Issues on Managed Lanes," Research Report 0-4160-11, January 2003. *(31)*
4	Data	Corridor lane geometric design and measurements
5	Data	Corridor origin-destination (O-D) patterns
6	Data	HOV ramp volumes and terminus volumes
7	Data	Weave volumes/Corridor volume level-of-service (LOS)
8	Data	Current facility sign inventory, pricing points where new signs might be needed
9	Website	Census data: http://factfinder.census.gov
10	Website	State Implementation Plans for Texas: http://tnrcc.state.tx.us/oprd/sips/siptexas.html
11	Plans	Plans for intelligent transportation systems (ITS) implementation for toll collection and verification and incident management
12	Plans	Definition of primary or target users, i.e., express bus, long distance commuters, etc.
13	Plans	Ongoing maintenance and equipment resources for supporting operations: law enforcement, incident management, maintenance

Table 4-2. Data Collection Form – Facility Considerations.

Factor	Resources Needed (Table 4-1)	Corresponding Scoring Decision Tree Table (Appendix B)	HOT START Questions	Answer Choices
Cross Section	1, 2	B-1	Does the design envelope satisfy AASHTO minimum requirements for the entire length?	Yes No
	4	B-1	If "No," what are lengths of unsatisfied sections?	<100 ft 100-1000 ft 1000 ft-1 mile 1 mi – ½ facility > ½ facility entire facility
Lane Separation for Toll Collection	1, 2	B-2	What type of lane separation exists?	Rigid Flexible Buffer
	1, 4	B-2	Are AASHTO guidelines satisfied for this type of separation?	Yes No
	11	B-2	Can tolls be collected?	Yes No
Facility Access Satisfies O-D Requirements	12	B-3	Are primary or target users defined?	Yes No
	5	B-3	If "Yes," are access points located to serve primary users?	Yes No
Facility Access Design	6	B-4	What type of access is provided?	At-grade slip ramp Direct connect ramp No designated access (continuous)
	4	B-4	If "at-grade slip ramp," is buffer/barrier opening length 1300-1500 ft?	Yes No
	N.A.	B-4	What is design year LOS on freeway?	C/D E/F
	7	B-4	What is weaving volume (HOV ramp entrance)?	less than 400 vph less than 250 vph
	7	B-4	Is up to 10 mph mainlane (ML) speed reduction for managed lane weaving allowed?	Yes No
	7	B-4	What is the minimum length of weaving distance per lane?	950 ft 900 ft 750 ft 700 ft 600 ft 650 ft 500 ft

Note: More information related to the descriptions and questions addressed by each factor can be found in Appendix A.

Table 4-2. Data Collection Form – Facility Considerations (continued).

Factor	Resources Needed (Table 4-1)	Corresponding Scoring Decision Tree Table (Appendix B)	HOT START Questions	Answer Choices
Ability to Enforce	1, 2	B-5	What is operating scheme?	Pay by exception Credit or free by exception (universal tag)
	3	B-5	If "pay by exception," how is occupancy check performed?	Stationary Roving
	4	B-5	If stationary, do enforcement areas conform to AASHTO?	Yes No
	4	B-5	How is occupation verification performed?	High speed Low speed
	11	B-5	Is there supporting technology (vehicle-based tag read units)?	Yes No
	13	B-5	Is there adequate law enforcement?	Yes No
Facility Traffic Control	12	B-6	Are target users defined?	Yes No
	8	B-6	If yes, are any special signing features to be used?	Yes No
	2, 8	B-6	Does sign placement conform to guidance?	Yes No
Pricing Strategy	11	B-7	Is there an operating policy for the HOT lanes?	Yes Partial No
Incident Management	1, 11, 13	B-8	Operational treatments for incident management that can be provided to assure travel time reliability	Tow truck, Emergency access points, closed circuit television (CCTV), changeable message sign (CMS), Speed monitoring [loops, automatic vehicle identification (AVI)] None
Maintenance	4	B-9	Is the facility reversible?	Yes No
	13	B-9	Level of maintenance support available	Full Most Some None

Note: More information related to the descriptions and questions addressed by each factor can be found in Appendix A.

Table 4-3. Data Collection Form – Performance Considerations.

Factor	Resources Needed (Table 4-1)	Corresponding Scoring Decision Tree Table (Appendix B)	HOT START Questions	Answer Choices
HOV Lane Utilization	N.A.	B-10	Percent buses (to be used to determine f_b for vphpl calculation)	
	N.A.	B-10	Type of terrain (to be used to determine f_b for vphpl calculation)	Level Rolling Mountainous
	N.A.	B-10	Vphpl on facility (non-toll paying) = (autos + buses * f_b)/# lanes	<1200 1200-1400 >1400
	N.A.	B-10	Is LOS on general-purpose lane D, E, or F?	Yes No
	N.A.	B-10	Will conversion have positive impact on HOT lane?	Yes No
Travel Time	N.A.	B-11	What are the average travel-time savings?	>1 min/mile & >5 min overall >0.25 min/mile & >2 min overall <2 min overall
	N.A.	B-11	Will there be a higher reliability of travel times on the HOT lane?	Yes No
	N.A.	B-11	Will the conversion create a negative impact on HOT lane(s) speed?	Yes No
Benefits	N.A.	B-12	How will the net agency/societal benefits change?	Increase No change Decrease
Willingness to Pay Tolls	9	B-13	Are there many high-income travelers?	Yes No
	N.A.	B-13	Are there other local toll facilities?	Yes No
	N.A.	B-13	If yes, are the tags interoperable?	Yes No
Safety	N.A.	B-14	Is there currently a high crash rate on the facility?	Yes No
	N.A.	B-14	How will HOT lanes affect the crash rate on the facility?	Increase Slight reduction No change Great reduction

Note: More information related to the descriptions and questions addressed by each factor can be found in Appendix A.

Table 4-3. Data Collection Form – Performance Considerations (continued).

Factor	Resources Needed (Table 4-1)	Corresponding Scoring Decision Tree Table (Appendix B)	HOT START Questions	Answer Choices
Environment	10	B-15	Is facility in non-attainment area?	Yes No
	N.A.	B-15	How will conversion affect fuel use?	Increase No change Decrease
	N.A.	B-15	How will conversion affect emissions?	Increase No change Decrease

Note: More information related to the descriptions and questions addressed by each factor can be found in Appendix A.

Table 4-4. Data Collection Form – Institutional Considerations.

Factor	Resources Needed (Table 4-1)	Corresponding Scoring Decision Tree Table (Appendix B)	HOT START Questions	Answer Choices
Public Acceptance	N.A.	B-16	Which of the following is the public familiar with?	Tolling Electronic toll collection (ETC) HOV Video enforcement
	N.A.	B-16	Which of the following does the public find acceptable?	Tolling ETC HOV Video enforcement
Political Acceptance	N.A.	B-17	Is there a political champion for conversion?	Yes No
	N.A.	B-17	Is there political familiarity with the conversion concept?	Yes No
	N.A.	B-17	Is there political support for conversion?	Yes No
	N.A.	B-17	Does conversion achieve statewide or national goals?	Yes No
Environmental Justice/Title VI Issues	9	B-18	Are low income/minority populations negatively affected by conversion?	Yes No
	N.A.	B-18	If yes, are low income/minority populations involved in the planning process?	Yes No
	N.A.	B-18	Can a mitigation plan be developed?	Yes No

Note: More information related to the descriptions and questions addressed by each factor can be found in Appendix A.

Table 4-4. Data Collection Form – Institutional Considerations (continued).

Factor	Resources Needed (Table 4-1)	Corresponding Scoring Decision Tree Table (Appendix B)	HOT START Questions	Answer Choices
Revenue Use	N.A.	B-19	Is there agreement among agencies and the public on net revenue use?	Yes No
	N.A.	B-19	If no, does revenue use support public policy goals?	Yes No
	N.A.	B-19	If no, is revenue use determined by Federal requirement?	Yes No
Interagency Cooperation	N.A.	B-20	Do all agencies support the HOT lane concept?	Yes No
	N.A.	B-20	If no, are any agencies actively opposed to HOT lane concept?	Yes No
Media Awareness	N.A.	B-21	Is there media awareness and support?	Yes No Misrepresentation
	N.A.	B-21	If no, is media receptive to new ideas?	Yes No
Public Education/ Information	N.A.	B-22	What is the level of outreach efforts for public education and information?	Active Minimal None

Note: More information related to the descriptions and questions addressed by each factor can be found in Appendix A.

4.2 KEY ELEMENTS OF THE MODEL

4.2.1 Definition of Factors by Category

There are numerous factors to consider when investigating a conversion from an HOV lane to a HOT lane. Researchers separated these factors into facility, performance, and institutional categories to meet the project objectives specified earlier in the report. The many potential factors were narrowed down to those anticipated as the most important in each category. These factors are shown in Tables 4-5 through 4-7 for facility, performance, and institutional issues, respectively. These tables illustrate the depth and breadth of the number of factors that should be evaluated when considering the conversion of an HOV lane to a HOT lane at the sketch-planning level. The default weights provided in each table indicate the relative importance of each of the factors. The next section describes factor weighting in more detail.

Table 4-5. Facility Factors When Considering HOV Lane to HOT Lane Conversion.

Factor	Description and/or Question(s) Addressed	TTI Default Weight
Facility Cross Section	This factor is concerned with the design envelope available along the proposed HOT lane. AASHTO's *Guide for HOV Facilities* (*15*) provides examples of cross sections for barrier- and buffer-separated HOV facilities. These cross sections, including lane width and shoulder width, are typically applicable to HOT facilities. Typical questions include: Is there adequate space to bypass a disabled vehicle? For buffer-separated facilities, is there adequate space for a vehicle to avoid an encroaching vehicle?	6
Lane Separation for Toll Collection	This factor is concerned with the adequacy of lane separation between HOT and general-purpose lanes to support tolling operations. Three types of lane separation can be considered, each with advantages and drawbacks: • rigid barrier, • flexible barrier, and • buffer.	6
Facility Access Satisfies O-D Requirements	The principal consideration for this factor is, "do the access points serve potential HOT lane demand?" Answering this question begins with defining the primary or target users of the facility. HOV lanes are designed to serve buses, carpools, and long-distance commute trips. If the facility becomes a HOT lane, will these still be the primary users? Do lower-occupant vehicles buying into the lane have a different set of O-D patterns? By defining the primary or target users, in priority order, along with their O-D patterns, the location of access points can be determined based on how best to serve their needs.	5
Facility Access Design	The design of access points can impact the operation of both the HOT lane and adjacent general-purpose lanes. This factor evaluates the access design in terms of the ability to meet guidelines developed in Texas research (*39*) and other nationally accepted guidance. There are three types of access that can be provided: • at-grade slip ramp, • direct connect ramp, and • no designated access (continuous).	5

Table 4-5. Facility Factors When Considering HOV Lane to HOT Lane Conversion (continued).

Factor	Description and/or Question(s) Addressed	TTI Default Weight
Ability to Enforce	HOT lane enforcement involves verifying occupancy requirements as well as toll account validity. This factor asks the question: "Can adequate compliance be achieved through planned enforcement operations?" There are three areas of consideration: • adequate space for occupancy verification, • ease of occupancy check, and • level of law enforcement.	5
Facility Signage	Signing, pavement marking, and other forms of driver communication can be challenging for HOT lanes for several reasons. First, the HOT lanes are located in an existing freeway corridor with its own set of signing needs and requirements, sometimes conflicting with messages and information requirements for drivers in the HOT lanes. This creates the potential for confusion and information overload. Second, there are additional messages for a HOT lane operation that are not necessary for a typical HOV lane, namely price level that can vary by time of day and/or user group. This facility factor poses the question, "Can effective driver communication be accommodated when converting to a HOT lane?" Since there is limited specific guidance available in the Manual on Uniform Traffic Control Devices (MUTCD), the general guidance and best practices come from Texas research *(40)* and current research with FHWA: • define target users and their information needs, • signing features, and • signing placement.	5
Pricing Strategy	Pricing strategy refers to the overall operating strategy for the HOT lane and how it works in combination with eligibility requirements, facility design, and supporting technology: • lane management for priority or target users, and • setting the toll rate and eligibility requirements.	5
Incident Management	Can reasonable incident management be provided to assure travel time reliability?	3
Maintenance	Is there adequate maintenance support to assure quality service and operations, including all ITS technology, flexible barriers, operation policy, and changes to service?	2

Table 4-6. Performance Factors When Considering HOV Lane to HOT Lane Conversion.

Factor	**Description and/or Question(s) Addressed**	**TTI Default Weight**
HOV Lane Utilization	This factor examines actual usage (or predicted usage in the case of a planned HOV lane) of the HOV lane by non-toll-paying vehicles from three viewpoints: • Can the conversion to a HOT lane remedy an existing utilization problem? • Is there a potential that the increased use of the HOV lane will have a positive impact on general-purpose level-of-service? • Will the conversion have a positive impact on person-movement in the corridor?	6
Travel-Time Savings / Reliability	This factor examines both the amount of travel-time savings offered by the HOT lane and the reliability of travel times on both the HOT lane and the general-purpose lanes. Like the lane-utilization factor, the travel-time factor will be examined from three viewpoints: • Does the HOT lane offer significant travel-time savings over the general-purpose lanes? This savings must include any additional time required for travelers to access the HOT lanes in the case where access is restrictive (as with the Katy HOV lane in Houston or I-15 express lanes in San Diego). This is a key consideration for conversion as few drivers will pay for small travel-time savings. • Does converting the lane to a HOT lane negatively impact the travel time on the HOT lane? If there is a negative impact, is it large and does it reduce the operating speed of the HOT lane below an agency-prescribed minimum acceptable speed? • Are travel times on the HOT lane significantly more reliable (have less variance) than travel times on the general-purpose lanes? Even if the average travel-time saving is small, travelers will pay for additional reliability in their travel times. This must include the impact of incidents (crashes, stalls, etc.) on travel times for both the HOT lane and the general-purpose lanes.	6
Public Agency / Societal Benefits	This factor includes the HOV lane conversion's benefits from both an agency revenue point of view and a net benefit to society point of view. From the agency point of view, the greater the toll revenue exceeds costs of the HOT lane conversion (start-up, operating, and maintenance) the better. From society's point of view, any overall travel-time savings, reduction in emissions, or reduction in fuel use are all benefits.	5
Willingness to Pay Tolls	This factor examines local drivers' willingness to pay tolls, both from their familiarity with tolls and their income levels. An interaction of these two issues will yield the appropriate values. • Are there other toll facilities already in the area? Do these other local facilities use the same toll technology as on the HOT lanes, and will the transponders be interoperable? • Travelers with higher incomes generally have higher value of travel-time savings and are therefore more willing to pay a toll to avoid congestion and reduce their total travel time.	4
Safety	This factor examines the likelihood that the conversion will adversely affect safety on the HOV lane. A reduction in safety causes concerns for additional injuries due to the conversion. Additionally, if there are frequent crashes on the HOT lane, then travelers will not pay to use the lane due to a fear of their own safety and the travel delays caused by crashes.	4
Environment	This factor includes the HOT lane conversion's impact on both emissions and fuel use. Due to the high likelihood that the conversion will have minimal impact on either fuel or emissions, the default weight of this factor is relatively low. The minimal impact is caused by travelers in the (presumably congested) general-purpose lanes reducing some fuel use and emissions output by changing to the faster-moving HOT lane, but travelers in HOV modes switching to HOT lane use will increase the amount of fuel use and emissions output.	2

Table 4-7. Institutional Factors When Considering HOV Lane to HOT Lane Conversion.

Factor	Description and/or Question(s) Addressed	TTI Default Weight
Public Acceptance	This factor is concerned with public acceptability of converting an HOV lane to a HOT lane or implementing a new HOT lane. The level of acceptability can be ascertained through focus groups or surveys. Additionally, public perception research can identify issues that are of importance to the public so that they can be addressed proactively.	6
Political Acceptance	This factor is concerned with the political knowledge of and acceptability for implementing a HOT lane. The political acceptance should be measured at all levels (e.g., local, regional, and state). Acceptance can be determined through stakeholder interviews, supporting legislation, project champions, and media reports. Acceptance of HOT lanes can be demonstrated by the adoption of such strategies into the long-range plan of an area and by enacting legislation that allows for such conversions. A conversion of an HOV lane to a HOT lane may also facilitate other regional goals, such as increasing person movement or increasing auto occupancy.	6
Environmental Justice/Title VI Issues	This factor concerns the disproportionate impact on low-income or minority populations that would be affected by a HOT lane. This may be different depending on whether the project proposes to convert an HOV lane or to implement a HOT lane where none currently exists. This factor can be measured by the participation of affected groups in the planning process and through focus groups or surveys.	6
Revenue Use	There should be agreement prior to project implementation on the use of revenues derived from the project, if any. There may also be federal requirements that stipulate what excess revenues may be used for.	5
Interagency Cooperation	Will multiple entities be responsible for maintenance and operation of the HOT lane? If so, then interagency cooperation will be paramount to the success of a HOT lane. All agencies will need to support a conversion. Operating agreements that are drafted may be required to stipulate certain provisions such as level-of-service or bus speeds per federal regulations.	4
Media Relations	This factor deals with the media's portrayal of the project. It may be influenced by an existing project or familiarity with the HOT lane concept. It can be measured through editorials, media stories, and news clippings.	2
Sustained Public Education / Information	This factor concerns the mechanisms in place to generate support for a HOT lane project and the willingness to continue public outreach after the project is implemented. Project success depends on the promotion of benefits the project provides. Cross-jurisdictional support for project implementation is important to project success. Additionally, continued funding for advertising and outreach is needed.	2

4.3 WEIGHTING AND SCORING EACH FACTOR (INPUTS)

This program uses weighting and scoring (Steps 1 and 2) as a way to compare alternatives for HOV lane to HOT lane conversion. Based on a community's needs and project specifics (e.g., political, public, operations, geometry), conversion may or may not be practical. This tool allows the analyst to compare alternatives for their unique community. Weights should be understood as the quantitative value of the importance of each factor for any community in the analysts' jurisdiction, whereas the score for each factor represents how the particular project performs. The more important a factor is to the analyst, the heavier the weight should be. A high score for a factor denotes that the factor is satisfied, while a low score means the factor is relatively unsatisfied. Weights are from 0 to 10, while scores range from -5 to 5.

4.3.1 Weighting Each Factor

After narrowing the list of factors within each category to those listed in Tables 4-4 through 4-7, researchers developed a weighting strategy for the factors. The selected procedure ensures that factors from all of the three primary categories (facility, performance, institutional) are assigned weights and compared relative to each other categorically and globally. This also allows the analyst to assign weights different from the default values.

The sum of the weights must equal 100. Therefore, the analyst has 100 "points" to allocate in a manner believed appropriate for the community. The analyst can either use the TTI default weights or weights the analyst deems appropriate. The default weights used in the actual program and shown in Figure 4-1 are those weights shown in Tables 4-4 through 4-7.

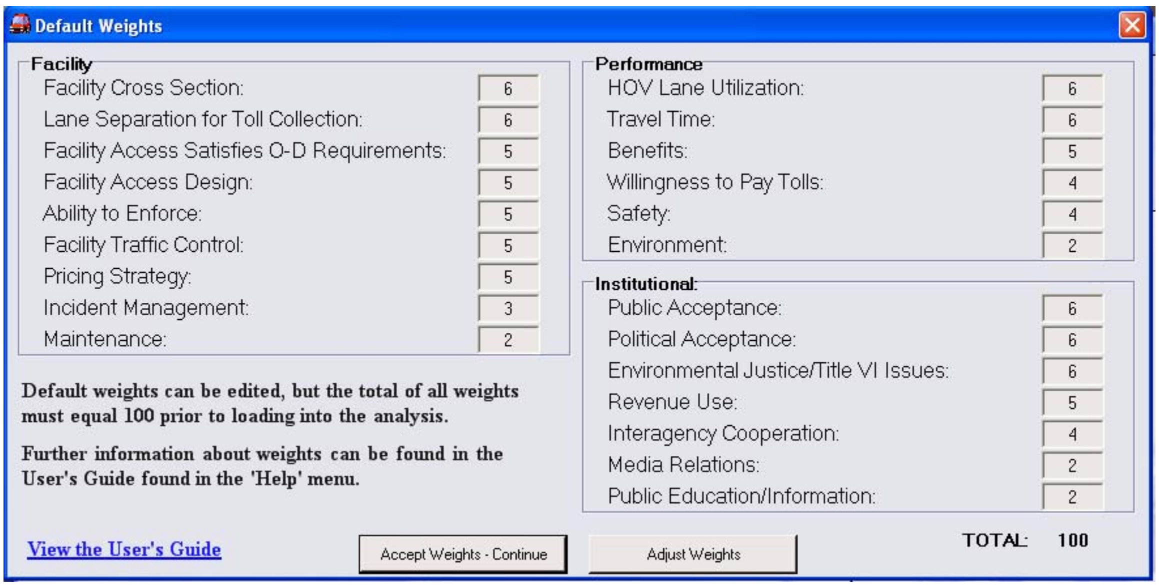


Figure 4-1. HOT START Screen Shot of Default Weights.

The analyst can change the weights by selecting "Adjust Weights," and the analyst has the opportunity to save the new weighting profile. However, the sum of the weights must equal 100 before the user can continue. This weighting strategy forces the user to consider all the factors simultaneously that are anticipated to affect the decision whether to convert from an HOV lane to a HOT lane.

4.3.2 Weight Summary

After scoring each factor, the user is reminded of the weight profile used by looking at the Weight Summary page (Figure 4-2). Here, the user can see the factors in order of priority instead of by category and make necessary weight adjustments by comparing each factor to each other and entering the new weight. Once the total weight equals 100, the user is allowed to proceed to Step 3, calculate scores, as discussed in the next section.

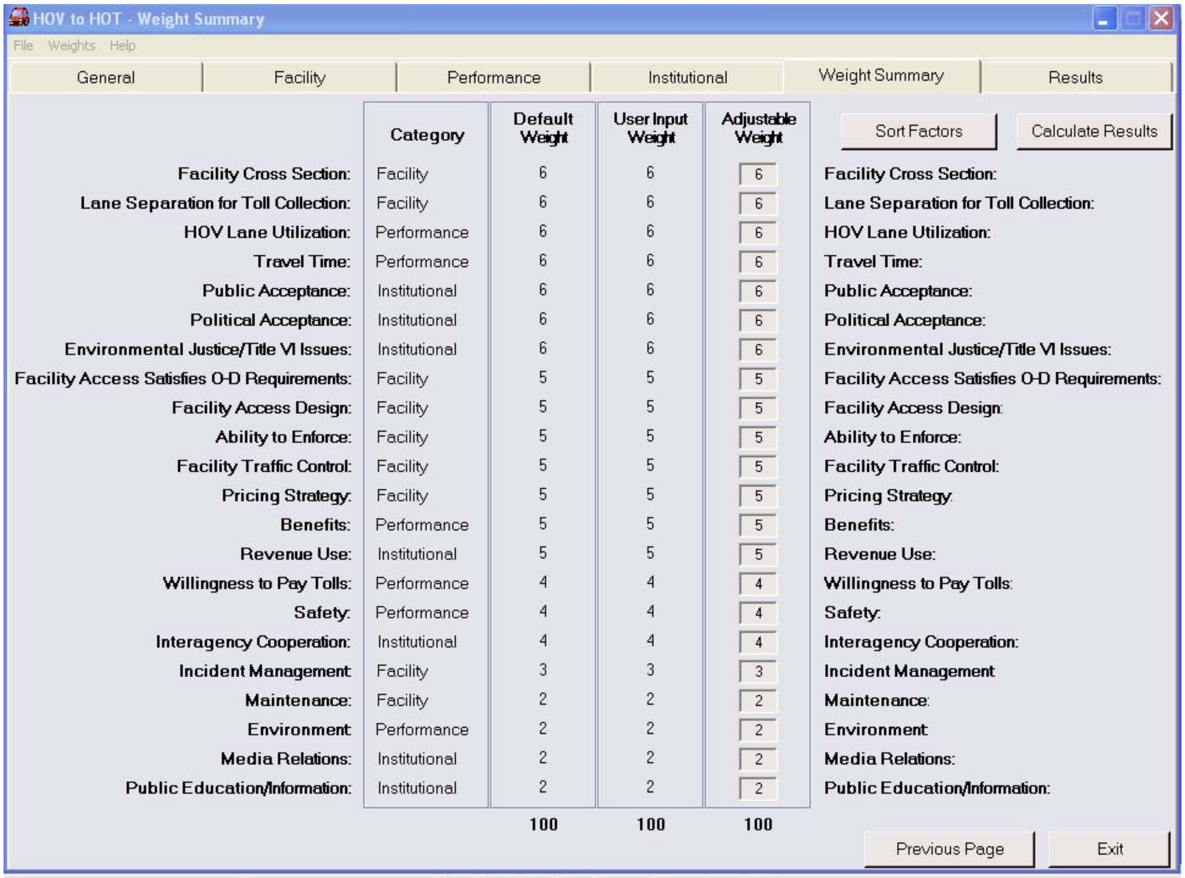


Figure 4-2. HOT START Screen Shot of Weight Summary.

4.3.3 Scoring Each Factor

After addressing the factors and associated weights, researchers developed a scoring method for each of the factors. Typically, the scoring of any factor ranges from a value of 5 (highest) to -5 (lowest), with a score of zero indicating a minimally acceptable level for that factor. A negative score implies that the factor is not fully achieved as is desirable. Decision trees were created for each factor to assist in scoring. The decision trees walk the analyst through pertinent questions/issues for a given factor to determine the score. The score is then entered for each factor into the software tool. The software tool itself can guide a new user with questions that ultimately result with the proper scoring.

Figures 4-3 and 4-4 are illustrations of typical scoring decision trees for the "Facility Cross Section" and "Travel Time" factors, respectively. They give an example of how the user is guided to a particular score for each factor depending upon the characteristics of the corridor. Appendix A contains decision trees for all the factors.

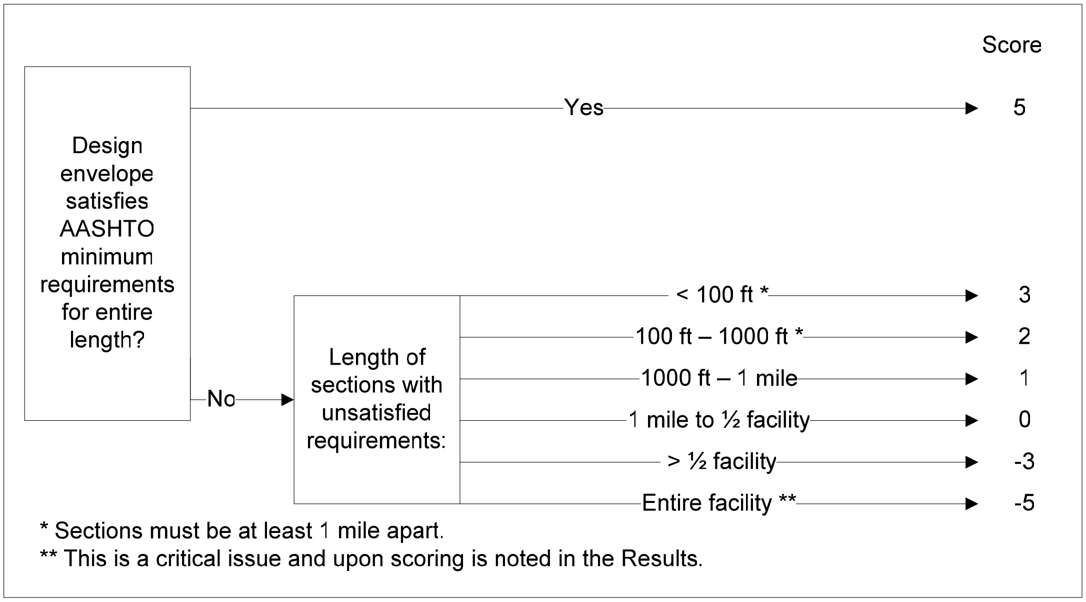


Figure 4-3. Sample Scoring Decision Tree for the "Facility Cross Section" Factor.

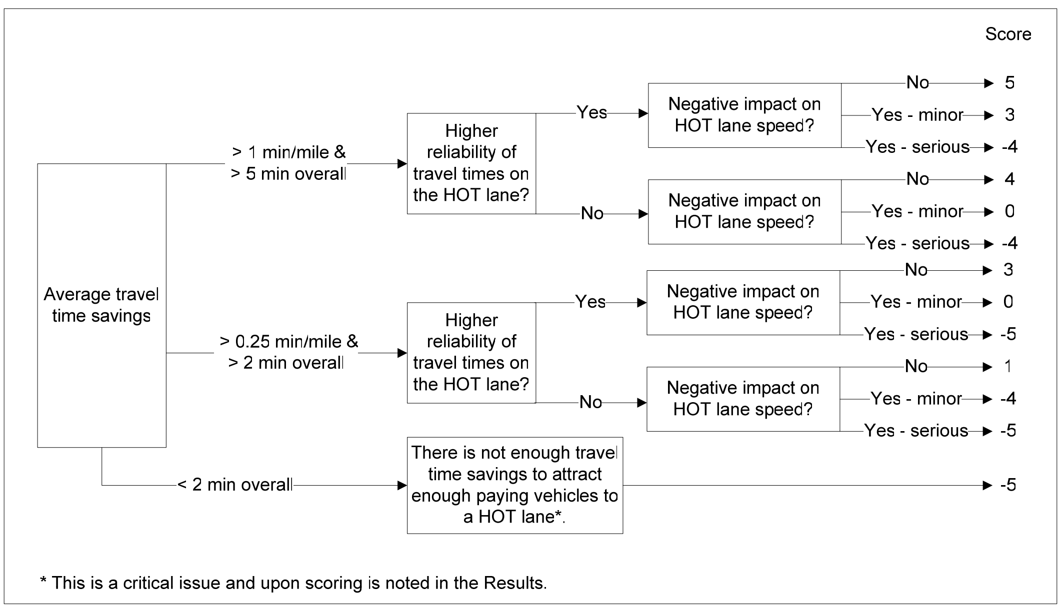


Figure 4-4. Sample Scoring Decision Tree for "Travel Time" Factor.

4.3.4 Factor Interactions

Once researchers identified the final list of the most important performance, facility, and institutional factors, it was necessary to investigate any possible interactions between these factors. This would also affect scoring. For example, a poor (narrow) facility cross section would have a negative impact not only on the cross section factor, but on several performance factors as well. The narrow cross section could reduce the vehicle capacity of the lane, thereby reducing HOT lane utilization. It could also increase the crash rate, decrease average travel speeds, and decrease travelers' willingness to pay to use the lane. After examining the factors from each area, researchers determined that those with the most impact were between the facility characteristics and performance measures. Although both can certainly have some interaction with institutional factors, those interactions would be much smaller in magnitude and would make the analysis unnecessarily complex without significantly impacting the outcome. Therefore, the remainder of this section, and the software itself, focuses on the interactions between performance and facility factors.

An argument can be made that almost any of the important facility features listed in Table 4-4 can, in some way, impact any of the performance measures in Table 4-3. It is the goal of this research, and the accompanying software program, to focus on those interactions that will make a material impact on the decision whether or not to convert an HOV lane to a HOT lane. To identify these interactions, researchers first identified facility and performance measures with interactions that were ranked (1) strong, (2) moderate, and (3) weak, but still of significance (see Table 4-8). Second, researchers examined each of these interactions as discussed in Table 4-9. Finally, researchers adjusted the software package such that these interactions were accounted for in the final HOV to HOT rating.

Table 4-8. Interaction of Factors Impacting the Conversion of an HOV Lane to a HOT Lane.

	Interaction Level					
	Performance Factor					
Facility Factor	HOV Lane Utilization	Travel Time	Willingness to Pay Tolls	Safety	Environment	Benefits
Cross Section	Strong	Weak	Moderate	Strong		Anytime any of the first five perform. factors are impacted, then the benefits of the HOT lane are impacted.
Lane Separation		Moderate		Strong		
Facility Access for HOT O-D	Weak		Moderate			
Facility Access Design		Moderate	Moderate	Strong		
Ability to Enforce			Weak	Weak		
Facility Signage	Moderate		Moderate	Weak		
Pricing Strategy	Strong		Strong			
Incident Management	Weak	Weak	Moderate	Weak	Weak	Secondary
Maintenance	Weak	Weak	Weak	Weak		Secondary

Legend:
- Strong Interaction
- Moderate Interaction
- Weak, but Significant, Interaction
- Secondary Interaction

These strong, moderate, and weak interactions are accounted for in the software by first obtaining the relevant facility characteristic (for example, "Cross Section") score from the user. If the value of the characteristic is less than ideal, then some adjustment of the related performance factor (for example, "Lane Utilization") is required as the default performance factor values assume an ideal facility. The software will automatically update the performance factor to reflect this suboptimal facility characteristic by subtracting a set number of points from the value of the performance factor. While the number of points subtracted varies by interaction type and strength of the interaction, typical reductions are 1 to 2 points. Figures 4-5 and 4-6 illustrate the interaction concept, as shown in the HOT START program.

Table 4-9. Discussion of Significant Interactions between Factors.

Facility Factor	Performance Factor	Interaction Discussion
Cross Section	HOV Lane Utilization	As the cross section narrows, the volume of vehicles accommodated on the lane at free-flow speeds decreases.
	Travel Time	As the cross section narrows, the free-flow speed drops, decreasing the travel-time benefits of the HOV lane.
	Willingness to Pay Tolls	With very narrow lanes, travelers may not feel comfortable and safe in the lanes, decreasing their willingness to pay for travel in those lanes.
	Safety	Both actual and perceived safety may decrease as lane widths decrease. Increased crashes will also adversely impact travel times. Additionally, if insufficient room exists to move stalled or crashed vehicles out of the way on a barrier-separated lane, then travel times could be much worse than on the general-purpose lanes.
Lane Separation	Travel Time	If a significant blockage occurs in a barrier-separated facility (frequently), then travel times on the HOV lane will deteriorate significantly.
	Safety	Limited research suggests barrier-separated lanes to be safer than lanes separated by a buffer or a flexible barrier.
Facility Access for HOT Lane Origins and Destinations.	HOV Lane Utilization	If the access points for toll-paying drivers are congested, then the number of non-paying travelers at those access points will decrease.
	Willingness to Pay Tolls	If the access points for toll-paying drivers are congested or located long distances from their preferred entry point, then this will reduce the travel-time savings offered by the HOV lane.
Facility Access Design	Travel Time	Poor access/egress points can add travel time to the HOV lane option.
	Willingness to Pay Tolls	Poor access/egress points can impact travel time to/from the HOV lane, reduce perceived/actual safety, and reduce ease of use, impacting customers' willingness to pay for the lane.
	Safety	Poor access/egress points can reduce perceived/actual safety.
Ability to Enforce	Willingness to Pay Tolls	Some potential paying customers may choose to be violators instead if they perceive/recognize lax enforcement.
Facility Signage	Willingness to Pay Tolls	Adequate pricing/occupancy requirement information must be available before many travelers elect to pay for HOV lane use.
Pricing Strategy	HOV Lane Utilization	The pricing strategy clearly has a major impact on both the utilization of the lane and the traveler's willingness to pay the toll. The software provides guidance on the preferred pricing strategy for different lane options and assumes the HOV lane operator selects an appropriate strategy.
	Willingness to Pay Tolls	
Incident Management	All	An aggressive incident management strategy that rapidly clears incidents from the HOV lane can improve all performance aspects.
Maintenance	All	If there is debris in the lane on a regular basis or there are issues with reversing a reversible lane, then this will impact all aspects of HOT lane performance.

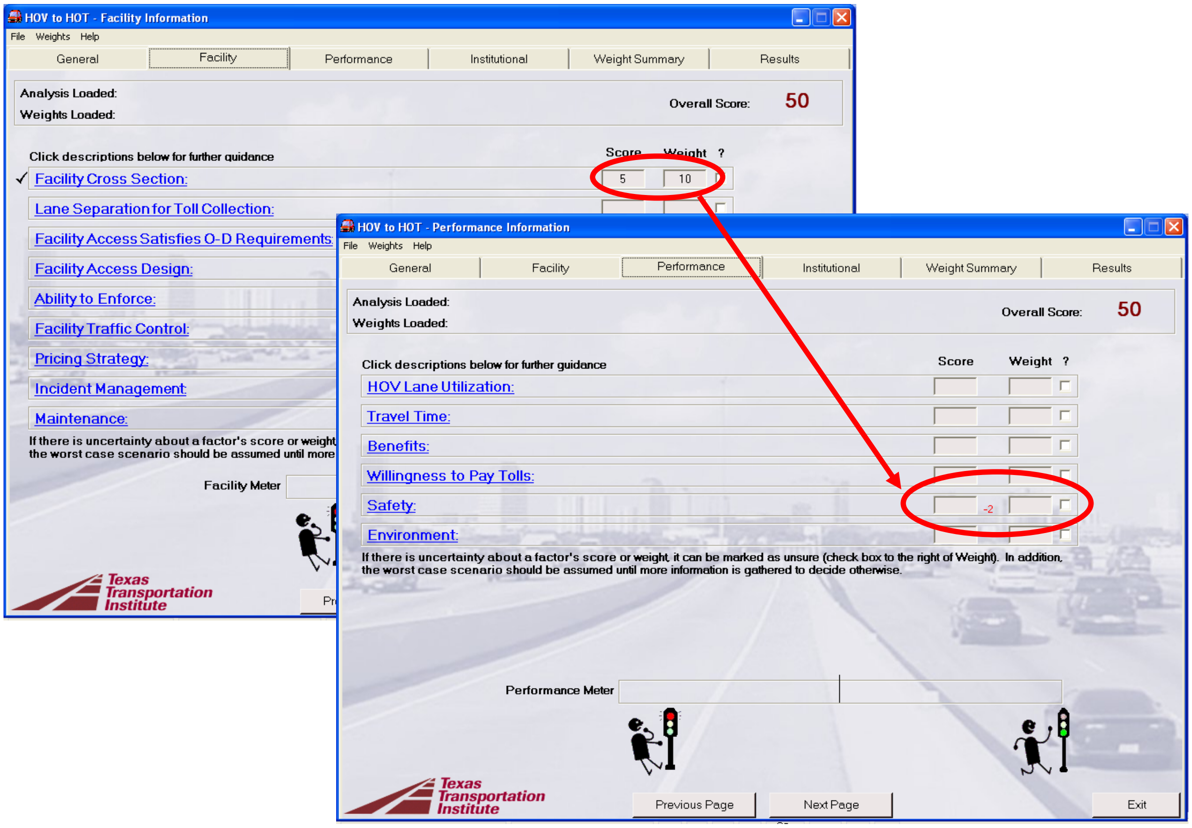


Figure 4-5. Perfect Score for "Facility Cross Section" Factor.

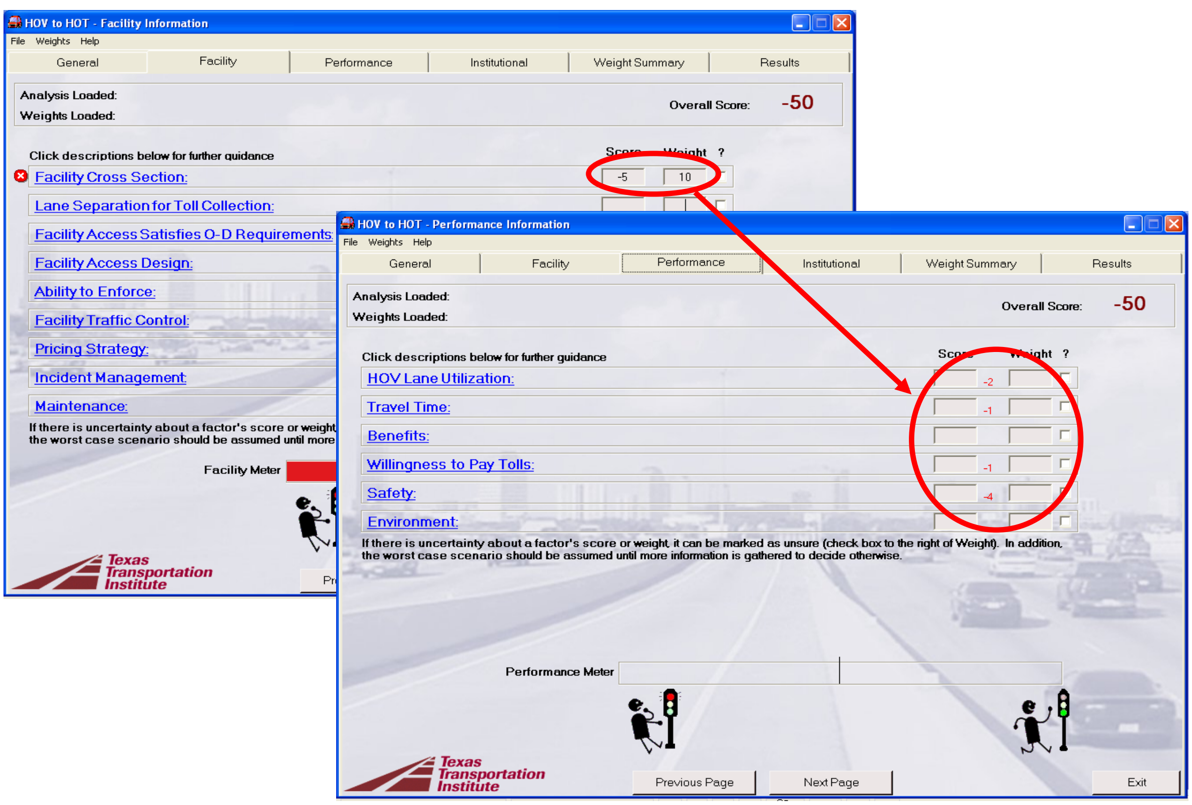


Figure 4-6. Worst Possible Score for "Facility Cross Section" Factor.

As shown in Figure 4-5, a perfect score of 5 for "Facility Cross Section" results in only the default interaction effect of subtracting two points from the "Safety" factor score in the Performance category. This automatic deduction is removed when "rigid barrier" is specifically selected as the lane separation technique in the "Lane Separation for Toll Collection" factor. Contrastingly, the low score of -5 for the "Cross Section" factor, as shown in Figure 4-6, leads to multiple point deductions for several performance category factors. All interaction effects are automatically accounted for in the HOT START program. In these figures, the point deductions due to interactions are in red, between the "Score" and "Weight" columns. All other attributes of these screen shots are discussed in the HOT START development guide (*41*).

4.4 INTERPRETING HOT START RESULTS (OUTPUTS)

Step 4 of the HOT START process is to interpret the results. The results of HOT START will not produce go/no-go indicators, at least not by themselves. These results are not decision makers themselves but rather indicators of the potential positive or negative impacts of a conversion. The presence of low scores or warning indicators may be more reliable as cautions than high scores are as indicators of success. There are two measures to consider: 1) the overall scores, and 2) a review of critical factors to be resolved. The interpretation of HOT START's results is further illustrated through two case studies in the next section.

CHAPTER 5

CASE STUDIES

The analytical tool is applied to two Texas freeways in this report—Loop 1 in Austin and I-10 HOV in Houston. As more research becomes available related to any of the key factors considered in HOT START, the factors (scoring, interactions) can be updated in future versions of the software.

5.1 LOOP 1, AUSTIN, TEXAS

The Loop 1 (MoPac Expressway) Corridor in Austin, Texas, is one of the two primary north-south highway facilities in the region and is heavily congested in both directions during peak periods, operating at LOS E to F in both directions. The Austin District of TxDOT is initiating a study to better move transit through Central Austin by implementing dedicated HOV or bus lanes on Loop 1 between downtown and US 183. Loop 1 was designated as an HOV corridor in the long-range transportation plan until recently, when its designation was changed to "managed lanes." Strategies investigated included some form of managed lane, either as an HOV lane dedicated to carpools and transit, or a HOT lane in which pricing augments eligibility to allow use by more different types of users. HOT START can be employed to evaluate the feasibility of converting the planned HOV lane to a HOT lane. Appendix B includes the data collection form used to determine the input for HOT START for the Loop 1 case study.

Figure 5-1 shows the default weights used and the assigned score for the facilities category. Note the low score (-5) for "Facility Cross Section" results in a critical factor as marked with the red circled "x." The orange color in the facility meter at the bottom of the page represents that the score for the facility factor is relatively low. A caution symbol ( ) appears next to three factors (Facility Access Satisfies O-D Requirements, Facility Access Design, and Ability to Enforce) that also have reddened boxes for the score and weight. This caution symbol is because these factors have been marked as "Uncertain" by clicking in the boxes in the "?" column corresponding to those factors. It is important to keep in mind that many of the low scores can be attributed to the fact that only conceptual level evaluation has been performed at this point, and many of the factors, particularly those related to access and operating strategy, are unknown at this time.

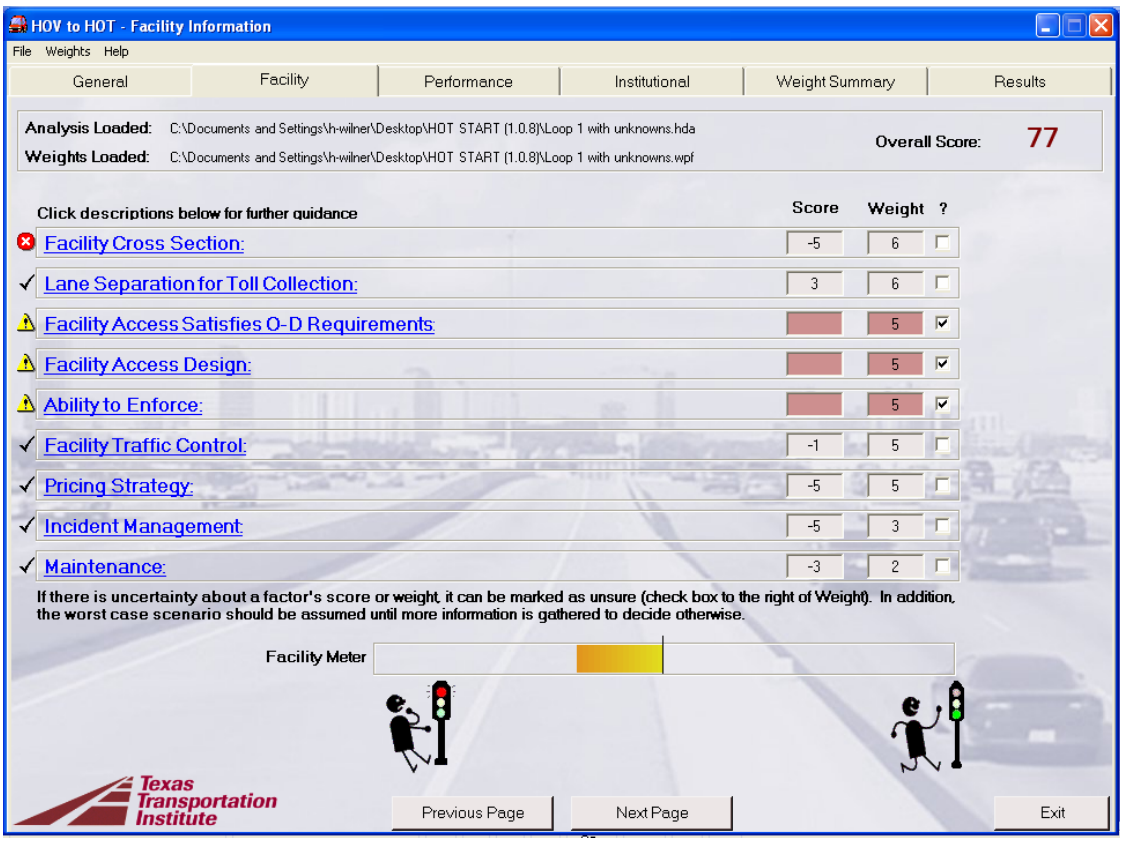


Figure 5-1. Loop 1 Facility Factors Weights and Scores.

Figure 5-2 shows the default weights and assigned scores for the performance factors. The numbers in red between the "Score" and "Weight" columns represent the points deducted from the score for that factor to account for interactions with the "Cross Section" factor in the facilities category. The yellow bar in the performance meter implies that the score is still not positive and that there are some low-scoring factors. However, "Benefits" received a perfect score, while the lowest scores of zero still satisfy minimums. The reason this category is below zero is because of the score deductions due to interactions.

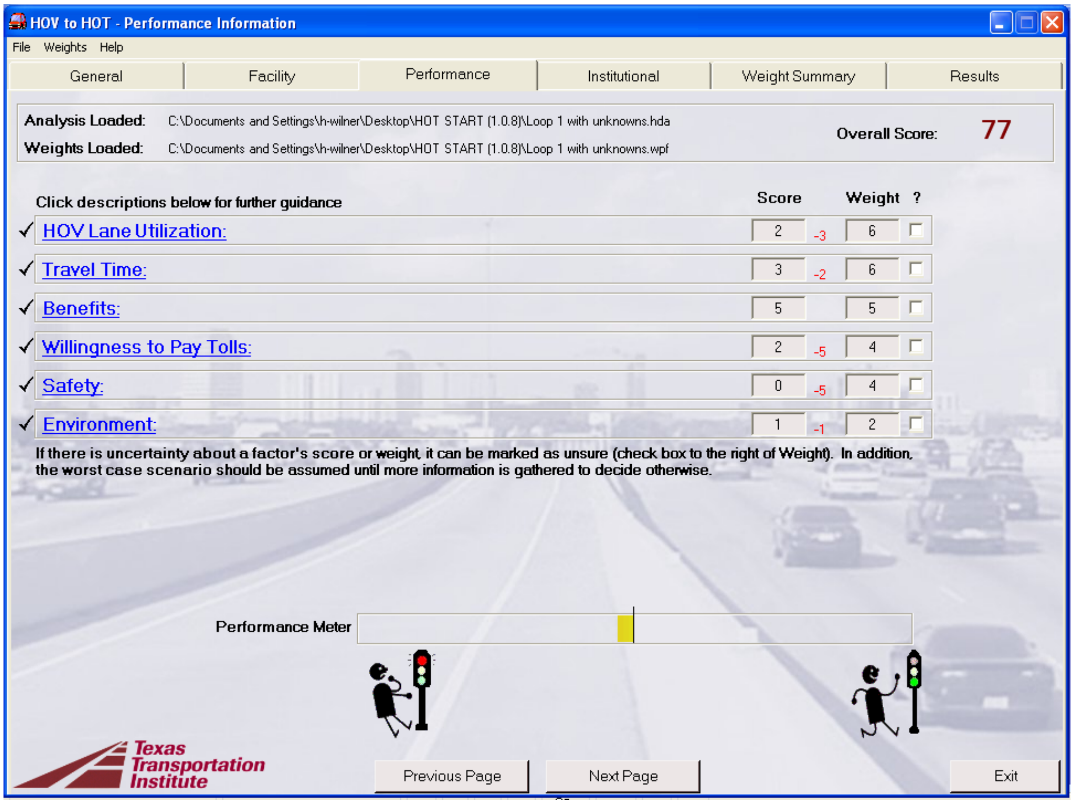


Figure 5-2. Loop 1 Performance Factors Weights and Scores.

Unlike the results for facility and performance considerations, the bar for institutional considerations is green, indicating high-scoring factors. Figure 5-3 shows the results for the institutional factors. All factors received a perfect score except for "Interagency Cooperation," which still received a good score (3 points). As is the case with the facility scores, the institutional scores may be misleading since the study has not been initiated and interaction with the public – though positive – has been limited to a small number of elected officials and a handful of civic/neighborhood organizations.

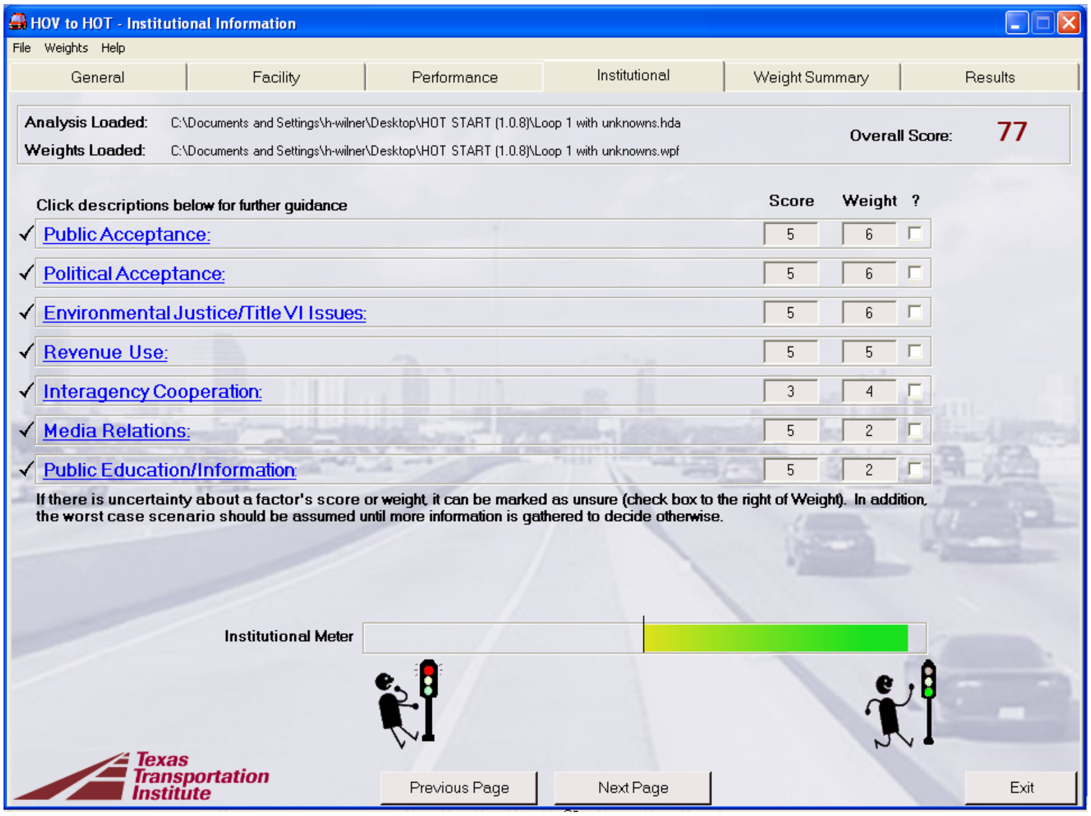


Figure 5-3. Loop 1 Institutional Factors Weights and Scores.

Figure 5-4 shows the first page of the final results ("Resulting Scores" page), including the graphical results of the analysis for Loop 1 HOV lane to HOT lane conversion. The red circles with white x's indicate there are at least two critical issues—critical factor(s) or critical interaction(s)—that need to be resolved in the facilities and performance categories. The caution symbol denotes that there is at least one factor marked as "Uncertain."

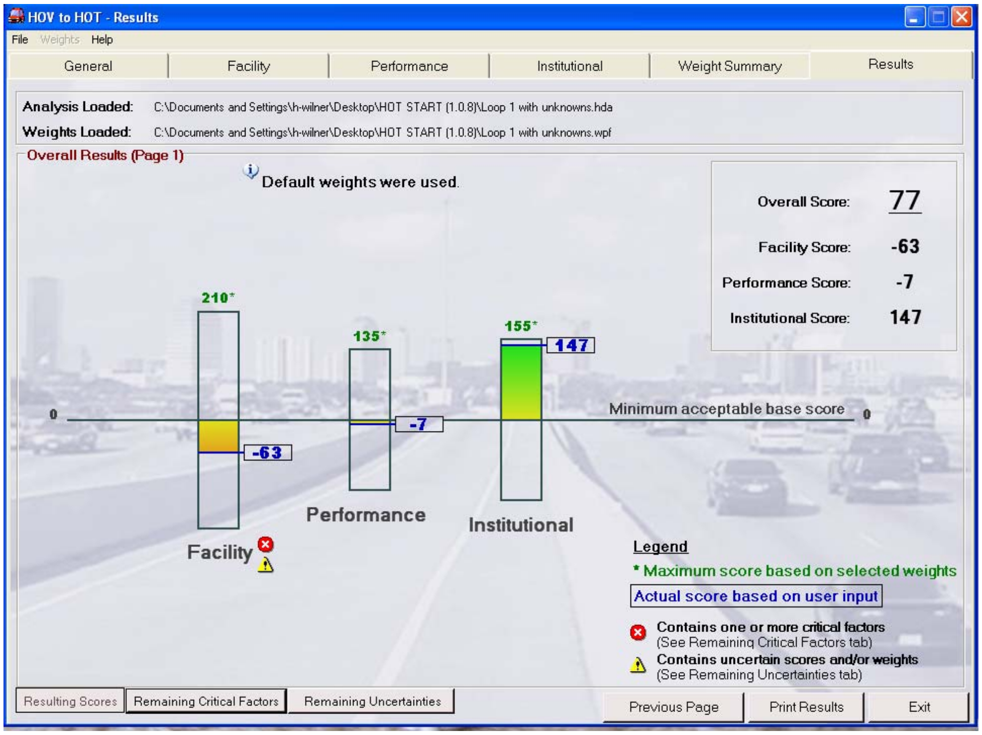


Figure 5-4. Loop 1 Resulting Scores.

Figure 5-5, the second page of the results in the program ("Remaining Critical Factors" page), describes these issues further. The analyst is reminded of the three facility factors marked as unknown (see Figure 5-1) in the "Uncertain Issues" page of the results, as shown in Figure 5-6.

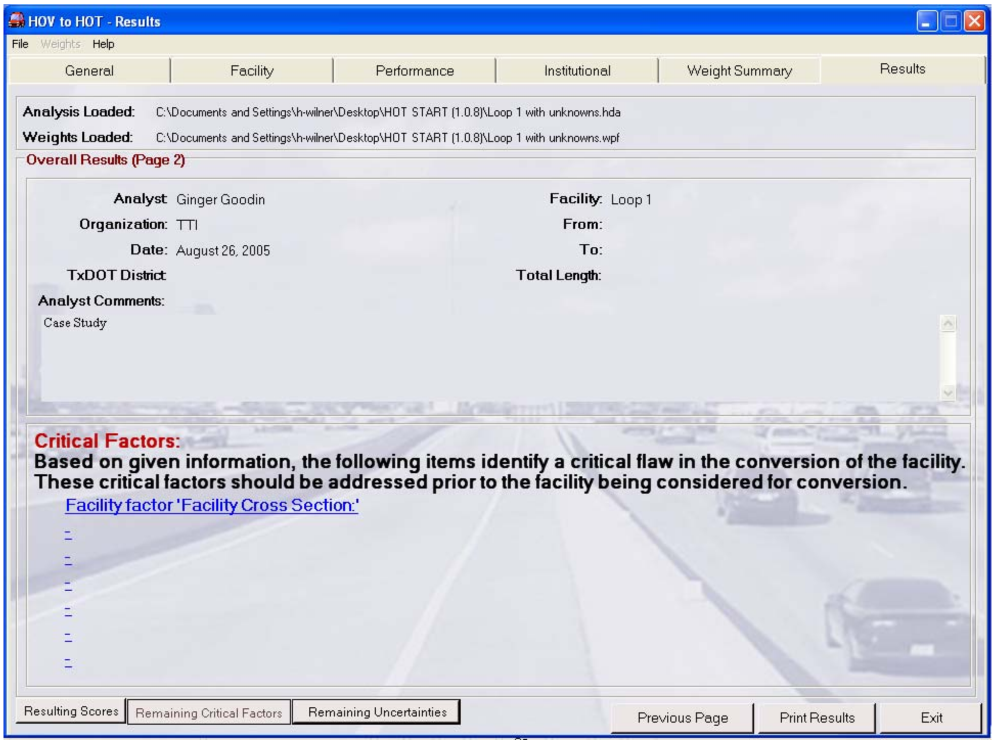


Figure 5-5. Loop 1 Remaining Critical Factors.

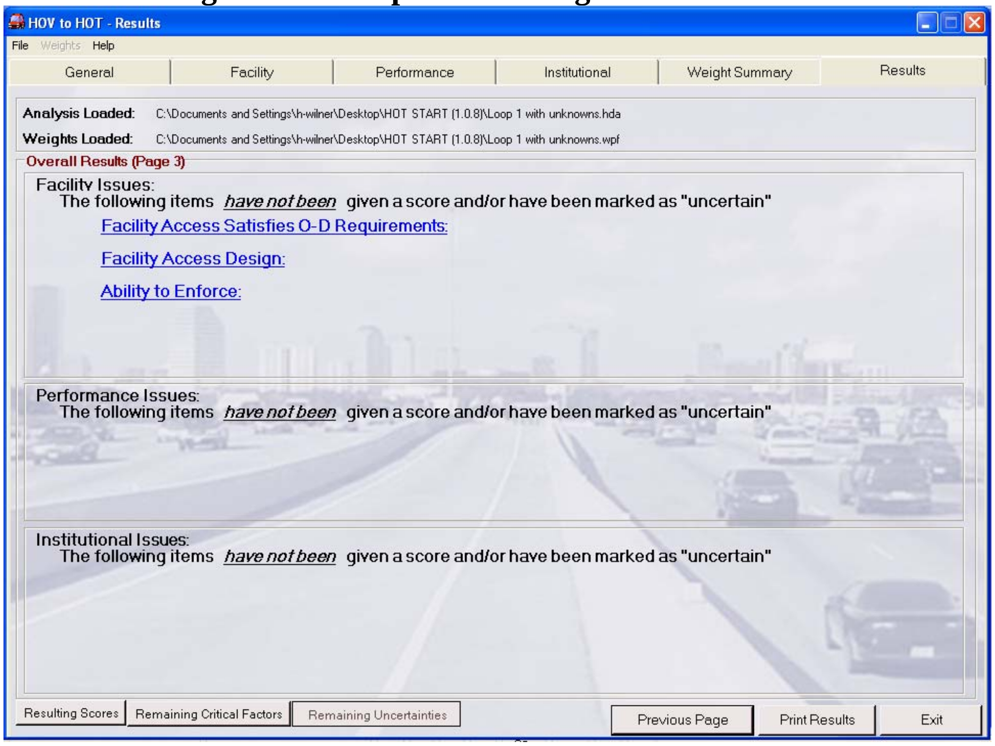


Figure 5-6. Loop 1 Remaining Uncertainties.

In the results, the height of each column provides a visual depiction of the combined weight assigned by the analyst for each of the categories (Figure 5-4). The values above each column are the maximum possible scores (if every factor were scored at the maximum of 5 points) defined by the weighting profile set by the analyst. The second important value is the category (actual) score. This value is shown in blue and has a box around it.

The minimum acceptable value for each category is zero. This value can be considered as an approximate lower limit for a successful HOT lane conversion. In the judgment of the research team, negative scores contain at least one factor score that is not acceptable.

It should be noted that the overall score could be a positive number and still contain unacceptable factors, thus the second measure: critical factors. In the course of the analysis, there may have been important factors that received unacceptably low scores. These factors then appear on the Critical Factors section of the output (Figure 5-5). While their relevant category may not have a low score overall, the presence of a critical factor should signal to the analyst that the issue must be resolved to achieve a successful conversion. Therefore, either an unacceptable overall score or irresolvable critical factors should serve as bold cautions for the analyst.

For the Loop 1 case study, the maximum possible score based on the default weighting profile used is 210 for facilities, 135 for performance, and 155 for institutional. The actual scores for the individual categories are -63, -7, and 147, respectively. Therefore, this score illustrates that quantitatively, the Loop 1 HOT lane concept is relatively strong from an institutional perspective but not from a facility or performance perspective. The overall score for the project is 77. However, without the scores from the three unknown factors, the overall score and the scores for the Facility and Performance categories are not reliable. Even though the uncertainty is for facility factors, the performance category score is not reliable because it is affected by facility factor scores via interaction effects.

The performance score of -7 is close to zero indicating that only small improvements may be necessary to achieve an acceptable score of zero. However, the red circled "x" indicates that conversion will most likely be unsuccessful if a particular issue is not addressed. Recall that the HOT START results include both 1) scores (Figure 5-4), and 2) critical factors to be resolved. Figure 5-5 illustrates the "Remaining Critical Factors" page and identifies the critical issues that were brought to the analyst's attention on the "Resulting Scores" page (see Figure 5-4).

The "Facility Cross Section" factor is considered critical because of the low score. Converting the planned HOV lane to a HOT lane is not advisable until these issues are resolved. Figure 5-6 reminds the analyst of any remaining uncertainties that need to be addressed.

This case study demonstrates that the HOT START program can be a useful planning tool in identifying the vulnerabilities associated with a project in the very early, conceptual stages.

5.2 I-10 HOV, HOUSTON, TEXAS

The I-10 (Katy Freeway) HOV lane has been open since 1984. Continuing increases in HOV lane travel caused the lane to bog down during peak hours, so the peak hour occupancy requirement was raised to HOV 3+ in 1988. To improve overall efficiency, the Texas Department of Transportation and the Metropolitan Transit Authority of Harris County (joint operations partners) considered the HOT lane option during 1997, later implementing the HOT lane in 1998. This case study is based on the conditions in place in 1997, during the period when the initial evaluation would have occurred. The data collection form containing the information input into HOT START for the I-10 case study can be found in Appendix C.

The default weights used and the assigned score for the facilities category are shown in Figure 5-7. The green color in the facility meter at the bottom of the page indicates that the score for the facility factor is acceptable. The only low score (-2) is for the Ability to Enforce factor. All the other factors have positive scores.

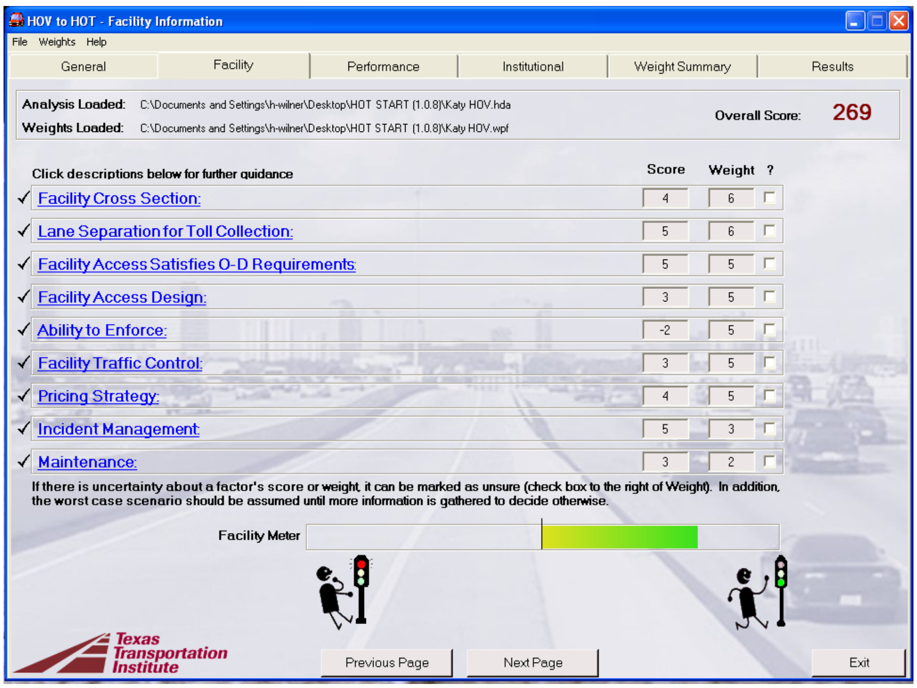


Figure 5-7. I-10 HOV Facility Factors Weights and Scores.

The default weights and assigned scores for the performance factors are shown in Figure 5-8. The number in red (-1) between the "Score" and "Weight" columns represents the points deducted from the score for that factor to account for interactions, as discussed previously. The green bar in the performance meter implies that the score is positive.

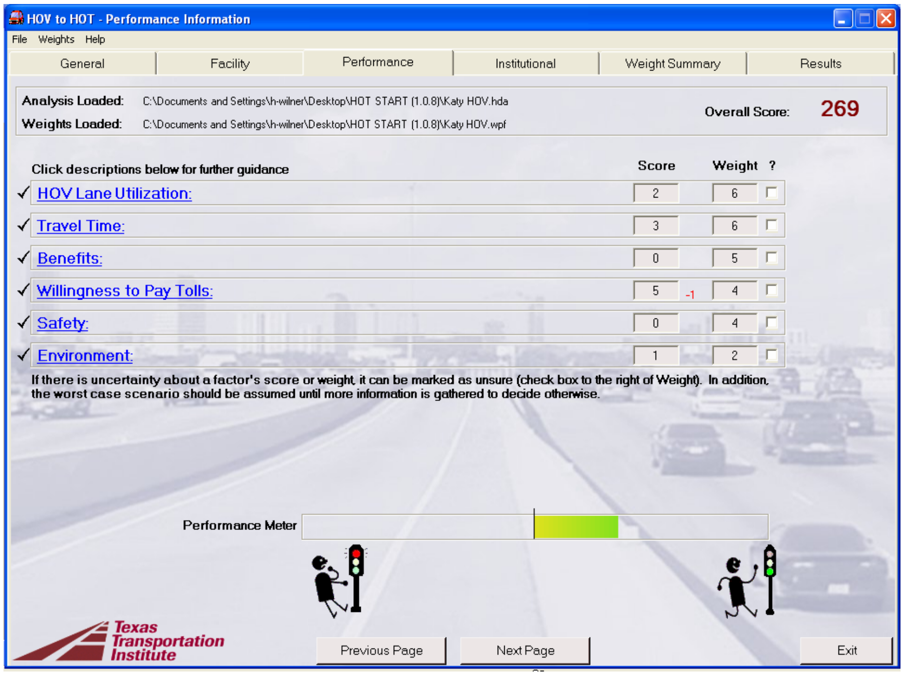


Figure 5-8. I-10 HOV Performance Factors Weights and Scores.

Like the results for facility and performance considerations, the bar for institutional considerations is also green, indicating positive-scoring factors. The results for the institutional factors are displayed in Figure 5-9. All factors scored above zero except for "Public Education/Information," which scored a -3. However, because of the low weight of this factor and the higher scores of the other factors within institutional considerations, the -3 score hardly impacted this category.

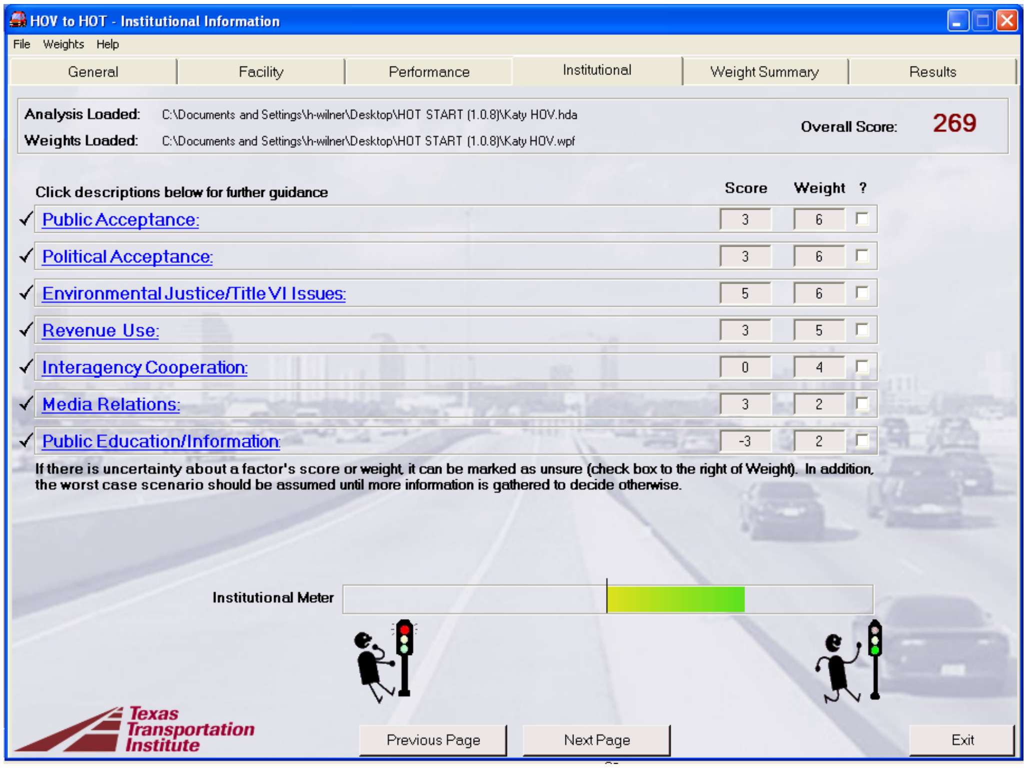


Figure 5-9. I-10 HOV Institutional Weights and Scores.

The graphical results of the analysis for I-10 are shown in Figure 5-10 ("Resulting Scores" page—see lower left of Figure 5-10). In this example, there are no critical factors to be addressed. Had there been critical factors, a red circled "x" would appear adjacent to the appropriate category column. The "Remaining Critical Factors" page would then summarize the critical factors identified in the analysis. In this analysis, none of the factors were marked as "unknown." Therefore, no such items are identified on the "Remaining Uncertainties" page of the results. As shown in Figure 5-10, the maximum possible score based on the default weighting profile used is 210 for facilities, 135 for performance, and 155 for institutional. The actual scores for the individual categories are 140, 48, and 81, respectively. Therefore, quantitatively, the potential conversion to a HOT lane results in relatively positive results for the facility, performance, and institutional categories. The overall score for the project is 269. The overall value can be used to compare projects where the same weighting scheme has been used.

It should be noted that the overall score cannot be compared across corridors unless exactly the same weighting scheme was used on the corridors being compared.

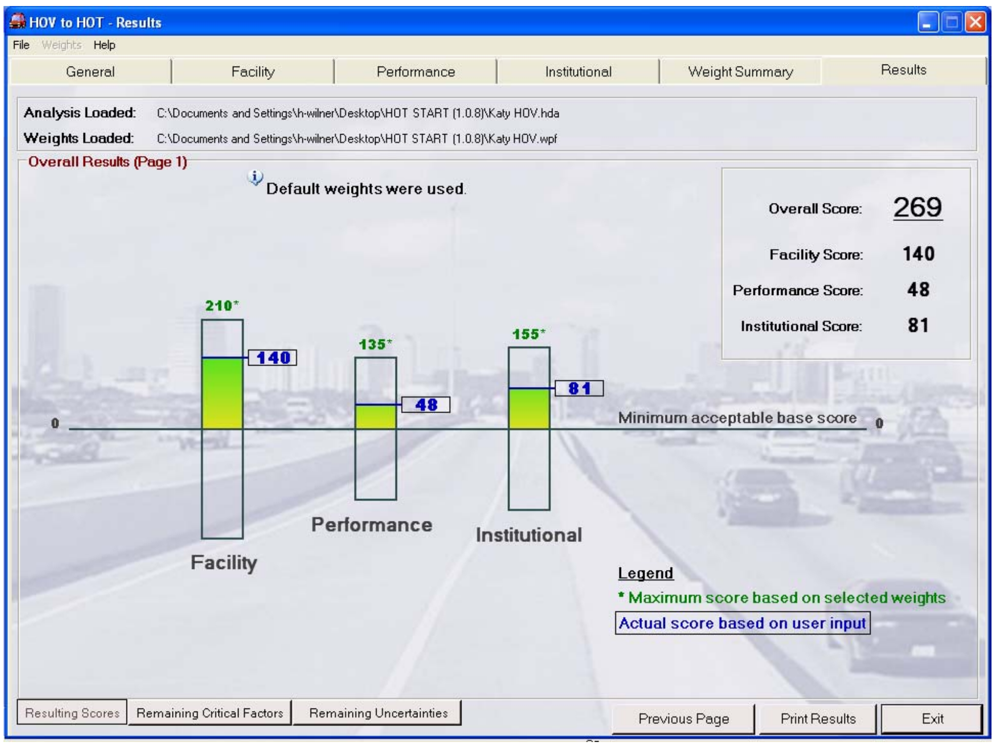


Figure 5-10. I-10 HOV Resulting Scores.

Despite minor shortcomings, the I-10 analysis confirmed the decisions made several years earlier to proceed with converting the HOV lane to a HOT lane. Currently, the facility is being reconstructed to include two managed lanes in each direction.

CHAPTER 6

RECOMMENDATIONS AND DISCUSSION

This report documents research that provides an analytical framework (HOT START program) to assess the factors that should be examined when considering the conversion of an HOV lane to a HOT lane. That framework allows analysts to quickly determine those HOV lanes that, when converted to HOT lane operations, have a high probability of successfully meeting several key goals. This information allows agencies to then focus detailed analyses (such as a benefit cost calculation) on those facilities most deserving of the additional analytical effort. Key conclusions of the research are provided below.

6.1 COMPILATION OF KEY FACTORS

The research provides the first attempt in the literature of the development of an analytical tool for assessing important factors prior to the conversion of an HOV lane to a HOT lane. In particular, the research provides a framework for the consideration of factors that relate to key facility, performance, and institutional factors in a diagnostic software tool that can be tailored to the specific needs of the community in which the particular project is located.

6.2 DECISION TREE SCORING

The HOT START tool provides a unique method of scoring each factor with decision trees. The decision trees guide the analyst to the appropriate score (-5 to +5) by answering questions related to each factor. The decision trees are based on the latest research on HOV, HOT, and managed lanes. The decision trees also provide a method of scoring factors that are relatively qualitative.

6.3 INTERACTION EFFECTS

The interactions between factors are also considered in the software tool. For example, clearly the design of the facility affects facility performance, and HOT START provides an analytical way to consider and include these interaction effects.

6.4 CASE STUDY APPLICATION

The HOT START analytical tool is applied to the case study of I-10 (Katy Freeway) in Houston, Texas. The example illustrates how the tool can be applied to evaluate the facility, performance, and institutional factors of interest when considering converting an HOV lane to a HOT lane. The sample case study illustrates how an overall score and critical factors can be identified with a “real-world” example.

6.5 LIMITATIONS

As evidenced in the Loop 1 case study (Section 5.1), the resulting score in HOT START is only as accurate as the data entered. Other alternatives to be analyzed with HOT START may also be in the conceptual stage, which means there could be factors the analyst is unsure about. In HOT START, factors marked as uncertain are treated the same way as zero-scoring factors. They neither increase nor decrease the specific category and overall scores. However, this should not deflect from the program's capability to identify vulnerabilities associated with the project in these very early, conceptual stages.

6.6 FLEXIBILITY

As more research becomes available related to any of the key factors considered in HOT START, the factors (such as scoring and interactions) can be updated in future versions of the software.

CHAPTER 7

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APPENDIX A

DECISION TREES FOR SCORING

Facility Considerations

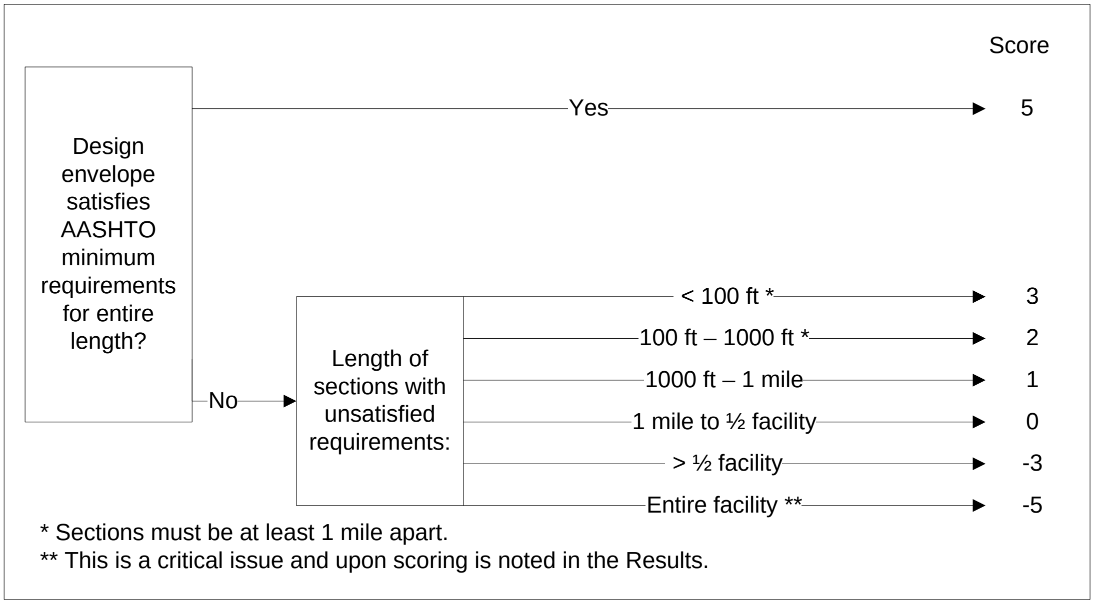

Figure A-1. Facility Cross Section.

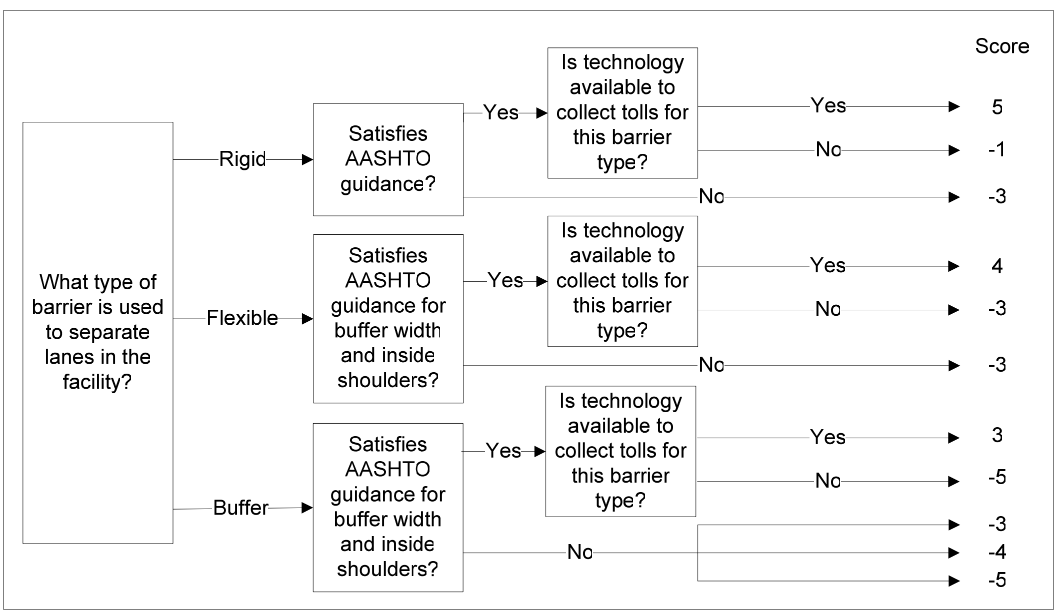

Figure A-2. Lane Separation for Toll Collection.

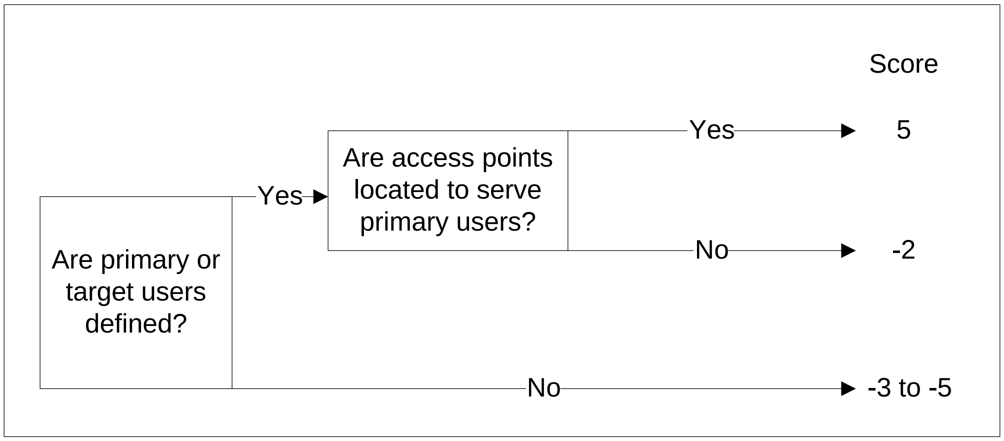

Figure A-3. Facility Access Satisfies O-D Requirements.

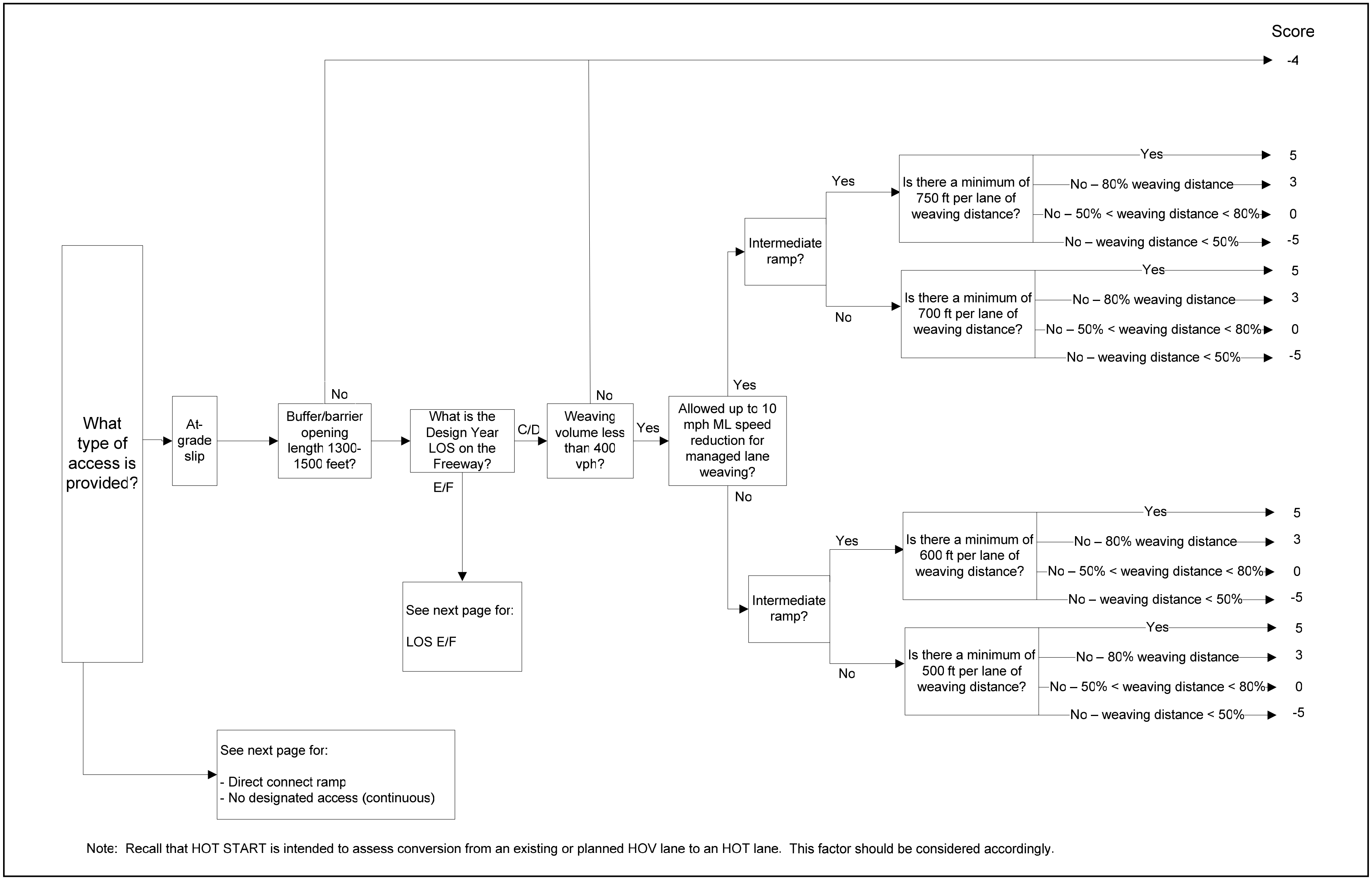

Figure A-4. Facility Access Design.

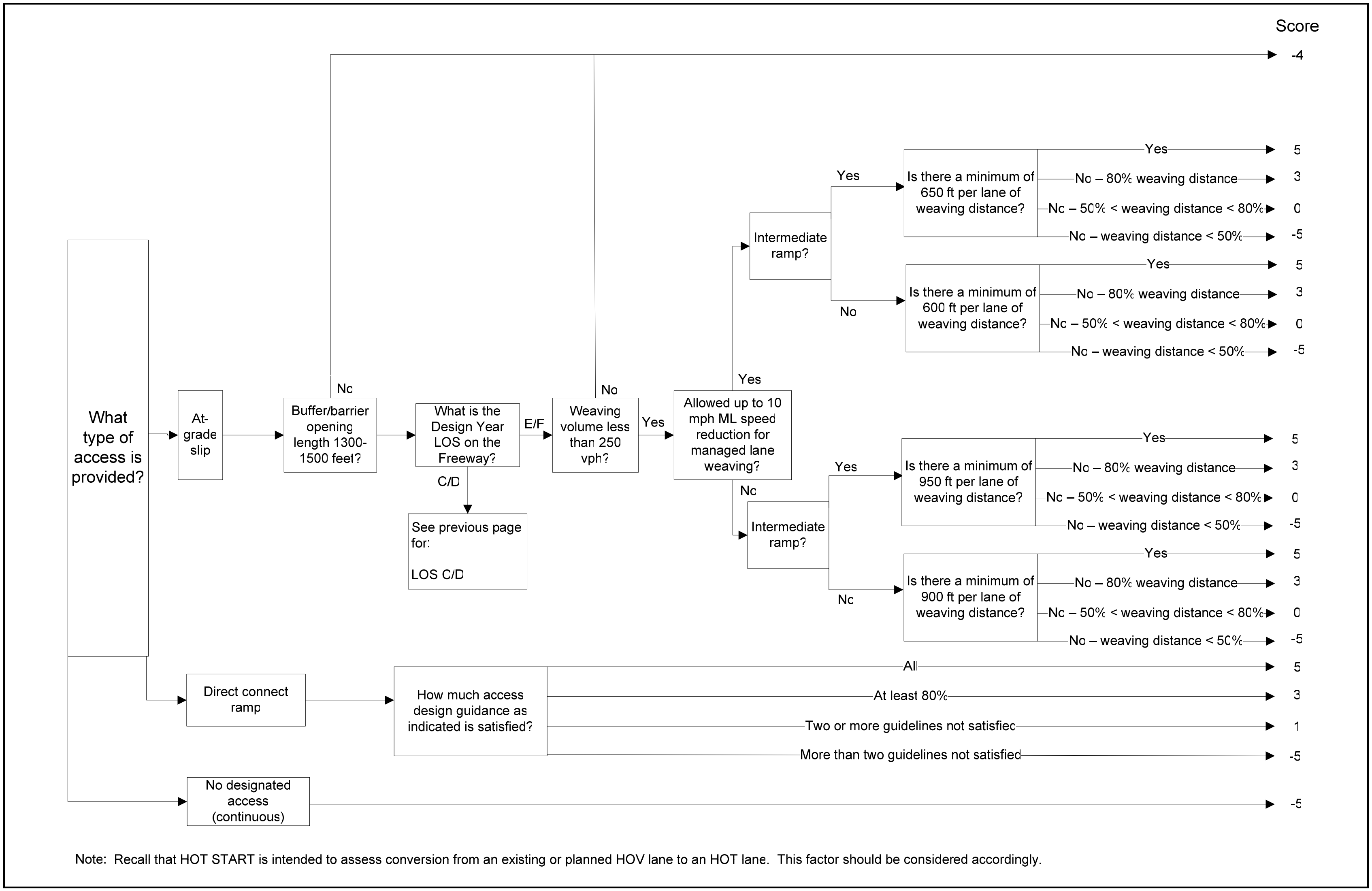

Figure A-4. Facility Access Design (continued).

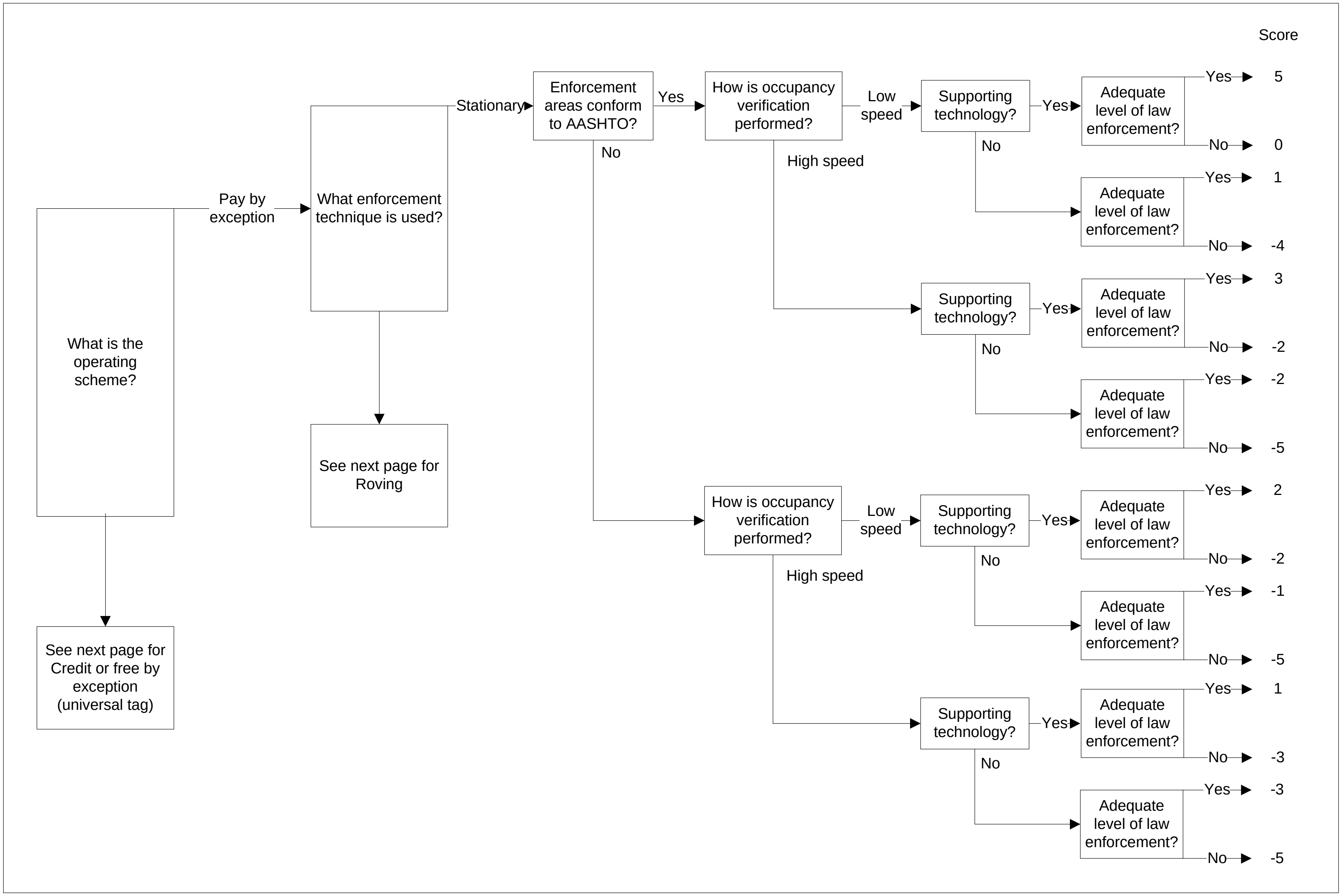

Figure A-5. Ability to Enforce.

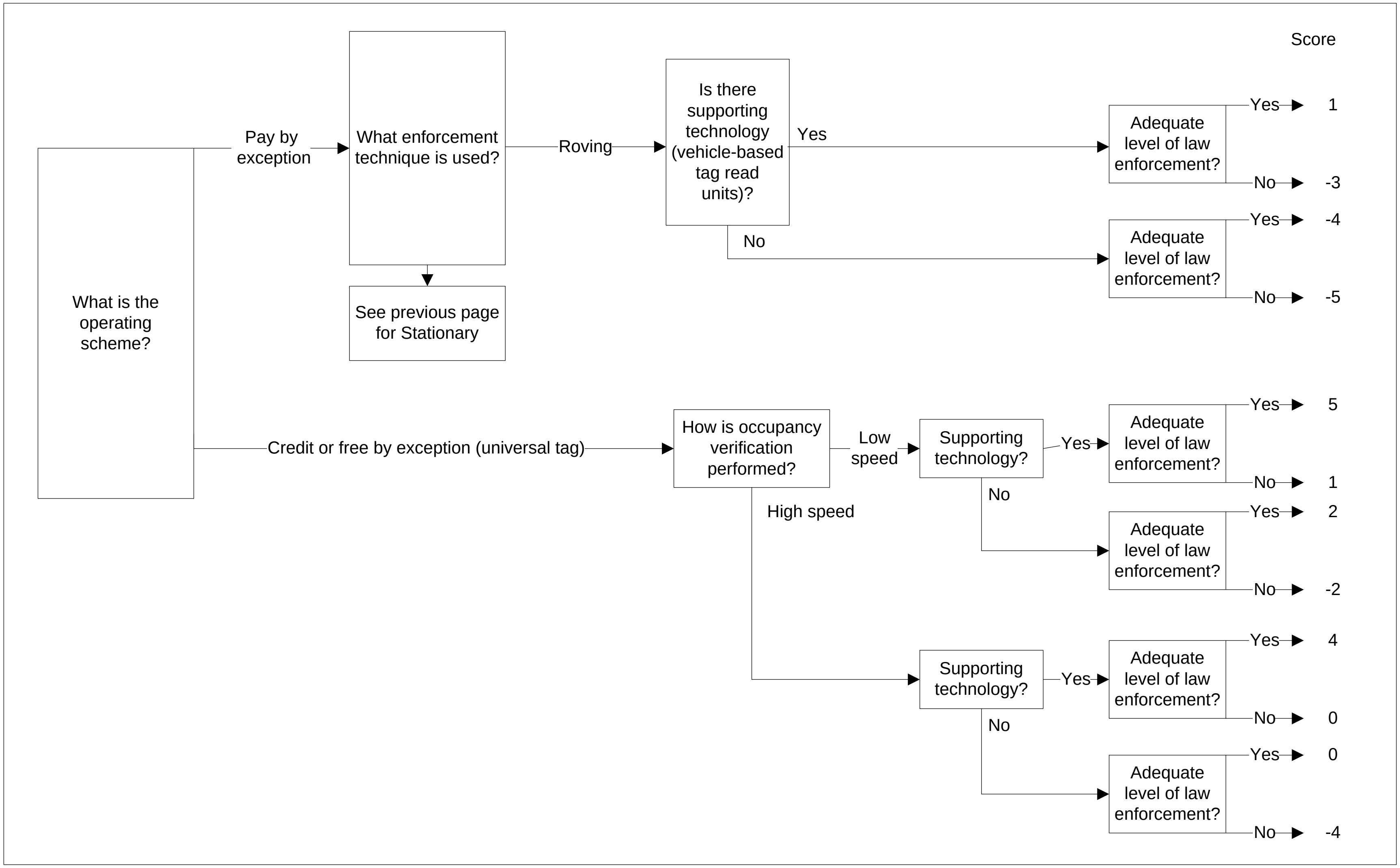

Figure A-5. Ability to Enforce (continued).

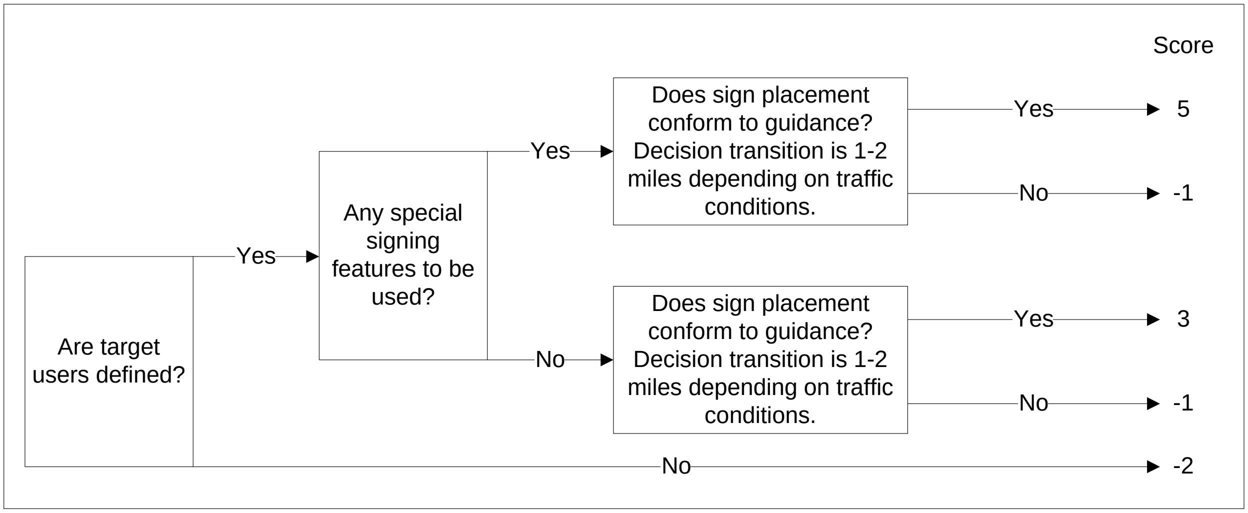

Figure A-6. Facility Traffic Control.

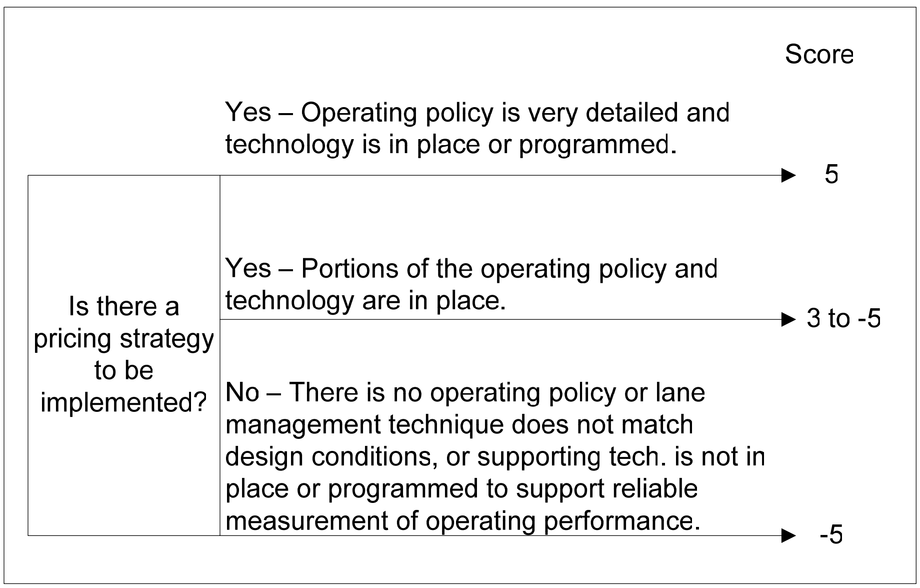

Figure A-7. Pricing Strategy.

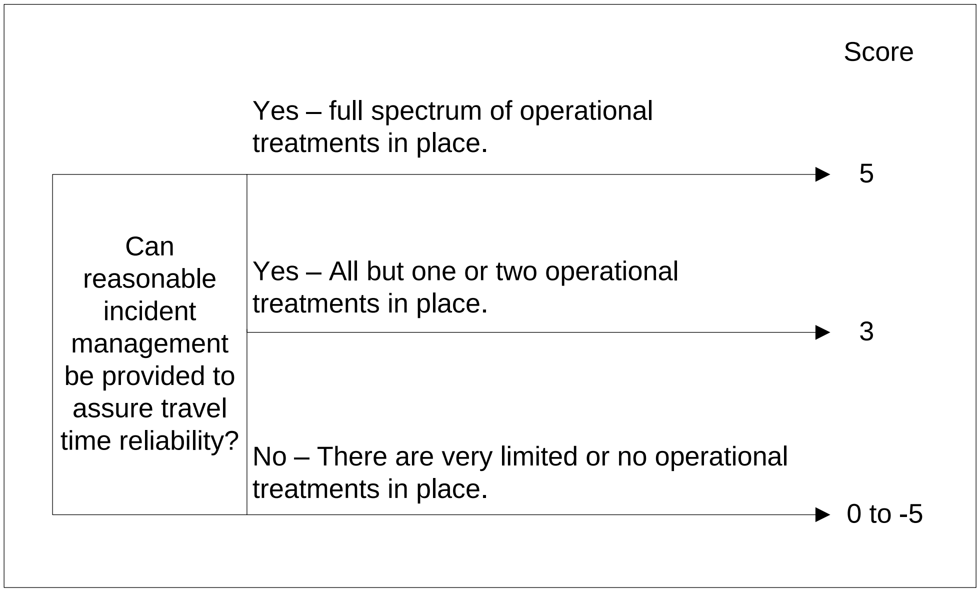

Figure A-8. Incident Management.

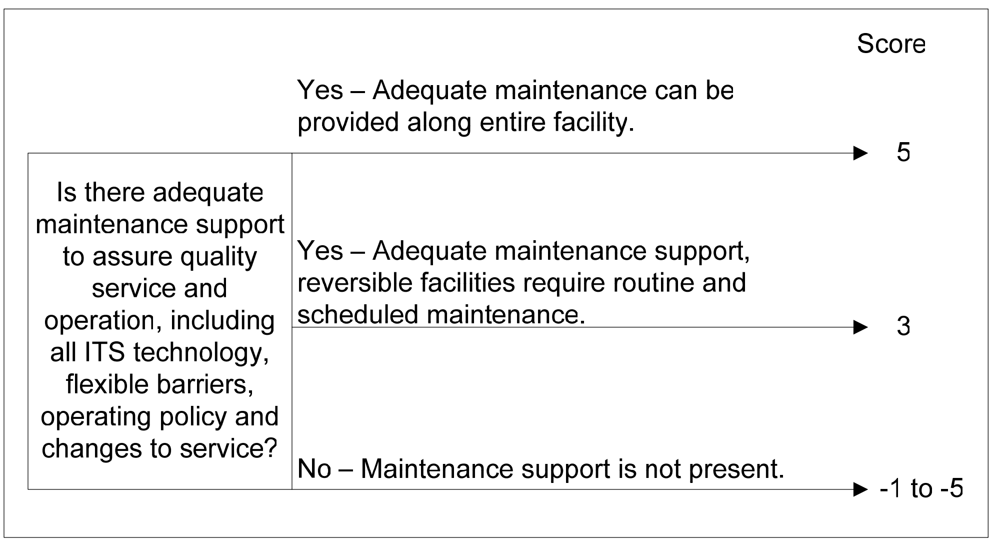

Figure A-9. Maintenance.

Performance Considerations

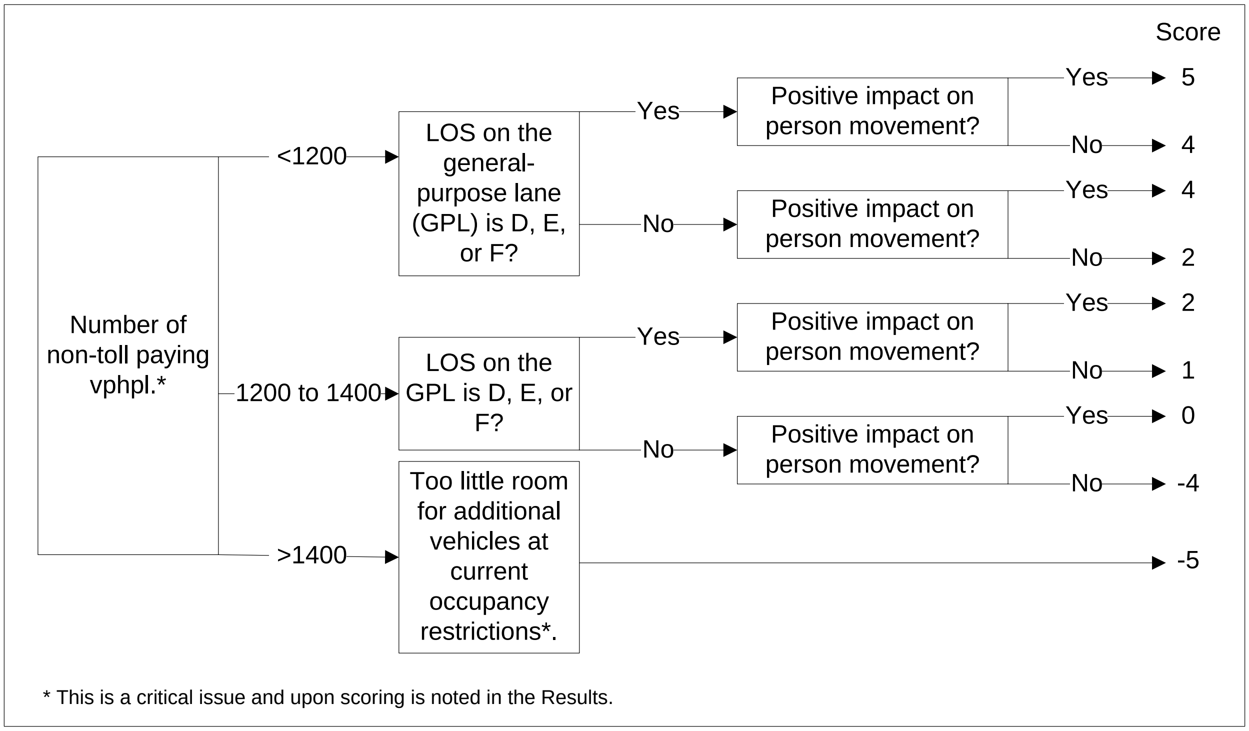

Figure A-10. HOV Lane Utilization.

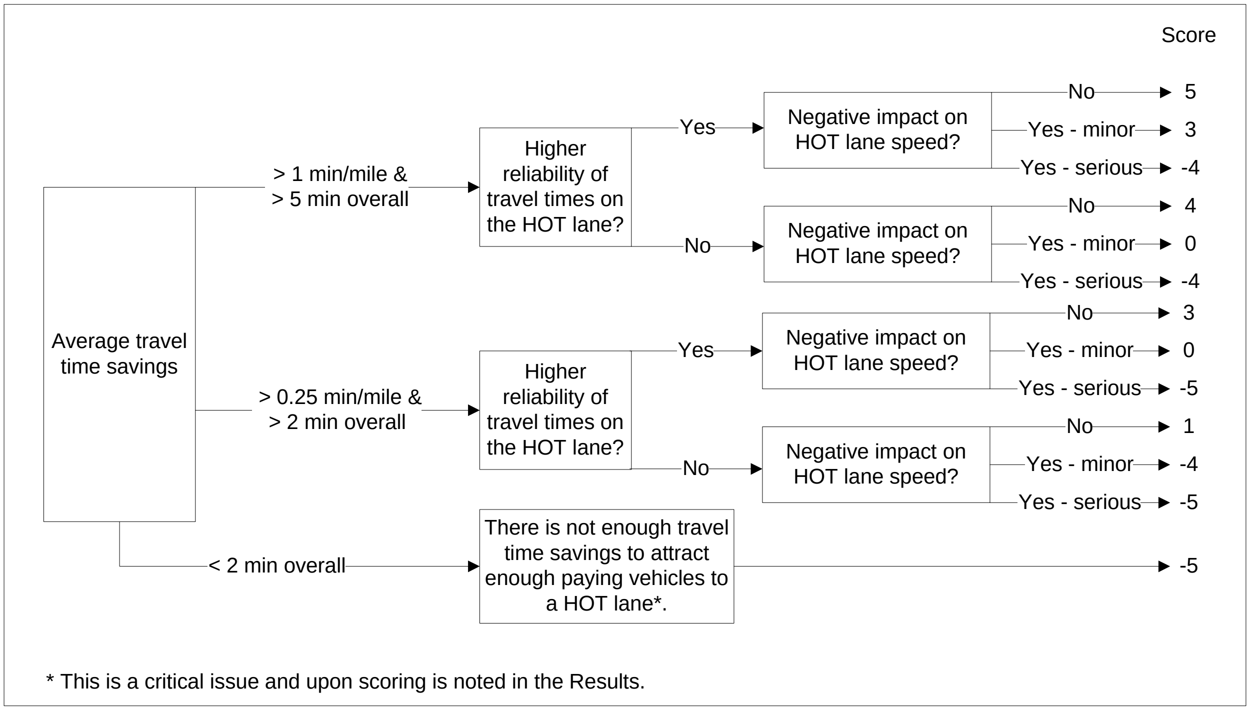

Figure A-11. Travel-Time.

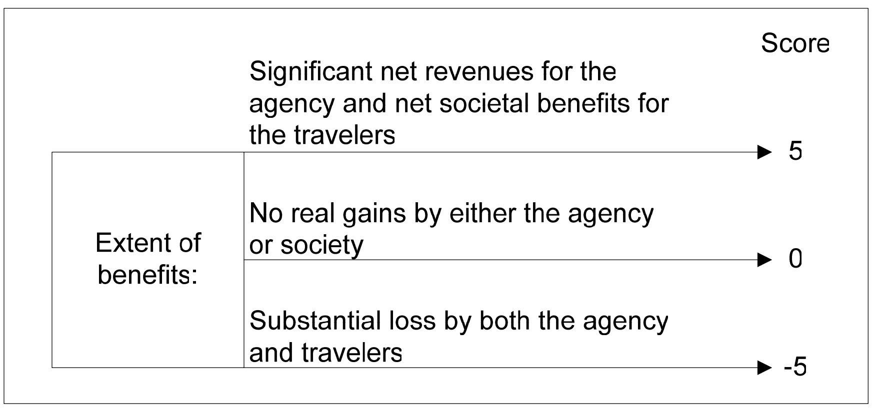

Figure A-12. Benefits.

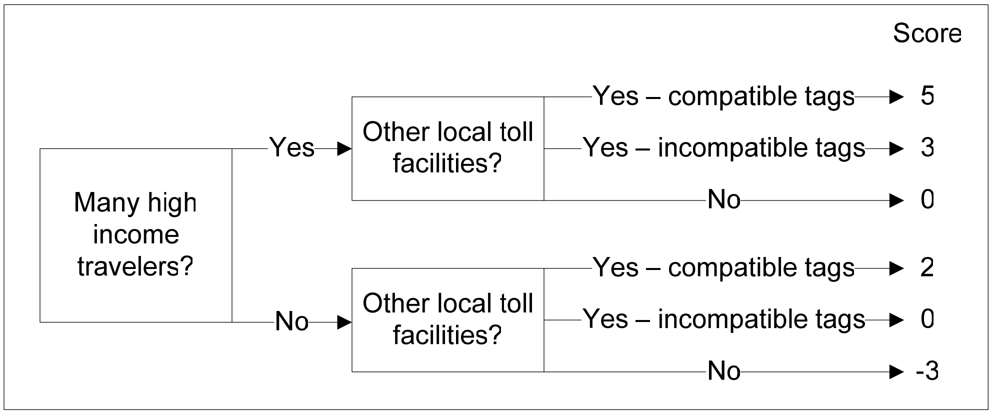

Figure A-13. Willingness to Pay Tolls.

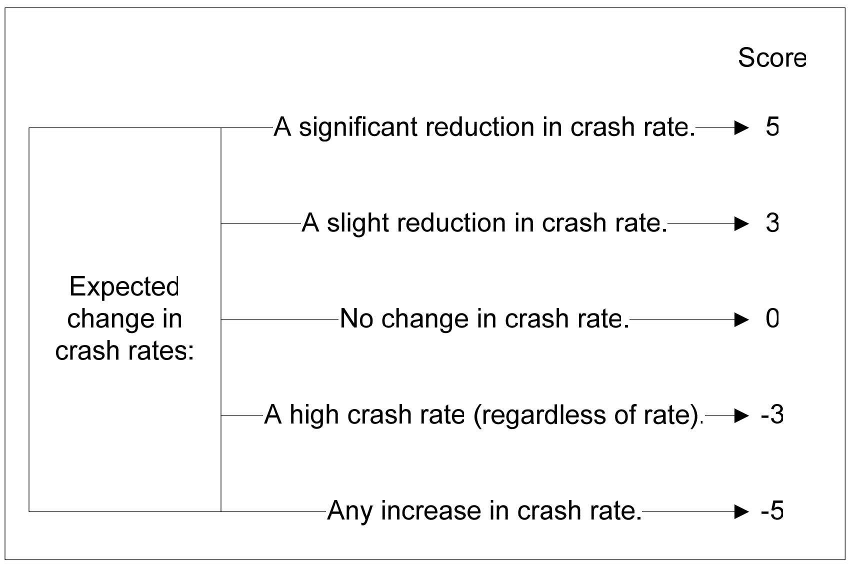

Figure A-14. Safety.

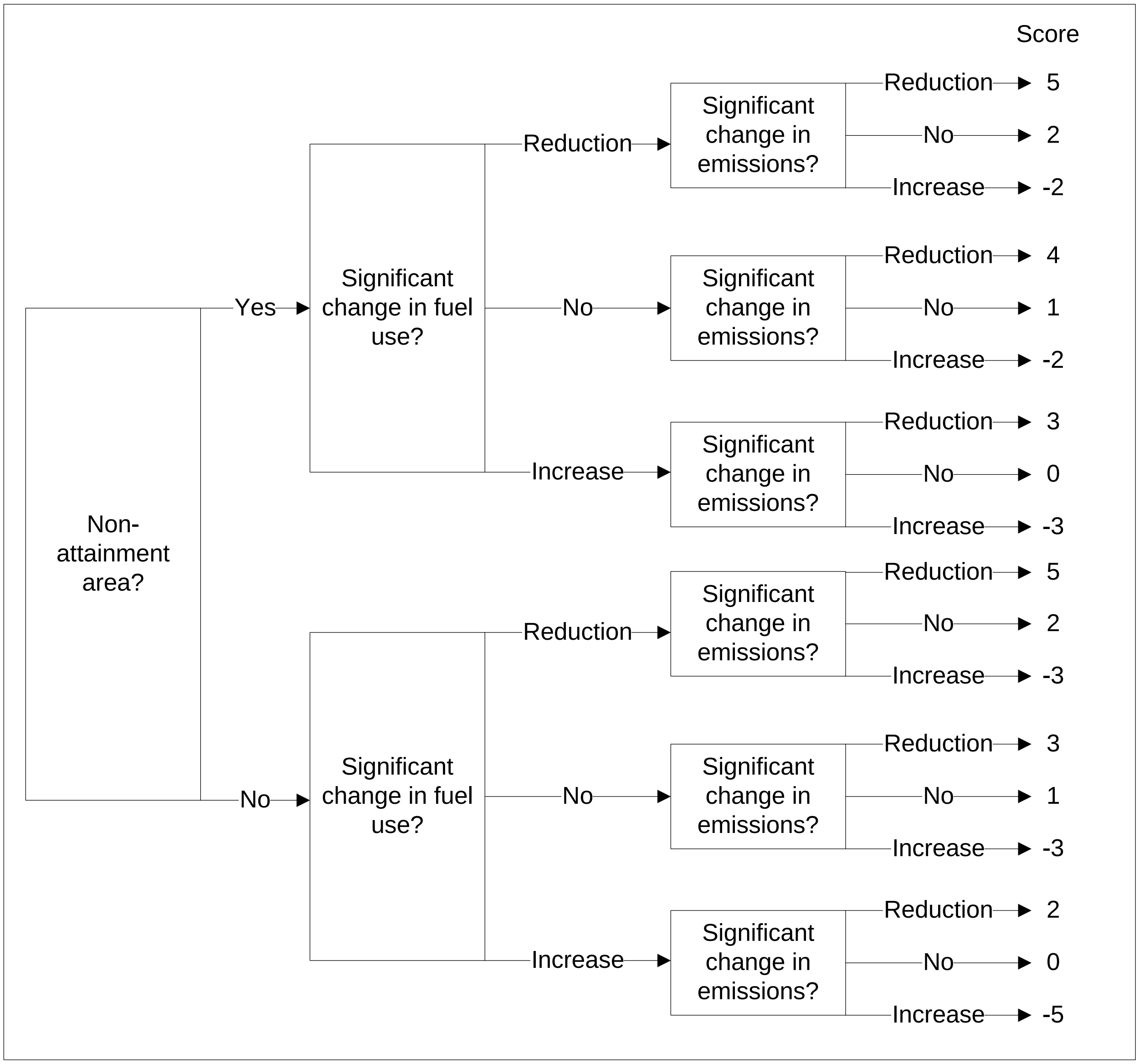

Figure A-15. Environment.

Institutional Considerations

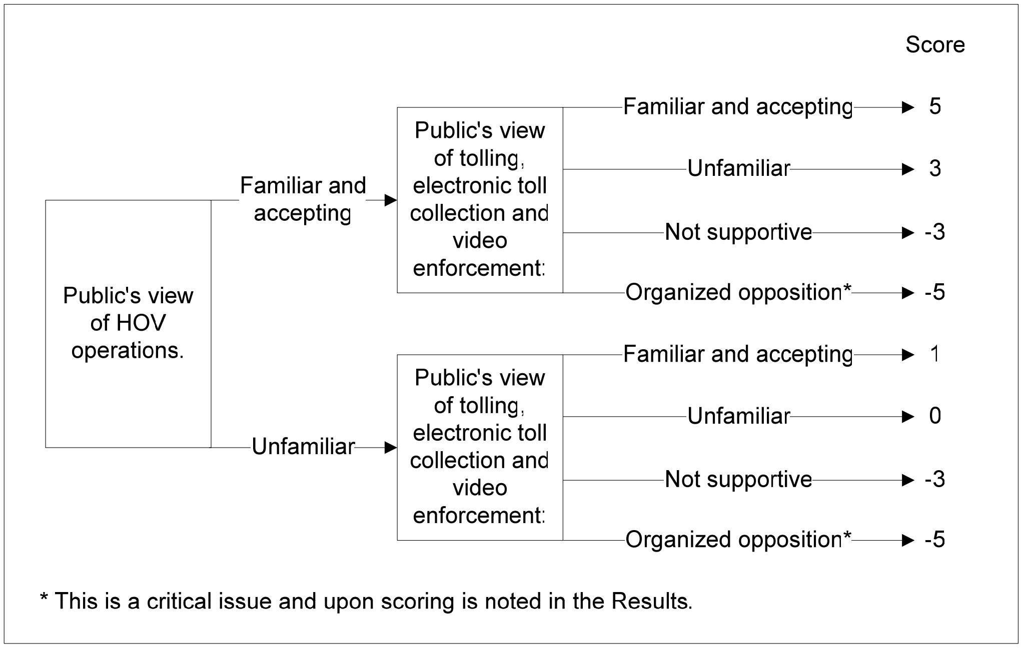

Figure A-16. Public Acceptance.

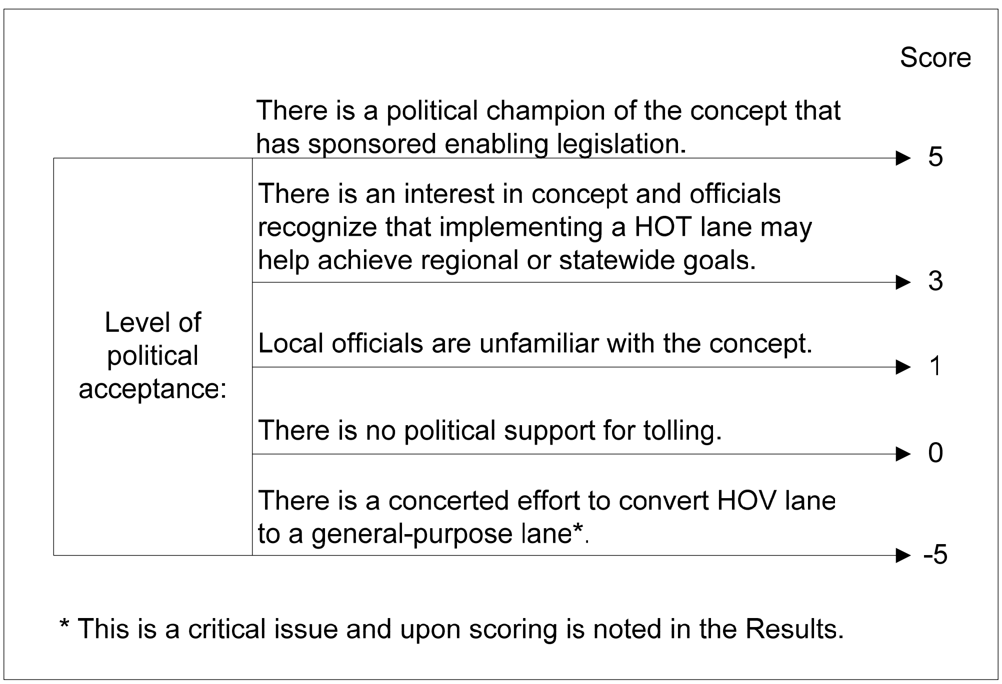

Figure A-17. Political Acceptance.

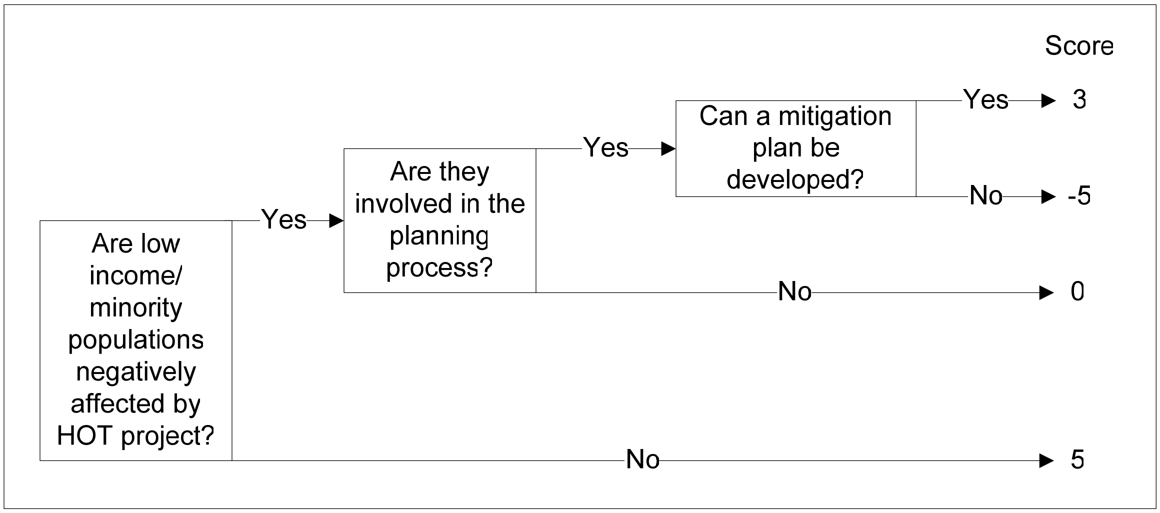

Figure A-18. Environmental Justices/Title VI Issues.

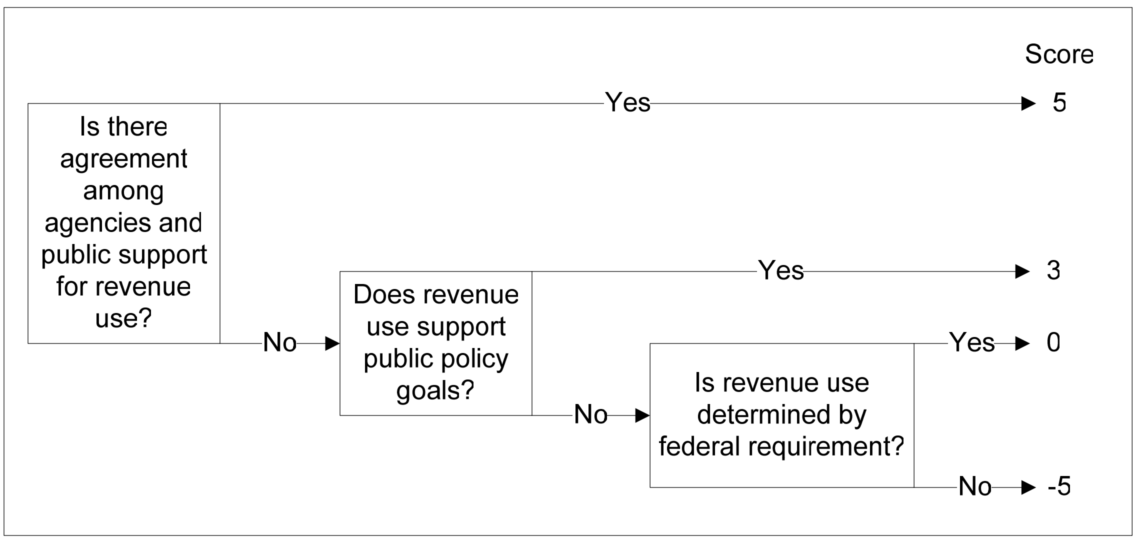

Figure A-19. Revenue Use.

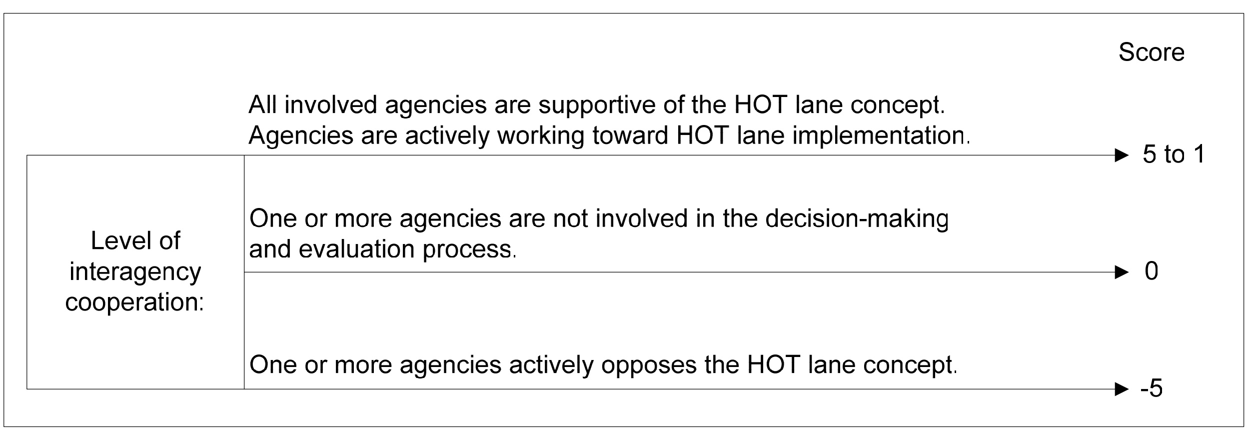

Figure A-20. Interagency Cooperation.

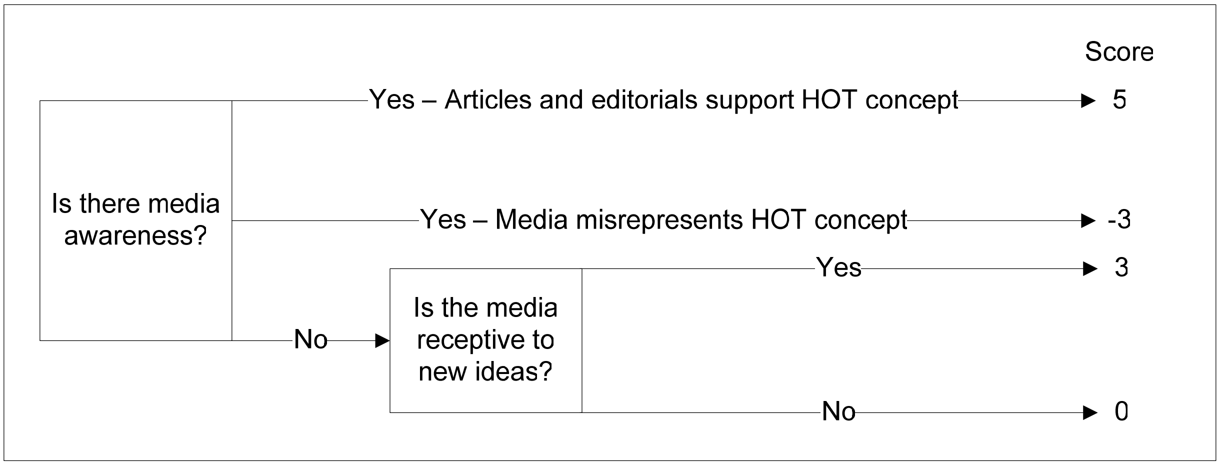

Figure A-21. Media Relations.

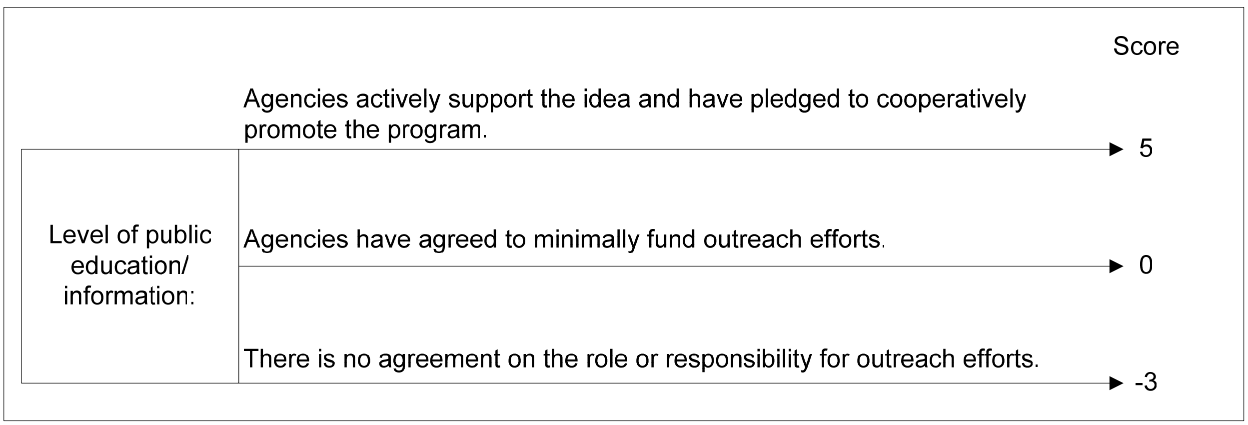

Figure A-22. Public Education/Information.

APPENDIX B

LOOP 1 CASE STUDY DOCUMENTS

Table B-1. HOT START Resources Needed.

Resource Number	Type	Description
1	Report	"Guide for High-Occupancy Vehicle (HOV) Facilities." American Association of State Highway and Transportation Officials. Washington, D.C., 2004. *(38)*
2	Report	Perez, B., and G. Sciara. "A Guide for HOT Lane Development." FHWA-OP-03-009FHWA, Federal Highway Administration, Washington, D.C., 2003. *(31)*
3	Report	Cothron, A.S, D.A. Skowronek, and B.T. Kuhn. "Enforcement Issues on Managed Lanes," TTI Report 0-4160-11, January 2003.
4	Data	Corridor lane geometric design and measurements
5	Data	Corridor O-D patterns
6	Data	HOV ramp volumes and terminus volumes
7	Data	Weave volumes/ Corridor volume (LOS)
8	Data	Current facility sign inventory, pricing points where new signs might be needed
9	Website	Census data: http://factfinder.census.gov
10	Website	State Implementation Plans for Texas: http://www.tceq.state.tx.us/nav/eq/sip.html

Table B-2. Loop 1 Data Collection Form – Facility Considerations.

Factor	Resources Needed (from Table B-1)	Corresponding Scoring Decision Tree Table (Appendix B of Guidebook)	HOT START Questions	Answer Choices
Cross Section	1, 2	B-1	Does the design envelope satisfy AASHTO minimum requirements for the entire length?	Yes No
	4	B-1	If "no," what are lengths of unsatisfied sections?	<100 ft 100-1000 ft 1000 ft-1 mile 1 mi – ½ facility > ½ facility entire facility
Lane Separation for Toll Collection	1, 2	B-2	What type of lane separation exists?	Rigid Flexible Buffer
	1, 4	B-2	Are AASHTO guidelines satisfied for this type of separation?	Yes No
	4	B-2	Can tolls be collected?	Yes No
Facility Access Satisfies O-D Requirements	N.A.	B-3	Are primary or target users defined?	Yes No
	5	B-3	If "yes," are access points located to serve primary users?	Yes No unknown at this time
Facility Access Design	6	B-4	What type of access is provided?	At-grade slip ramp Direct connect ramp No designated access (continuous)
	4	B-4	If "at-grade slip ramp," is buffer/barrier opening length 1300-1500 ft?	Yes No unknown at this time
	N.A.	B-4	What is design year LOS on freeway?	C/D E/F
	7	B-4	What is weaving volume (HOV ramp entrance)?	Less than 400 vph less than 250 vph unknown at this time
	7	B-4	Is up to 10 mph mainlane speed reduction for managed lane weaving allowed?	Yes No
	7	B-4	What is the minimum length of weaving distance per lane?	950 ft 900 ft 750 ft 700 ft 600 ft 650 ft 500 ft unknown at this time

Table B-2. Loop 1 Data Collection Form – Facility Considerations (continued).

Factor	Resources Needed (from Table B-1)	Corresponding Scoring Decision Tree Table (Appendix B of Guidebook)	HOT START Questions	Answer Choices
Ability to Enforce	1, 2	B-5	What is operating scheme?	Pay by exception Credit or free by exception (universal tag)
	2	B-5	If "pay by exception," how is occupancy check performed?	Stationary Roving
	4	B-5	If stationary, do enforcement areas conform to AASHTO?	Yes No
	2	B-5	How is occupation verification performed?	High speed Low speed not required: HOV preference to consist of HOV and registered vanpools only
	3	B-5	Is there supporting technology (vehicle-based tag read units)?	Yes No not required
	N.A.	B-5	Is there adequate law enforcement?	Yes No unknown at this time
Facility Traffic Control	N.A.	B-6	Are target users defined?	Yes No
	8	B-6	If yes, are any special signing features to be used?	Yes - using TxDOT's new standards No
	2, 8	B-6	Does sign placement conform to guidance?	Yes No
Pricing Strategy	N.A.	B-7	Is there an operating policy for the HOT lanes?	Yes Partial No
Incident Management	1	B-8	Operational treatments for incident management that can be provided to assure travel time reliability	Tow truck, Emergency access points, CCTV, CMS, Speed monitoring (loops, AVI) None
Maintenance	N.A.	B-10	Is the facility reversible?	Yes No
	N.A.	B-10	Level of maintenance support available	Full Most Some None

Table B-3. Loop 1 Data Collection Form – Performance Considerations.

Factor	Resources Needed (from Table B-1)	Corresponding Scoring Decision Tree Table (Appendix B of Guidebook)	HOT START Questions	Answer Choices
HOV Lane Utilization	N.A.	B-11	Percent buses (to be used to determine f_b for vphpl calculation)	<2%
	N.A.	B-11	Type of terrain (to be used to determine f_b for vphpl calculation)	**Level** Rolling Mountainous
	N.A.	B-11	Vphpl on facility (non-toll paying) = (autos + buses * f_b)/# lanes	<1200 **1200-1400** >1400
	N.A.	B-11	Is LOS on general-purpose lane D, E, or F?	**Yes** No
	N.A.	B-11	Will conversion have positive impact on HOT lane?	**Yes** No
Travel Time	N.A.	B-12	What are the average travel-time savings?	>1 min/mile & >5 min overall **>0.25 min/mile & >2 min overall** <2 min overall
	N.A.	B-12	Will there be a higher reliability of travel times on the HOT lane?	**Yes** No
	N.A.	B-12	Will the conversion create a negative impact on HOT lane(s) speed?	Yes **No**
Benefits	N.A.	B-13	How will the net agency/societal benefits change?	**Increase** No change Decrease
Willingness to Pay Tolls	9	B-14	Are there many high-income travelers?	Yes **No**
	N.A.	B-14	Are there other local toll facilities?	**Yes** No
	N.A.	B-14	If yes, are the tags interoperable?	**Yes** No
Safety	N.A.	B-15	Is there currently a high crash rate on the facility?	Yes **No**
	N.A.	B-15	How will conversion affect the crash rate on the facility?	Increase Slight reduction **No change** Great reduction

Table B-3. Loop 1 Data Collection Form – Performance Considerations (continued).

Factor	Resources Needed (from Table B-1)	Corresponding Scoring Decision Tree Table (Appendix B of Guidebook)	HOT START Questions	Answer Choices
Environment	10	B-16	Is facility in non-attainment area?	Yes No
	N.A.	B-16	How will conversion affect fuel use?	Increase No change Decrease
	N.A.	B-16	How will conversion affect emissions?	Increase No change Decrease

Table B-4. Loop 1 Data Collection Form – Institutional Considerations.

Factor	Resources Needed (from Table B-1)	Corresponding Scoring Decision Tree Table (Appendix B of Guidebook)	HOT START Questions	Answer Choices	
Public Acceptance	N.A.	B-17	Which of the following is the public familiar with?	Tolling ETC HOV Video enforcement	
	N.A.	B-17	Which of the following does the public find acceptable?	Tolling ETC HOV Video enforcement	
Political Acceptance	N.A.	B-18	Is there a political champion for conversion?	Yes	No
	N.A.	B-18	Is there political familiarity with the conversion concept?	Yes	No
	N.A.	B-18	Is there political support for conversion?	Yes	No
	N.A.	B-18	Does conversion achieve statewide or national goals?	Yes	No
Environmental Justice/Title VI Issues	9	B-19	Are low income/minority populations negatively affected by conversion?	Yes	No
	N.A.	B-19	If yes, are low income/minority populations involved in the planning process?	Yes	No
	N.A.	B-19	Can a mitigation plan be developed?	Yes	No
Revenue Use	N.A.	B-20	Is there agreement among agencies and the public on net revenue use?	Yes	No
	N.A.	B-20	If no, does revenue use support public policy goals?	Yes	No
	N.A.	B-20	If no, is revenue use determined by federal requirement?	Yes	No
Interagency Cooperation	N.A.	B-21	Do all agencies support the HOT lane concept?	Yes	No
	N.A.	B-21	If no, are any agencies actively opposed to HOT lane concept?	Yes	No
Media Awareness	N.A.	B-22	Is there media awareness and support?	Yes Misrepresentation	No
	N.A.	B-22	If no, is media receptive to new ideas?	Yes	No
Public Education/ Information	N.A.	B-23	What is the level of outreach efforts for public education and information?	Active Minimal None	

APPENDIX C

I-10 HOV CASE STUDY DOCUMENTS

Table C-1. HOT START Resources Needed.

Resource Number	Type	Description
1	Report	"Guide for High-occupancy Vehicle (HOV) Facilities." American Association of State Highway and Transportation Officials. Washington, D.C., 2004. *(38)*
2	Report	Perez, B., and G. Sciara. "A Guide for HOT Lane Development." FHWA-OP-03-009FHWA, Federal Highway Administration, Washington, D.C., 2003. *(31)*
3	Report	Cothron, A.S., D.A. Skowronek, and B.T. Kuhn. "Enforcement Issues on Managed Lanes," TTI Report 0-4160-11, January 2003.
4	Data	Corridor lane geometric design and measurements
5	Data	Corridor O-D patterns
6	Data	HOV ramp volumes and terminus volumes
7	Data	Weave volumes/ Corridor volume (LOS)
8	Data	Current facility sign inventory, pricing points where new signs might be needed
9	Website	Census data: http://factfinder.census.gov
10	Website	State Implementation Plans for Texas: http://www.tceq.state.tx.us/nav/eq/sip.html

Table C-2. I-10 Data Collection Form – Facility Considerations.

Factor	Resources Needed (from Table C-1)	Corresponding Scoring Decision Tree Table (Appendix B of Guidebook)	HOT START Questions	Answer Choices
Cross Section	1, 2	B-1	Does the design envelope satisfy AASHTO minimum requirements for the entire length?	Yes No
	4	B-1	If "no," what are lengths of unsatisfied sections?	<100 ft 100-1000 ft 1000 ft-1 mile 1 mi – ½ facility > ½ facility entire facility
Lane Separation for Toll Collection	1, 2	B-2	What type of lane separation exists?	Rigid Flexible Buffer
	1, 4	B-2	Are AASHTO guidelines satisfied for this type of separation?	Yes No
	4	B-2	Can tolls be collected?	Yes No
Facility Access Satisfies O-D Requirements	N.A.	B-3	Are primary or target users defined?	Yes No
	5	B-3	If "yes," are access points located to serve primary users?	Yes No
Facility Access Design	6	B-4	What type of access is provided?	At-grade slip ramp Direct connect ramp No designated access (continuous)
	4	B-4	If "at-grade slip ramp," is buffer/barrier opening length 1300-1500 ft?	Yes No
	N.A.	B-4	What is design year LOS on freeway?	C/D E/F
	7	B-4	What is weaving volume (HOV ramp entrance)?	Less than 400 vph less than 250 vph
	7	B-4	Is up to 10 mph mainlane speed reduction for managed lane weaving allowed?	Yes No
	7	B-4	What is the minimum length of weaving distance per lane?	950 ft 900 ft 750 ft 700 ft 600 ft 650 ft 500 ft

Table C-2. I-10 Data Collection Form – Facility Considerations (continued).

Factor	Resources Needed (from Table C-1)	Corresponding Scoring Decision Tree Table (Appendix B of Guidebook)	HOT START Questions	Answer Choices
Ability to Enforce	1, 2	B-5	What is operating scheme?	Pay by exception Credit or free by exception (universal tag)
	2	B-5	If "pay by exception," how is occupancy check performed?	Stationary Roving
	4	B-5	If stationary, do enforcement areas conform to AASHTO?	Yes No
	2	B-5	How is occupation verification performed?	High speed Low speed
	3	B-5	Is there supporting technology (vehicle-based tag read units)?	Yes No
	N.A.	B-5	Is there adequate law enforcement?	Yes No
Facility Traffic Control	N.A.	B-6	Are target users defined?	Yes No
	8	B-6	If yes, are any special signing features to be used?	Yes No
	2, 8	B-6	Does sign placement conform to guidance?	Yes No
Pricing Strategy	N.A.	B-7	Is there an operating policy for the HOT lanes?	Yes Partial No
Incident Management	1	B-8	Operational treatments for incident management that can be provided to assure travel time reliability	Tow truck, Emergency access points, CCTV, CMS, Speed monitoring (loops, AVI) None Traffic management center
Maintenance	N.A.	B-10	Is the facility reversible?	Yes No
	N.A.	B-10	Level of maintenance support available	Full Most Some None

Table C-3. I-10 Data Collection Form – Performance Considerations.

Factor	Resources Needed (from Table C-1)	Corresponding Scoring Decision Tree Table (Appendix B of Guidebook)	HOT START Questions	Answer Choices
HOV Lane Utilization	N.A.	B-11	Percent buses (to be used to determine f_b for vphpl calculation)	
	N.A.	B-11	Type of terrain (to be used to determine f_b for vphpl calculation)	**Level** Rolling Mountainous
	N.A.	B-11	Vphpl on facility (non-toll paying) = (autos + buses * f_b)/# lanes	<1200 **1200-1400** >1400
	N.A.	B-11	Is LOS on general-purpose lane D, E, or F?	**Yes** No
	N.A.	B-11	Will conversion have positive impact on HOT lane?	**Yes** No
Travel Time	N.A.	B-12	What are the average travel-time savings?	**>1 min/mile & >5 min overall** >0.25 min/mile & >2 min overall <2 min overall
	N.A.	B-12	Will there be a higher reliability of travel times on the HOT lane?	**Yes** No
	N.A.	B-12	Will the conversion create a negative impact on HOT lane(s) speed?	**Yes** No
Benefits	N.A.	B-13	How will the net agency/societal benefits change?	Increase **No change** Decrease
Willingness to Pay Tolls	9	B-14	Are there many high-income travelers?	**Yes** No
	N.A.	B-14	Are there other local toll facilities?	**Yes** No
	N.A.	B-14	If yes, are the tags interoperable?	**Yes** No
Safety	N.A.	B-15	Is there currently a high crash rate on the facility?	Yes **No**
	N.A.	B-15	How will conversion affect the crash rate on the facility?	Increase Slight reduction **No change** Great reduction

Table C-3. I-10 Data Collection Form – Performance Considerations (continued).

Factor	Resources Needed (from Table C-1)	Corresponding Scoring Decision Tree Table (Appendix B of Guidebook)	HOT START Questions	Answer Choices
Environment	10	B-16	Is facility in non-attainment area?	[Yes] No
	N.A.	B-16	How will conversion affect fuel use?	Increase [No change] Decrease
	N.A.	B-16	How will conversion affect emissions?	Increase [No change] Decrease

Table C-4. I-10 Data Collection Form – Institutional Considerations.

Factor	Resources Needed (from Table C-1)	Corresponding Scoring Decision Tree Table (Appendix B of Guidebook)	HOT START Questions	Answer Choices	
Public Acceptance	N.A.	B-17	Which of the following is the public familiar with?	Tolling ETC HOV Video enforcement	
	N.A.	B-17	Which of the following does the public find acceptable?	Tolling ETC HOV Video enforcement Unknown	
Political Acceptance	N.A.	B-18	Is there a political champion for conversion?	Yes	No
	N.A.	B-18	Is there political familiarity with the conversion concept?	Yes	No
	N.A.	B-18	Is there political support for conversion?	Yes	No
	N.A.	B-18	Does conversion achieve statewide or national goals?	Yes	No
Environmental Justice/Title VI Issues	9	B-19	Are low income/minority populations negatively affected by conversion?	Yes	No
	N.A.	B-19	If yes, are low income/minority populations involved in the planning process?	Yes	No
	N.A.	B-19	Can a mitigation plan be developed?	Yes	No
Revenue Use	N.A.	B-20	Is there agreement among agencies and the public on net revenue use?	Yes	No
	N.A.	B-20	If no, does revenue use support public policy goals?	Yes	No
	N.A.	B-20	If no, is revenue use determined by federal requirement?	Yes	No
Interagency Cooperation	N.A.	B-21	Do all agencies support the HOT lane concept?	Yes	No
	N.A.	B-21	If no, are any agencies actively opposed to HOT lane concept?	Yes	No

Table C-4. I-10 Data Collection Form – Institutional Considerations (continued).

Factor	Resources Needed (from Table C-1)	Corresponding Scoring Decision Tree Table (Appendix B of Guidebook)	HOT START Questions	Answer Choices
Media Awareness	N.A.	B-22	Is there media awareness and support?	Yes No Misrepresentation
	N.A.	B-22	If no, is media receptive to new ideas?	Yes No
Public Education/ Information	N.A.	B-23	What is the level of outreach efforts for public education and information?	Active Minimal None