


Project Bulletin 4160-12B

Project 0-4160: Operating Freeways with Managed Lanes

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Year 2 Annual Report of Progress: Operating Freeways with Managed Lanes



The managed lane concept is currently being considered on major freeway projects in Texas cities. While the high-occupancy vehicle (HOV) concept is familiar in most urban areas, motorists are less familiar with managed lanes.

In this multi-year research project, researchers are investigating the complex issues surrounding the safe and efficient operation of managed lanes using various operating strategies. The research team also plans to develop a managed lanes manual to help the Texas Department of Transportation (TxDOT) make informed planning, design, and operational decisions when considering these facilities across the state.

This bulletin summarizes the activities of the first two years of this multiyear project, highlights the accomplishments to date, provides a status report of

efforts underway, and outlines planned activities for the coming year.

Completed Work . . .

During the first two years of work, the project team undertook several tasks that helped set the tone for the entire effort. The following sections highlight these efforts.

Definition

With the guidance and consensus of the TxDOT Project Monitoring Committee, the project team defined a managed lanes facility as one that increases freeway efficiency by packaging various operational and design actions. Lane management operations may be adjusted at any time to better match regional goals.

This definition is very general yet reflects the

complexity and flexibility of the managed lanes concept. It allows each district to determine what “managed lanes” means for their jurisdiction. It also encourages flexibility, realizing that the needs of a region may change over time and require a different managed lane strategy.

Literature Review

Based on over 100 documents published over the past 20 years, the literature review highlights key managed lane operational strategies currently in use, including HOV lanes, high-occupancy/toll (HOT) lanes, value-priced facilities, exclusive lanes, separation and by-pass lanes, dual facilities, and lane restrictions. It also identifies key issues in implementing managed lanes, such as operations, safety, economics, legal and policy issues, environmental concerns,

social and public opinion issues, and enforcement. The complete literature review and its associated references are published as Appendix A in TxDOT Report 4160-2: *Year 1 Annual Report of Progress: Operating Freeways with Managed Lanes*.

Glossary of Terms

Managed lanes are a complex concept with an equally complex lexicon of terms. The inconsistent use and meanings of terms, phrases, and concepts across the country can at times be confusing. To help clarify the intended course of the research project and eliminate confusion, the research team compiled a glossary of terms related to managed lanes that emerged from other TTI work. The complete glossary is located in Appendix B of TxDOT Report 4160-2: *Year 1 Annual Report of Progress: Operating Freeways with Managed Lanes*.

Symposium

In February 2001, the research team organized a managed lanes symposium to begin generating a dialogue between all potential partners and to provide insight into their concerns regarding operation of managed lanes. Over 90 key staff, decision makers, and other related stakeholders from public transportation agencies and private firms across Texas met to discuss issues pertinent to planning, designing, and operating managed lane facilities. Attendees gained insight from experts around the country, who provided current thinking about managed lane operations. The complete symposium proceedings are contained in TxDOT Report 4160-1: *Managed Lane Symposium Conference Proceedings*.

Weaving Analysis

The intent of the weaving analysis was to demonstrate the impacts of alternative operating strategies on design and traffic operations considerations for managed lanes. Researchers used the VISSIM model as a platform for an analysis of the frequency and location of at-grade (i.e., from within the freeway) access points for managed lanes. The key issues on which they focused were

- freeway weaving from a freeway entrance to a managed lane entrance;
- freeway weaving from a managed lane exit to a freeway exit; and
- intra-freeway vehicle stream separation of vehicles destined for managed lane access.

Figure 1 illustrates some of these complex maneuvers. For each of these key issues, VISSIM models examined different combinations of freeway volume level, percentage of weaving vehicles, weaving distance, and weaving complexity.

The researchers found that complex operational issues, such as cross-freeway weaving and intra-freeway weaving, are most appropriately and practically studied using simulation. The standard analysis techniques, such as the Highway Capacity Manual and Highway Capacity Software,

are appropriate for isolated entrance, exit ramp, and one-sided weaving section analysis.

Researchers also developed typical managed lane design guidelines for weaving distances per lane and minimum distance between a freeway entrance or exit and a managed lanes facility entrance or exit as a function of the volume in the design year, the allowance of operating speed reduction due to managed lane related weaving, and the presence of intermediate ramp/ramps between the freeway entrance/exit and the managed lanes entrance/exit. The complete research results, including these specific guidelines, are included in TxDOT Report 4160-4: *Managed Lanes – Traffic Modeling*.

Ramp Design

The research team assessed published information on geometric design features for ramps, including that in the American Association of State Highway and Transportation Officials (AASHTO) Green Book, the Texas Roadway Design Manual, and other state design manuals, and discovered that ramp location with respect to other entrance and exit ramps is not well documented. General guidelines provided are not sensitive to the expected ramp volume, the anticipated destination

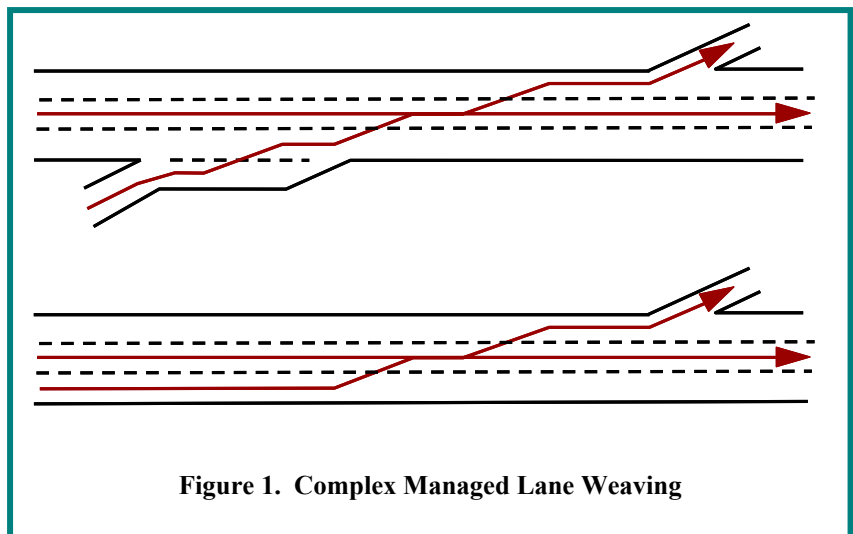


Figure 1. Complex Managed Lane Weaving

of the ramp vehicles (e.g., the next exit ramp or a downstream entrance to a managed lane facility), or the number of lanes on the freeway.

Research conducted under the geometric design task found that a direct connect ramp between a generator and the managed lane facility should be considered when 400 veh/hr is anticipated to access the managed lanes. If a more conservative approach to preserving freeway performance is desired, then a direct connect ramp should be considered at 275 veh/hr (which reflects the value when the lowest speeds on the simulated corridor for the scenarios examined were at 45 mph or less).

The New Jersey Turnpike has two separate roadways in each direction of travel with each roadway having its own exit and entrance ramps. The “dual-dual” roadway improves operations and safety by separating heavy vehicles from light vehicles and increases capacity (heavy vehicles are only permitted on the outer roadway). This separation is continued at entrances and exits, as shown in Figure 2.

The separation also increases flexibility for managing incidents as drivers can be directed to the roadway without the incident through the use of changeable message signs. Available crash information showed lower crash rates for the dual-dual portion as compared to segments of the Turnpike without separate roadways (between 26 and 61 percent for 1994 to 1998). The dual-dual design used on a portion of the New Jersey Turnpike has significant operational and safety benefits.



Figure 2. New Jersey Turnpike Entrance Ramp

These benefits need to be quantified and a benefit-cost evaluation needs to be performed to determine if this approach is feasible within Texas. If the approach is feasible, research should determine the conditions when the design should be considered.

Also, recent literature on ramp design speed and truck performance allows for as much as a 50 percent reduction in design speed from a freeway to a ramp. Research has shown that the use of these minimum values of design speed provides little to no margin for error for large and/or heavily loaded trucks and can also impact operating speeds as a vehicle moves from one facility to another. To maintain high performance for the managed lane facilities, the design speed selected for the ramps must consider the anticipated speeds of the vehicles entering the ramp, the desired speed of the vehicles on the ramp, and the speeds of the vehicles the ramp vehicles will encounter when they are attempting to merge.

A design speed less than the anticipated or desired operating speed will affect the performance of the managed lane. If trucks are a primary vehicle type for the facility, they need to be explicitly considered during the selection of the design features for both the ramp and the managed lane as well as the signing to be used. The complete results of this research task are provided in TxDOT Report 4160-10: *Managed Lane Ramp and Roadway Design Issues*.

Concept Marketing

The goal of marketing a managed lanes project is to build understanding, relationships, and constituencies for managed lanes. Using this as a starting point, the research team identified broad concept marketing strategies that defined the most effective approaches for communicating and building consensus for managed lanes based on corridor and community goals.

The team addressed several issues, including:

- determining public perception,
- identifying and communicating with stakeholder and special interest groups,
- communication techniques, and
- media relations.

They conducted a literature review that targeted various agencies around the country and their efforts to communicate the concept of managed lanes to the general public.

The research documented different approaches, key messages, success factors, and lessons learned. Complete results are included in TxDOT Report 4160-7: *Marketing the Managed Lanes Concept*. The research team also developed two papers, TxDOT 4160-P1: *Managed Lanes: More Efficient Use of the Freeway System: A Position Paper for Policy Makers*, and TxDOT 4160-P2: *Managed Lanes: A New Concept for Freeway Travel: A Position Paper for the Media*.

The team is currently developing these papers into user-friendly formats for distribution to their respective audiences, including elected officials, boards and commission members, executives of public agencies, TxDOT, cities, counties, transit authorities, metropolitan planning organizations (MPOs), newspaper editorial boards, television and radio news directors, and magazine editors.

Legislation

For transportation professionals to consider the managed lane concept on major freeway projects in Texas cities, they must have the authority to construct and operate such facilities using any of the possible strategies. In this task, researchers assessed the federal and state legislative needs necessary for Texas to successfully implement the various types of managed lane facilities across the state.

Numerous federal and state laws govern the operations of these facilities in Texas, and some gaps exist that prevent TxDOT and other operational agencies from being able to design, operate, and enforce managed lanes under a variety of control scenarios and make operational and eligibility changes over time as conditions change. At the federal level, FHWA fails to provide permanence to HOT lanes and tolling on interstates.

At the state level, researchers recommend the following changes to remedy gaps:

- allow TxDOT the authority to enter into contractual agreements with other transportation-related agencies for the design, operation, and/or maintenance of managed lane facilities;
- define managed lanes as an operational concept in Texas and authorize entities to develop these facilities for congestion mitigation purposes;
- allow entities operational flexibility with managed lane facilities;
- authorize entities to develop exclusive lane facilities for congestion mitigation purposes;
- authorize TxDOT to establish lane restrictions for congestion mitigation purposes and remove the time-of-day limitation on the current municipal authorization for this strategy; and
- make unlawful the violation of any managed lane facility in Texas punishable by fine.

For the entire research results related to legislation, please refer to

TxDOT Report 4160-8: *State and Federal Legislative Issues for Managed Lanes*.

Funding & Financing

Numerous innovative financing approaches may be applicable to managed lanes, each with a unique set of considerations related to capital costs and operating expenses. The research team explored available financing options and the applicability of each as they relate to financing managed lanes projects. They identified several alternative-financing methods from the traditional pay-as-you-go method that may be utilized for a managed lanes project. They also identified gaps in current state and federal legislation where changes could result in more financially feasible projects.

An advisory committee of personnel from various federal, state, and local agencies and the private sector provided input on the scope of the task and valuable insight into their concerns regarding financing. The full research report, TxDOT Report 4160-9: *Funding and Financing of Managed Lanes Project*, report includes recommendations and case studies which document the financial plans of several managed lanes projects that are in operation or are being developed across the country.



Enforcement

The purpose of the enforcement task was to outline enforcement procedures and design elements of managed lanes. These vary depending on user groups, operational parameters and application of available technologies. TxDOT Report 4160-11: *Enforcement Issues on Managed Lanes* highlights several corridors operating with managed lanes that incorporate multiple combinations of enforcement procedures and designs.

The enforcement strategy chosen for managed lanes is usually one of the following: routine enforcement, special enforcement, selected enforcement, or self-enforcement. Routine enforcement uses existing freeway patrols to monitor managed lanes while special enforcement uses dedicated equipment and manpower specifically to monitor the managed lanes. Selective enforcement is a combination of the two strategies and may be used for specific events or concerns, such as the opening of a new managed lane facility or to combat high violation rates. The last enforcement strategy relies on the concept of self-enforcement. This involves promoting citizen monitoring and self-regulation by users of the managed lane and the motorists in adjacent general-purpose lanes.

Traditional enforcement on managed lanes requires dedicated enforcement areas, which are usually located immediately adjacent to the managed lane facility and allow enforcement personnel to monitor the facility, pursue violators, and apprehend violators to issue appropriate citations. However, recent advances in automated enforcement technology may lower the number of dedicated enforcement areas needed in the future, thereby shifting the focus of design to

proper placement of electronic equipment. Enforcement areas can also be classified as either low-speed or high-speed and usually by type of separation from the general-purpose lanes.

Successful enforcement of managed lanes requires appropriate application of available resources. This project identified the various enforcement strategies concerning the amount of enforcement required to ensure that the rules and regulations of managed lanes are maintained. This amount ranges from continuous enforcement to the simpler process of self-enforcement. A review of the various enforcement practices across the country indicates that there are multiple variations for the enforcement of managed lanes with varying levels of success.

Barrier-separated facilities obviously experience less violation than buffer-separated facilities due to the more restrictive nature of the design. The level of importance that responsible enforcement agencies place on managed lane facilities also dictates the restrictive nature of the facility. The enforcement practices at several of the more well-known managed lane facilities from around the country are presented in the research to show the level of commitment to enforcement of several of the agencies. The most notable of these is the California Highway Patrol that has been contracted for the specific purpose of monitoring the SR-91 express lanes in Orange County and the I-15 express lanes in San Diego County.

This project also focused on the concurrent flow and barrier-separated, reversible HOV lanes in Minneapolis, Minnesota. Underutilization and excessive occupancy violations characterize HOV lane operation on both I-35W and I-394 because of limited enforcement. Previous attempts to

enforce these facilities resulted in severe congestion on the general-purpose lanes due to onlooker delay. Perhaps other enforcement techniques are in order that do not interrupt the flow of traffic. This is the case with automated enforcement technology.

The use of automated enforcement technology is growing at an ever-increasing rate. This project acknowledges the use of automated vehicle identification, license plate recognition, and electronic toll collection as the way of the future concerning enforcement of managed lanes.

Work Underway . . .

The research team has several tasks that are underway but which will be completed in subsequent years. The following sections outline milestones and progress to date and highlight key issues or interim findings that are of critical importance

Decision Matrix

The type of users authorized to use a managed lane facility will play a critical role in the feasibility, design, and operation of a managed facility. A matrix of possible operating strategies for various eligible user groups can correlate eligibility decisions with realistic considerations for planning, designing, and operating a managed lane facility.

Researchers are developing a framework for supporting decisions related to the development of managed lane projects that depicts the sequential elements considered in implementing a managed lanes project. Features of the framework include the following:

- incorporation of financial goals, particularly those involving

- revenue generation, into the general policy framework;
- objective-based decision-making in determining potential user groups and the use of pricing for demand management and/or revenue generation;
- the combination of vehicle user groups and operating strategy as the basis for determining design parameters for the project;
- the involvement of other agencies in the process, as well as multiple opportunities for public input;
- a strong link between design and operations in the development of schematic design; and
- a re-evaluation process if expected performance does not meet desired outcome.

As the backbone of the Managed Lanes Manual, this framework will ultimately be converted to a user-friendly computer-based decision support system (DSS) or expert system that provides links to supporting resources and information within a constructed database and/or on the Internet. Initial work has begun in developing a menu of project objectives and performance measures. As other research tasks are completed they will be incorporated into the framework.

AASHTO Support

The objective of this task is to assist AASHTO in updating the Guide for the Design of High-occupancy Vehicle Facilities and the Guide for the Design of Park-and-Ride Facilities. There are significant additional experiences and research in these areas that need to be incorporated into the guides since they were last published in 1992. National Cooperative Highway Research Program (NCHRP) 20-7 funding also supports work conducted under this task.

The Task Force for Public Transportation Facilities Design of the AASHTO Subcommittee on Design is responsible for updating the guides. After receiving updated changes to the documents from the Task Force, the research team then began editing and organizing the sections of the HOV guide. The research team also developed some sections that were not assigned to Task Force members and provided additional text to enhance the flow of the document. The first drafts of these guides are under review by the Task Force and final products are expected to be submitted to AASHTO for final approval and publication in June 2003.

Traffic Operations Manual

The Highway Operations volume of TxDOT's Traffic Operations Manual is a key document that TxDOT engineers and personnel use to plan, design, operate, and enforce highways within their jurisdiction. As the document currently stands, little is included regarding the issues associated with managed lanes.

In this task, researchers are developing recommendations for revisions and/or additions to this document to enhance its applicability and use by TxDOT personnel. These recommendations will be in the form of sample text and/or graphics as appropriate. The results from each of the previous tasks in the project that address these specific issues will be used to produce the material for the appropriate chapter(s).



Managed Lanes Manual

To assist in implementation of the managed lanes research results of this project, particularly in areas that are in the beginning phase of planning such a project, the team is developing a Managed Lanes Manual, which will be in interim form at the end of the third year of the project. This document will include all of the research in a usable format, providing a clear, concise, and step-wise approach to planning, designing, operating, and enforcing a managed lanes facility.

Year 3 Efforts . . .

In year 3 of the project, the research team will undertake a number of tasks, continuing to delve into the issues surrounding the operations of managed lanes facilities.

Traveler Information

One of the more critical aspects of managed lanes is the need for information of the traveler using the managed lanes. Depending on the intended user groups and the operational options of the lanes, the information needed to make critical travel decisions varies. For instance, if HOV lanes are provided, the traveler needs to know the restrictions of lane use and entrance and exit location information. If HOT lanes are provided, the traveler needs to know

restriction information as well as toll schedules. Specific travelers might have similar needs if they travel in truck lanes or other special-use lanes. All of this information is necessary in order for the intended user group to make informed decisions and perform required maneuvers in a safe and efficient manner so as to maximize the performance of the lanes.

During this task, the project team will conduct a thorough investigation of the various user information needs associated with managed lanes. Information needs will be identified depending on the intended user groups and the specific use of the lanes. Existing research findings on this topic will be incorporated as appropriate. The results will be recommendations on upstream driver information as a function of operational strategy and user group.

Traffic Control Devices

The user information system is a critical component of the managed lane facility, serving as the manner in which key operational information about the facility is provided to travelers. Delivered in the form of traffic signs, pavement markings, and general delineation, this system provides appropriate information to travelers at the correct time and in a format easily understood. If the user information system does its job correctly, travelers can make informed decisions regarding their use of the managed lane facility and can navigate into, through, and out of the facility in a safe and efficient manner. Obviously, the challenges associated with providing this information are complex given the varied information and decision-making needs that will be identified in Task 13.

Researchers will identify the appropriate traffic control devices necessary to successfully deliver the

correct operational and decision-making information required by the various user groups. Recommendations will include model plans for the physical layout of traffic control devices for managed lanes based on the user, operational, and design options. If necessary, the project team will work with TxDOT to develop requests for experimentation and/or requests for changes to initiate the process of using new devices/applications and changing the Texas Manual on Uniform Traffic Control Devices.

Incident Management

A key strategy to successfully operating a facility with managed lanes is to have an organized procedure for handling incidents within the facility. This procedure needs to consider the various agencies that might be involved in handling an incident, their specific needs related to their role in incident management, the institutional and technical challenges for inter-agency cooperation, and the variety of strategies available to handle incidents of different types and severity.

Researchers will offer a framework for managing incidents within a managed lane facility such

that the incident is cleared in a safe, effective, and efficient manner so as to minimize its impact on the managed lanes and the entire facility. This framework might include a matrix for use in identifying the appropriate strategy or strategies for handling specific incidents and the decisions and procedures for incident management based on the agencies involved and the needs of the travelers.

Ongoing Activities . . .

Internet Site & Newsletter

To help implement research results, the research team developed a project website to provide an avenue for disseminating research results and exposure to the research surrounding managed lanes. The managed lanes site (<http://www.managed-lanes.tamu.edu>), as shown in Figure 3 highlights ongoing research that TTI is conducting for TxDOT on managed lanes, provides key research results and access to related products, has information on meetings and other events related to managed lanes across the country, and has links to key related Internet sites.

Readers can also access the quarterly newsletter, FastLane,

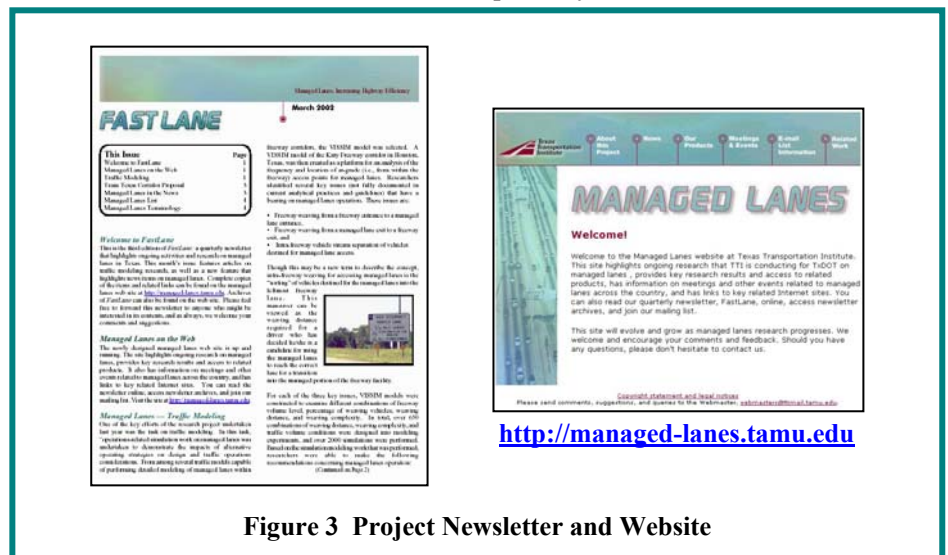


Figure 3 Project Newsletter and Website

online and join the mailing list. The newsletter is published quarterly to document lessons learned throughout the duration of the project. It allows department engineers and other key personnel quick access to implementable research findings without having to wait until completion of the project. The team publishes the newsletter electronically, with the approval of the Project Director (PD), and distributes it to the project mailing list of over 300 transportation professionals and reaches an even broader audience by posting the newsletter on the project website.

Project Contacts

The project team continues to periodically contact TxDOT staff who are instrumental in the various managed lanes projects across the state. Since the inception of this project, the research team has met with representatives from the Austin, Dallas, Fort Worth, Houston, San Antonio, and Waco TxDOT districts to discuss project progress and key findings relevant to their specific projects.

Final Remarks . . .

The research team looks forward to another productive project year and the success of finding more pieces of the complex puzzle of managed lanes.

For More Details . . .

Related Report:

Report 4160-12, *Year 2 Annual Report of Progress: Operating Freeways with Managed Lanes.*

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Disclaimer

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