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16. Abstract

The System Planning Methodology was developed jointly by the Texas Department of Transportation (TxDOT), North Central Texas Council of Governments (NCTCOG), Dallas Area Rapid Transit (DART), and Texas Transportation Institute (TTI) as a transportation corridor and system analysis tool that would bridge the gap between regional planning and detailed corridor design. It allows for the examination of peak hour person movement for different facility types within a corridor and estimates associated public costs (e.g., right-of-way, construction, operation, congestion, and environmental costs). The objective of the methodology is to find the lowest total public cost alternative. This project extends the methodology to include costs associated with traffic incidents (nonrecurrent congestion) and tests the results on five corridors in the Dallas area to determine if it alters the recommended alternative previously identified for each corridor. It also adds toll lanes and high occupancy/toll lanes (HOT) as alternatives that can be evaluated against other combinations of general purpose lanes, high occupancy vehicle (HOV) lanes, and express lanes.

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HIGHWAY PLANNING AND OPERATIONS FOR THE DALLAS DISTRICT: FREEWAY SYSTEM PLAN METHODOLOGY

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IMPLEMENTATION RECOMMENDATIONS

This project was intended to enhance the System Planning Methodology (SPM) that was developed by the Texas Department of Transportation (TxDOT), North Central Texas Council of Governments (NCTCOG), Dallas Area Rapid Transit (DART), and Texas Transportation Institute (TTI) as a transportation corridor and system analysis tool that would bridge the gap between regional planning and detailed corridor design. Limited funding for transportation improvements make it more important than ever that the facilities recommended for implementation move the most people for the lowest overall cost. The results of this project should be implemented in the following ways:

1. Nonrecurrent congestion resulting from incidents on the roadway do not affect the type of facility that should be constructed in any given corridor. However, the method employed to estimate nonrecurrent congestion in this study indicates that its effect on traffic flow may be even greater than previously thought. This indicates that continued emphasis should be placed on the deployment of effective incident management programs in congested areas. The revised System Planning Methodology can be used to help estimate these effects in support of these programs.

2. The best alternatives in high demand corridors will generally include general purpose lanes in combination with high occupancy vehicle (HOV) or high occupancy vehicle/toll (HOT) lanes. Feasibility studies for major corridors in Texas should include a comprehensive examination of HOV and HOT lane alternatives.

3. The System Planning Methodology is an effective tool for examining many different corridor alternatives with limited data. It should be utilized in major investment studies and corridor studies to assist in the quick assessment of many different alternatives.

This report should be distributed to TxDOT districts and MPOs in urban areas to maximize its effectiveness.

DISCLAIMER

The contents of this report reflect the views of the authors who are responsible for the opinions, findings, and conclusions presented herein. The contents do not necessarily reflect the official views of the Texas Department of Transportation (TxDOT). This report does not constitute a standard, specification, or regulation, nor is it intended for construction, bidding, or permit purposes. The engineer in charge was Carol H. Walters, P.E. #51154.

ACKNOWLEDGMENT

The System Plan Methodology is the result of several research projects and more than seven years of collaborative effort between the Texas Department of Transportation (TxDOT), North Central Texas Council of Governments (NCTCOG), Dallas Area Rapid Transit (DART), and the Texas Transportation Institute (TTI). The authors wish to acknowledge the contributions made by each of these agencies. In particular, the enhancements included in this project have been successfully completed with assistance from Jim Hunt and Stan Hall from the Dallas District of TxDOT, and Michael Morris, Dan Kessler, and Mike Copeland from NCTCOG.

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SUMMARY

The System Planning Methodology was developed jointly by the Texas Department of Transportation (TxDOT), North Central Texas Council of Governments (NCTCOG), Dallas Area Rapid Transit (DART), and Texas Transportation Institute (TTI) as a transportation corridor and system analysis tool that would bridge the gap between regional planning and detailed corridor design. It allows for the examination of peak hour person movement for different facility types within a corridor and estimates associated public costs (e.g., right-of-way, construction, operation, congestion, and environmental costs). The objective of the methodology is to find the lowest total public cost alternative.

This project was intended to enhance the System Planning Methodology by addressing two primary objectives: (1) modify the approach used to estimate costs associated with traffic incidents (nonrecurrent congestion) and test the results on five corridors in the Dallas area to determine if it alters the recommended alternative previously identified for each corridor; and (2), add toll lanes and high occupancy/toll lanes (HOT) as alternatives that can be evaluated against other combinations of general purpose lanes, high occupancy vehicle (HOV) lanes, and express lanes.

The results of this project confirmed previous work that low and moderate demand facilities are best served by improving general purpose lanes in the corridor and, in some cases, adding express lanes.

It was thought that the introduction of nonrecurrent costs might cause the addition of general purpose lanes to become the preferred alternative for high demand corridors, but results from the test corridors showed that HOV lanes continue to be part of the best solution. Nonrecurrent congestion did not have a significant impact on the determination of the best alternative.

The evaluation of toll lanes in the test corridors showed that congested corridors with all toll lane or general purpose/toll lane combinations did not perform as well as alternatives that included a combination of general purpose and HOV lanes based on the lowest total public cost criteria.

However, alternatives that combined general purpose lanes with HOT lanes tended to perform as well as and slightly better, in some cases, than HOV lanes.

In general, the System Planning Methodology suggests that any lanes added to an existing, high demand facility should be either HOT or HOV lanes. This recommendation must be tempered by the fact that HOT lanes represent a new approach to serving travel demand, and there are many public policy, implementation, and operations issues that need to be examined before HOT lanes can be given an unqualified endorsement.

The best application of the System Planning Methodology will be in major investment studies and corridor studies because it (1) allows sufficient time to develop input data to a greater level of detail and to test the sensitivity of the model to variations in the inputs, (2) matches the level of detail commonly found in these studies, and (3) can then be used as an input into the regional transportation planning process that must be updated every three years.

I. INTRODUCTION

DESCRIPTION OF THE SYSTEM PLANNING METHODOLOGY

The System Planning Methodology (SPM) was developed jointly by the Texas Department of Transportation (TxDOT), North Central Texas Council of Governments (NCTCOG), Dallas Area Rapid Transit (DART), and Texas Transportation Institute (TTI) to provide a transportation analysis tool that would help bridge the gap between regional mobility planning and detailed corridor analysis (*1*). Since the transportation plans developed by different agencies tend to reflect the initial assumptions and priorities of those agencies, there was also a need to develop a tool that would help to provide system compatibility as the planned projects moved towards implementation. In other words, it was the intent of the SPM to ensure that the various elements of the transportation system worked together so that the capacity available in each segment could be utilized to its maximum.

In order to achieve these basic objectives, the SPM was developed as an iterative approach that evaluates alternatives for each corridor, then looks at how the best alternatives in each corridor fit together to form a system.

Corridor Analysis

The "corridor analysis" begins with the collection of required data input items, including travel data (existing and design year daily volumes for freeways, HOV lanes, bus systems, and transit systems; percent of daily traffic in the peak hour, peak hour directional splits, and peak hour truck percentages), roadway data (existing lanes, right-of-way limits, roadway structures, and buildings adjacent to the corridor), and information on planned projects in the region. These data are input into the SPM spreadsheets to evaluate a variety of cross section alternatives for a corridor. Cross sections can include a mix of facility types, such as general purpose lanes, high occupancy vehicle (HOV) lanes, and express lanes. Given a particular volume of peak hour person trips, the spreadsheets determine the critical lane volumes for each facility type based on known relationships and capacity constraints which recognize that people will change their travel behavior when given the opportunity to avoid congestion. Finally, a total net present cost is calculated to rank the performance of the various alternatives in the corridor. The original System Plan considered capital (rehabilitation, construction, and right-of-way), operating and maintenance, and congestion delay as costs. Subsequent refinements to the methodology have added other costs (e.g., environmental and congestion from incidents) into the evaluation. The alternative with the lowest total net present cost is considered to be the "best" alternative for that corridor and is used as the initial input into the system analysis.

System Analysis

The "system" analysis looks at the results of the corridor analysis to determine if the "best" alternatives for each corridor will operate efficiently as a transportation system. If there are lane balance or continuity problems between adjoining or intersecting corridors, then lower ranking alternatives for a particular corridor may be considered to ensure system compatibility.

The original SPM was developed in conjunction with the NCTCOG Mobility 2010 Plan Update in 1992 and was used as one of the inputs in the decision making process for that study. Refinements to the methodology were subsequently undertaken as a part of two research studies (*2,3*). These studies modified the spreadsheets to include additional HOV data and extended the public cost model to include environmental costs (fuel consumption, air quality, noise, and visual impacts), congestion delay costs associated with incidents (nonrecurrent congestion), and costs associated with commercial vehicles.

PURPOSE OF THIS RESEARCH

Reexamination of Nonrecurrent Congestion Effects

One of the most important findings of the original System Planning study was that the best alternatives for congested corridors tended to include the addition of HOV lanes and a limitation on the number of general purpose lanes so that they experience peak hour congestion. In other words, the lowest total public cost alternative involved a tradeoff of reducing capital costs and accepting increased congestion (delay) costs on the general purpose lanes in order to encourage increased HOV formation. However, the public cost model in the original SPM did not include "nonrecurrent" congestion costs, and since the number of incidents rises with the level of congestion and nonrecurrent delay from incidents accounts for at least as much delay as recurrent congestion, there was some concern that the inclusion of nonrecurrent delay costs might lead to different conclusions.

SPR Project 1451, completed in 1995, included the first effort to incorporate the cost effects of "nonrecurrent" congestion into the SPM. An application of the revised methodology to evaluate a section of LBJ Freeway (IH635) east of Central Expressway (US 75) as part of its Major Investment Study (MIS) revealed that the current approach would generate little or no nonrecurrent costs when analyzing a freeway with high congestion levels. Subsequent tests also showed that recurrent congestion costs were inflated for longer roadway sections.

This research will address these issues and test the revised model using data from the original System Plan to determine if the inclusion of nonrecurrent congestion costs significantly changes the recommended alternatives.

Incorporation of Toll Road Effects

Under the 1991 Intermodal Surface Transportation Efficiency Act (ISTEA), NCTCOG was charged with developing a capital-constrained, long- range transportation plan for the Dallas/Ft. Worth region based on the levels of funding expected to be available. In response to a substantial revenue shortfall for transportation projects, the local MPO adopted a requirement that toll roads be considered in addition to tax-financed roads throughout the region. This could make a substantial difference in the conclusions regarding peak hour person movement.

In addition, the MIS for LBJ Freeway in Dallas was recently completed that recommended a portion of the reconstructed freeway include eight general purpose lanes and six high occupancy/toll (HOT) lanes. The combination of toll lanes and preferential treatment for high occupancy vehicles is a new option that was implemented on California's SR 91 in 1996 and is being considered for several other facilities around the country.

Previous work on the SPM did not allow for toll lanes to be explicitly evaluated as part of the methodology. It has been recommended that toll lanes be handled in a similar manner to rail transit, i.e., estimate the demand for the toll lanes outside of the SPM spreadsheet and remove it from the corridor demands being served by the freeway. Provided that the final plan derived from the system planning methodology is similar to the assumed system that generated the toll demand, the results should be considered valid.

This research responds to the renewed focus on toll lanes and their potential to be coupled with HOV lanes by extending the SPM spreadsheets to explicitly include toll lanes as an option when considering cross section alternatives in a corridor. The revised methodology will be applied in five corridors using data from the NCTCOG Mobility 2020 planning process to compare results with the recommendations that came out of the traditional planning process.

Spreadsheet Revisions to Improve Functionality and Updated User Manual

As the SPM is expanded to include alternative options and costs, there are opportunities to revise the structure of the spreadsheet to make it more efficient and user friendly. These changes will be documented in this report and an updated user manual provided in an appendix.

II. REVIEW OF PREVIOUS WORK

ORIGINAL SYSTEM PLANNING METHODOLOGY AND REVISIONS

The System Planning Methodology has been developed and enhanced as a part of three previous research projects conducted between 1989 and 1996. The original SPM was jointly developed by TxDOT, NCTCOG, DART, and TTI to help bridge the gap between the planning level work being done at a regional level and the detailed corridor designs being prepared by the Dallas District of TxDOT. It was initially applied in Dallas to assist the NCTCOG in preparation of their Mobility 2010 Update for the Dallas/Ft. Worth region. This effort established the basic framework for the methodology which has not changed significantly with subsequent enhancements. Some key elements of the SPM approach are summarized below (*1*):

- The SPM utilized peak hour person movement as the primary unit of analysis because different transportation modes are more or less efficient at moving people. The number of persons forecast to be traveling in a particular corridor was held constant; then, different facility alternatives for the corridor were analyzed to see how they performed.

- The facility types that were explicitly evaluated in the SPM were general purpose, HOV, and express lanes.

- The HOV relationships used to predict the amount of carpool formation relative to the level of congestion in adjacent general purpose lanes were based on data from Houston HOV lanes.

- The "least total public cost" approach was adopted as the primary measure to determine the best alternative for each corridor. Initially, costs included right-of-way, construction, operation, and recurrent congestion delay.

- After analyzing corridors individually, the "best" alternatives were evaluated relative to other intersecting corridors to ensure that the pieces worked together as a system.

- The most significant finding was that in high demand corridors, the lowest cost alternative would generally be a combination of general purpose lanes, operating with some congestion, and HOV lanes providing a travel time advantage for persons willing to shift to carpools or transit to avoid congestion costs.

Incorporating Intermodalism into Freeway System Planning

This project was sponsored by the Southwest Region University Transportation Center (Project #465030) and was intended to enhance the SPM by improving the estimation of HOV ridership and delay associated with congestion, and by accounting for some additional costs in the "total public cost" calculation. The report's findings can be summarized as follows (*3*):

- This project sought to advance the HOV ridership relationship by analyzing data from HOV systems in operation across the country. However, it was determined that variations in data collected and differences in project/urban area characteristics were substantial enough that it would be best to utilize data from Texas projects to predict ridership.

- The method to estimate delay due to recurrent congestion from the original SPM was reviewed and changed to better reflect real freeway lane capacity and flow conditions. A linear relationship of volume to delay and speed was approximated to improve the congestion cost methodology. The relationship between freeway speed and alternate route speed in the original method was found to be sound after an evaluation of additional travel data and was not altered.

- Additional costs considered in this project included energy, emissions, and congestion costs for commercial vehicles. Fuel consumption rates were derived using the ARFCOM computer program, and emission rates were obtained from the MOBILE5a model. The amount of fuel consumption or emissions was estimated using an average speed methodology that takes the daily travel in a given corridor and multiplies it by the applicable rate based on the average speed in that corridor. This approach resulted in good estimates for fuel consumption, but emission estimates were not included in the revised methodology because of inaccuracies in the MOBIL5a estimates that are the subject of other current research projects. The cost estimate per hour for trucks was obtained from the American Trucking Association and was used to estimate the annual cost of congestion for commercial vehicles.

Multimodal System Planning Technique -- An Analytical Approach to Peak Period Operation

TxDOT sponsored the last project undertaken to expand on the SPM (Project #1451), and it was designed to organize information about the methodology so that it could be used as an analysis tool by planners and engineers to examine transportation corridors anywhere in Texas (*2*). The most significant addition to the methodology in this project was the inclusion of "nonrecurrent congestion," or congestion caused by incidents in the estimation of total public cost. The next section describes the approach that was developed to estimate nonrecurrent congestion.

NONRECURRENT CONGESTION

Nonrecurrent congestion is generally understood to be a result of incidents that cause a reduction of roadway capacity. Because incidents have a wide variation in the impact on a freeway, it was necessary to determine the impact on the freeway of a "typical" incident. The percent reduction in freeway capacity from a typical incident was estimated using data found in the literature (*4*) as well as data obtained from Motorist Assistance Patrols in the Dallas area. The percent reduction in freeway capacity from a typical incident is shown in Table 1.

Table 1. Percent Capacity Remaining During an Average Freeway Incident

Number of Lanes in Each Direction	Percent Remaining Capacity
2	75 %
3	82 %
4	85 %
5	87 %
6	89 %

The frequency of incidents was estimated using data observed in the Dallas area, which resulted in a rule-of-thumb value of about one incident per 40,000 vehicle kilometers (25,000 vehicle miles). However, the frequency of incidents appears significantly higher where recurrent congestion occurs. In Dallas, the available data suggested that in heavy congestion, the number of normal incidents is one per 24,000 vehicle kilometers (15,000 vehicle miles).

Figure 1 is a graphical depiction of the potential relationship between incident frequency and recurrent congestion. On freeways, any speed below 64 kph (40 mph) indicates the presence of congestion. If a linear relationship is positioned between speeds below 64 kph (40 mph) and an increasing frequency of incidents, up to a maximum value of one per 24,000 vehicle kilometers (15,000 vehicle miles) at speeds of 16 kph (10 mph), then the expected frequency of incidents for a given speed could be taken from this graph and used with the above estimates of capacity reductions for the average incident, based upon the number of freeway lanes.

Since the SPM refined in the 1451 project may, in some cases, create justification for increased congestion under the lowest-public-cost criteria, it was important to attempt some assessment of the full impacts of congestion, including an increased frequency of incidents. This study utilized the rough, but defensible, methodology described above to estimate the cost impacts of increasing incidents due to congestion. Costs were limited to increased delay. Although the costs of incidents themselves, to those involved and to the public agencies responsible for their clearance, could be significant, their inclusion would have required more extensive research on the types of incidents which increase in congestion situations and a more reliable basis for incident frequency estimates. This level of detail was considered beyond the scope of the System Planning Methodology.

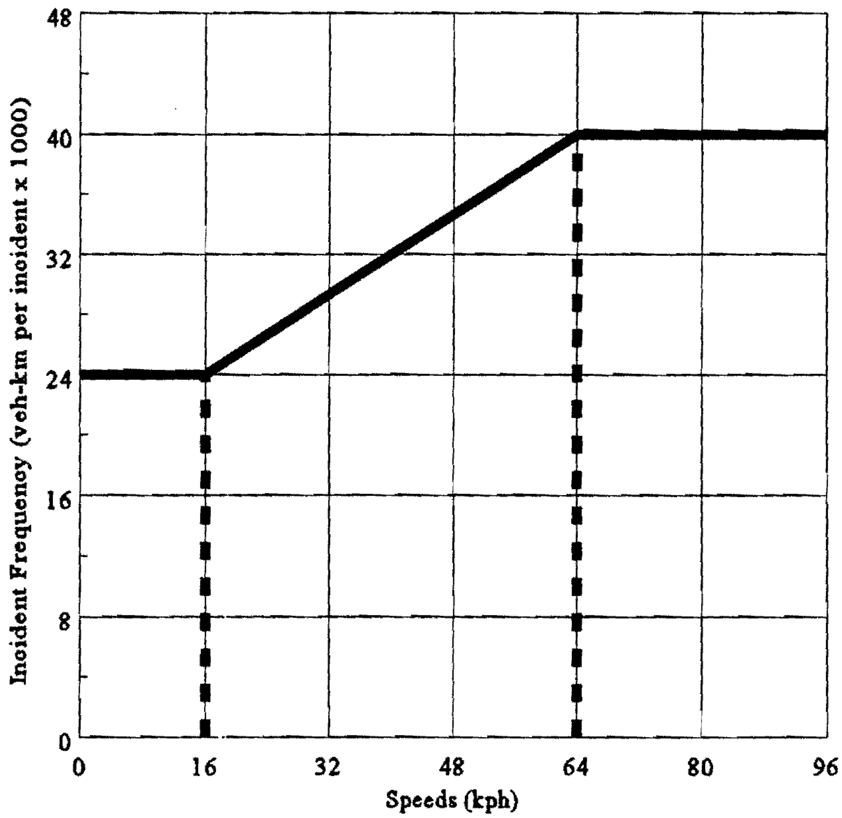

Figure 1. Incident Frequency on Freeways

TOLL LANES

Researchers conducted a literature review to find methods of establishing a relationship between toll road usage and freeway congestion. A keyword search using WinSPIRS 2.0 was made of the

Transport database. The Transport database is made up of entries from the Transportation Research Board as well as several other transportation libraries. Though the search did not identify a source of information that has established a relationship between freeway congestion and toll road usage, there is an increasing body of literature reporting on congestion pricing issues and the development of HOT lanes.

Many of the reports focused on the SR91 Express Lanes east of Los Angeles in Orange County, California, as well as some of the other demonstrations of congestion pricing or HOT lanes that are now underway or being developed (*5*). The SR91 Express Lanes are four dedicated lanes -- two in each direction -- in the median of the SR91 freeway. The free lanes and the dedicated lanes are separated by a buffer and pylons. The dedicated lanes are restricted to HOVs with three or more passengers traveling free or other passenger vehicles if they pay a toll ranging from $0.50 during the off peak to $2.75 during the peak period. The only other HOT lane project that has been implemented to date is the IH15 congestion pricing project in San Diego, California. IH15 is an eight-lane freeway with a two-lane, reversible HOV lane operating during the morning and evening peak hours in its median. The HOV lanes are separated by barriers from the mainlanes, and access to the lanes is available only at the two endpoints of the facility. The first phase of this project has opened these lanes to SOVs, provided that they have purchased one of the limited number of monthly passes. The next phase of the project, scheduled for early 1998, will automate toll collection for the lanes (*6*).

The level of interest in HOT lanes as a facility type that can be used to encourage higher occupancies and generate revenue to help pay for transportation improvements is growing. There are currently two projects in Texas that incorporate the HOT lane concept. The first is a project on the Katy HOV lane in Houston that currently operates as a three person HOV facility. This project will permit a limited number of two person carpools to pay a toll to access the HOV lane (*7*). The other HOT lane project is being undertaken by TxDOT as a part of their work to redesign LBJ Freeway (IH635) in North Dallas. The approved MIS recommends the addition of six HOT lanes between Stemmons (IH35E) and Central Expressway (US 75), while maintaining eight general purpose lanes (*8*).

Discussions with representatives from the Texas Turnpike Authority (TTA) and NCTCOG indicated that much of the travel forecasting work that has been done for toll roads has been conducted by private consulting firms to establish financial feasibility, and that their analysis procedures are considered proprietary. The NCTCOG includes toll roads in their travel demand forecasting model by assigning an impedance in the roadway assignment model that reflects the cost of the toll (*9*). This was referred to as the "generalized cost equation" and was determined to be the best available approach for incorporating toll lanes into the SPM because it would provide a direct relationship between the congestion delay experienced on general purpose lanes and the cost of using a toll lane. The implementation of this approach will be discussed in greater detail later in this report.

III. IMPROVEMENTS TO THE METHODOLOGY

NONRECURRENT CONGESTION EFFECTS

Application of the methodology indicated that the system effects of nonrecurrent congestion were not being fully included when a corridor was already congested as result of recurrent congestion. The primary problem of the initial method for estimating the additional delay due to nonrecurrent congestion is the assumption that the lowest acceptable speed for traffic on freeways was 24 kph (15 mph). This was based on a delay of 1.9 minutes a km (3 minutes a mile) over a free flow speed of 97 kph (60 mph). For recurrent congestion, this assumption remains valid since it basically assumes that traffic will shift to a different start time or divert to alternative routes when delay reaches 1.9 minutes a km (3 minutes a mile). However, since incidents are unpredictable, it must be assumed that vehicles will not have the opportunity to shift or divert from congestion resulting from an incident. In other words, due to incidents, minimum speeds must be assumed to be lower than 24 kph (15 mph).

By using the assumed minimum speed of 24 kph (15 mph), no additional nonrecurrent delay costs were estimated in sections where the estimated speed was already 24 kph (15 mph) due to recurrent congestion. The problem was only realized in sections with extreme congestion where demand greatly exceeds capacity (demand greater than 2400 vphpl). Since no sections with excessive demands were reviewed when nonrecurrent congestion was first added to the methodology, this problem was not recognized.

The System Plan method, as presented in the 1451 report, was used to analyze several alternatives for the Eastside of LBJ from US80 to US75 Central Expressway as part of the LBJ MIS process. The alternatives analyzed ranged from a no action alternative to an alternative with 10 mainlanes and four HOV lanes. One of the primary premises of the SPM is that each alternative for a corridor moves the same number of person trips, which means alternatives with fewer lanes will have greater demands per lane. This premise is essential for comparing corridor alternatives. Basically, the results of the initial method showed that alternatives with a high recurrent congestion cost, such as the no action alternative, had little or no nonrecurrent congestion cost, which appeared illogical when compared to other alternatives.

Listed below are the steps used to calculate the nonrecurrent congestion cost in the SPM as included in the 1451 report (*2*):

A. Using Figure 1 and calculated speeds per section, determine vehicle-distance per incident.
B. Determine vehicle-distance per hour for sections under analysis.
C. Divide B by A to determine number of incidents per hour.
D. Obtain percent of remaining freeway capacity from Table 1 based on number of lanes.
E. Multiply D x 2200 vphpl to reach a per lane adjusted capacity value per incident.
F. Utilize E to arrive at adjusted speeds using the volume to speed relationship.
G. Check Figure 1 to determine whether adjusted speed (G) alters the incident frequency, and iterate (repeat steps B and C if needed).
H. Calculate delay per incident.
I. Multiply the delay per incident (I) and the number of incidents per hour (C) to arrive at the delay per hour.

An example of the initial method is worked out below. In the example, average incident delay per vehicle resulted in a change from 72 kph (45 mph) to 24 kph (15 mph) per vehicle for the 2.0 kilometer (1.2 mile) section. This is equivalent to a loss of 3.2 minutes per vehicle on a typical day in the peak hour.

Example: 3 lanes, 2.0 km (1.2 miles) long, demand of 2200 vphpl in the critical section.

A. The volume to speed relationship gives a speed = 72 kph (45 mph) and, from Figure 1, 40,000 veh-km (25,000 veh-miles) per incident.

B. 2200 vphpl x 3 lanes x 2.0 km (1.2 miles)= 13,200 veh-km (7,920 veh-miles) in the peak hour.

C. 13,200 veh-km (7,920 veh-miles)/40,000 veh-km (25,000 veh-miles) per incident = 0.32 incidents per peak hour.

D. From Table 1, 82% capacity remaining per incident for a three-lane section.

E. 82% x 2200 vphpl = 1804 vphpl adjusted capacity.

F. 2200 vphpl demand/1804 vphpl capacity = 1.22 v/c, 1.22 > 2400/2200 or 1.09 failure. Freeway speeds will drop to 24 kph (15 mph).

G. Checking Figure 1 gives an adjusted incident frequency of 26,900 veh-km (16,700 veh-miles) per incident - iterate - repeat steps B and C.

B. 1804 x 3 lanes x 2.0 km (1.2 miles) = 10,824 veh-km (6,494 veh-miles).

C. 10,824/26,900 = 0.40 incidents per peak hour on the freeway at 24 kph (15 mph).

H. 24 kph (15 mph) should be used to calculate the delay per incident. This will add an average of 352 vehicle hours of nonrecurrent delay per incident over the 2.0 km (1.2 mile) section.

I. 352 vehicle hours per incident multiplied by 0.40 incidents per hour equals 141 vehicle hours of delay per hour.

In step F of the initial method, for any alternative that has an adjusted volume to capacity ratio greater than 1.09, the speed will drop to 24 kph (15 mph). If the initial demand is 2400 vphpl, the volume to speed relationship gives an initial speed of 24 kph (15 mph). The problem of not having any nonrecurrent congestion in this situation is readily apparent since there is no change in speed due to incidents - the speed remains at 24 kph (15 mph). The improved method simply establishes a linear relationship for speeds from 24 kph (15 mph) to 8 kph (5 mph), based on the demand to reduced capacity ratio. The lowest reduced capacity for "typical" incidents occurs for an incident in a two lane section at 1650 vphpl. The maximum demand is 2400 vphpl, so the theoretical maximum demand to capacity ratio where speed is 8 kph (5 mph) is 2400/1650 = 1.45. The additional linear relationship included in step F significantly changes the end result for demand to capacity ratios greater than 1.09.

The example from above is shown below for the improved method:

A. The volume to speed relationship gives a speed = 72 kph (45 mph) and, from Figure 1, 40,000 veh-km (25,000 veh-miles) per incident.
B. 2200 vphpl x 3 lanes x 2.0 km (1.2 miles)= 13,200 veh-km (7,920 veh-miles) in the peak hour.
C. 13,200 veh-km (7,920 veh-miles)/40,000 veh-km (25,000 veh-miles) per incident = 0.32 incidents per peak hour.
D. From Table 1, 82% capacity remaining per incident for a three lane section.
E. 82% x 2200 vphpl = 1804 vphpl adjusted capacity.
F. 2200 vphpl demand/1804 vphpl capacity = 1.22 v/c, 1.22 > 2400/2200 or 1.09 failure. With the improved relationship, the freeway speeds will now drop to 18.5 kph (11.5 mph).
G. Checking Figure 1 gives an adjusted incident frequency of 24,900 veh-km (15,500 veh-miles) per incident - iterate - repeat steps B and C.
B. 1804 x 3 lanes x 2.0 km (1.2 miles) = 10,824 veh-km (6,494 veh-miles).
C. 10,824/26,900 = 0.40 incidents per peak hour on the freeway at 24 kph (15 mph).
H. 18.5 kph (11.5 mph) should be used to calculate the delay per incident. This will add an average of 515 vehicle hours of nonrecurrent delay per incident over the 2.0 km (1.2 mile) section.
I. 515 vehicle hours per incident multiplied by 0.40 incidents per hour equals 216 vehicle hours of delay per hour.

The improved method results in an additional 75 veh-hours of congestion for the example shown.

Another problem identified with the initial method of estimating the nonrecurrent congestion costs was the assumption that the delay per incident occurred over the entire length of a section of the corridor. This had the result of creating higher delay in a long section over a short section, given the same conditions in both sections. For example, given a demand of 2200 vphpl for a three-lane section, the nonrecurrent delay for the 2.0 km (1.2 mile) section from the example above is 216 vehicle hours, and the nonrecurrent delay for a 8.0 km (5.0 mile) section would be 3749 vehicle hours. Given the same demand and lane conditions, the delay should be proportional to the length.

A better method of calculating the delay per incident was needed that did not have length as a factor. The queuing analysis equations from *Traffic Flow Fundamentals* by Adolf D. May (*10*) are ideal for estimating the delay due to incidents on freeways, given the level of data available with the SPM. To solve for the total delay per incident, only two additional variables are needed for the nonrecurrent congestion cost procedure: the average time of a 'typical' incident and a service flow rate for the duration of a 'typical' incident. A time of 30 minutes was used for the time of an incident. This assumes that an effective incident detection and response system is in place for all alternatives, and it is reflective of the fact that the majority of incidents are simple shoulder disablements (*4*). The service rate is not necessarily equivalent to the reduced capacity due to the speed volume relationship developed to estimate the recurrent congestion. If the initial volume demand to reduced capacity ratio is greater than 1.09, then the service rate is equivalent to the reduced capacity. If the v/c ratio is equal to or less than 0.84, then the service rate is equivalent to the initial demand, and there is no delay. However, for the v/c ratios between these two values, a service rate must be estimated. For instance, the speed volume relationship of the methodology gives a speed of 72 kph (45 mph) for a v/c ratio of one, and the service rate allows an equivalent delay to be estimated. The steps for the improved nonrecurrent congestion cost estimation procedure are listed below:

A. Determine vehicle-distance per hour for sections under analysis.
B. Using Figure 1 and the estimated speeds per section, determine the vehicle-distance per incident.
C. Divide B by A to determine number of incidents per hour.
D. Obtain percent of remaining freeway capacity from Table 1, based on number of lanes.
E. Multiply D x 2200 vphpl to reach a per lane reduced capacity value per incident.
F. Utilize E to arrive at adjusted speeds using the volume to speed relationship.
G. Check Figure 1 to determine whether adjusted speed (G) alters the incident frequency, and iterate (repeat steps B and C if needed).
H. Determine the service rate.
I. Calculate the duration of queue.
J. Calculate the total delay per incident per lane.

K. Multiply the total delay per incident (J) by the number of incidents per hour (C) and the number of lanes to arrive at the delay per hour.

For the example, the improved delay equations result in a nonrecurrent congestion delay for the 2.0 km (1.2 mile) section of 186 vehicle hours and a delay for the 8.0 km (5.0 mile) section of 773 vehicle hours. The additional delay is directly proportional to the lengths of the two sections. The results of the improved procedure are more logical than previous results and should allow for a better comparison of alternatives.

TOLL EFFECTS

TTI worked with NCTCOG to utilize their travel forecast model to establish a relationship between travel demand and price. This relationship is key to developing algorithms that define the effect that toll lanes have on mode of travel and various cost components. The equilibrium relationship for toll effects basically says that the dollar amount of toll collection is equivalent to the dollar amount of the recurrent congestion cost in the adjacent free lanes. In the revised SPM spreadsheet, there are three worksheets which adjust the corridor vehicle volumes for the different combinations of free lanes and toll lanes. The equilibrium equation is shown below:

$$V_T \times (C_T + (D_T/60 \times T_V)) = (V - V_T) \times (D_F/60 \times T_V)$$

V = volume of total vehicle demand

V_T = volume of tolled vehicles

C_T = cost of toll in \$ per unit distance

D_T = delay of tolled vehicles in minutes per unit distance

D_F = delay of free vehicles in minutes per unit distance

T_V = present value of time in \$ per vehicle hour

The first worksheet estimates the toll volume for a corridor which is a fully dedicated tollway. The equilibrium relationship for a full tollway assumes that there are adjacent parallel arterial routes that have a constant delay of 1.86 minutes per km (3.0 minutes per mile). It is assumed that the delay on the adjacent parallel arterial routes is set by signals and does not vary due to volume or incidents.

The second worksheet estimates the tolled volume for a corridor which has a mix of toll lanes and free general purpose lanes. The tolled lanes are assumed to be physically separated from the free lanes and to have more limited access but no occupancy restrictions. These facilities are essentially the same as the express lane facilities from the SPM, the only difference being the toll.

The third worksheet estimates tolled volume for HOT lane corridors. The HOT lane corridors are essentially the same as the HOV corridors, with the exception that the excess capacity of the HOV lanes is "sold" to SOVs. This worksheet assumes a 2+ HOV occupancy. In essence, the model gives first priority to high occupancy vehicles by allowing them to use the HOT lane first, as if it were an HOV-only lane. Single occupant vehicles are only allowed to use excess capacity available in the HOT lane. This approach may tend to overestimate HOV use for a HOT lane because it would not take into account drivers who may decide to pay a toll rather than form a carpool. This project did not develop an option for 3+ HOVs traveling free with all others paying a toll because of limited data from 3+ HOV facilities.

The potential annual revenue from toll lanes is calculated for all three options in the model. However, the effect of toll revenue does not affect the total public cost calculation because it is viewed as both a cost to the driver and a revenue that can be used to offset capital and/or operating costs. The net effect of toll revenue on total public cost was assumed to be zero.

ADDITIONAL FACTORS

The effects of transit, such as light rail transit, in a transportation corridor have not been included in the methodology due to the limited amount of available data. To properly calibrate the model, data from local transportation corridors are desired. The North Central Expressway (US 75) corridor from Dallas to Plano will probably be the best corridor for studying the effects of a light rail transit line adjacent to a freeway; however, North Central Expressway is still under reconstruction, and the light rail line currently only extends through a fraction of the corridor from the CBD to Park Lane. Theoretically, the availability of rail transit adjacent to North Central should limit recurrent congestion on the freeway.

The effects of HOV lanes operating concurrently with mixed-flow lanes and on a circumferential facility are being studied under another task of this project. The amount of data available is too limited to draw any conclusions on the different relationships that may result between congested freeways and concurrent HOV lanes and between HOV lanes and congested circumferential freeways. The Stemmons Freeway (IH35E) concurrent flow HOV lane opened in January of 1997, and the LBJ Freeway (IH635) concurrent flow HOV lanes opened in April of 1997.

Previous research efforts examined costs associated with air quality impacts of different alternatives. The levels of emissions were estimated with emissions factors generated by the NCTCOG using the MOBILE5a model. Many problems have been associated with the MOBILE5a model and this type of application of the emission factors, the primary problem being that the vehicle cycles used in the model are not necessarily similar to the type of driving associated with congested freeway conditions or high speed freeway conditions. Research projects from California and Georgia have been used to improve the MOBILE model. However, the MOBILE6 model is still in development, so the SPM spreadsheet has not been updated with respect to emission factors.

SPREADSHEET FUNCTIONALITY

The original SPM was contained within two Supercalc spreadsheets. The first spreadsheet was the DHV (Design Hour Volume) spreadsheet. With this sheet, each alternative for a corridor was run separately simply by changing the number of general purpose, express, and HOV lanes. The rest of the input data was the same for each alternative of a particular corridor and remained unchanged with the exception of 3+ HOV alternatives. Occupancy rates and HOV volumes were changed for 3+ HOV alternatives, though the same congestion relationship was used to generate the 3+ HOV demands. The output for each alternative was then manually input into a single cost spreadsheet for each corridor. The cost spreadsheet estimated the construction cost, the right-of-way cost, the operation and maintenance cost, the peak hour congestion cost, and the total congestion cost to arrive at the total public cost.

Subsequent research projects modified the spreadsheets and switched them to a Quattro Pro format. The functionality of the spreadsheets remained largely the same. However, the addition of the environmental and nonrecurrent congestion costs to the cost spreadsheet did not allow all the alternatives for a particular corridor to run in a single spreadsheet. Depending on the number of sections in the corridor, only three or four alternatives could be run at a time. With the 1451 project, the name of the DHV spreadsheet was changed to the CLV (Critical Lane Volume) spreadsheet.

The large cost spreadsheets had become unwieldy and difficult to use, which was the primary incentive to combine the CLV spreadsheet with the cost spreadsheet. The combined result is a more concise and simpler spreadsheet, though each alternative is now run separately. The combined spreadsheet was prepared as an Excel spreadsheet. The new spreadsheet has several features to make it user-friendly and to allow for a more consistent comparison of various alternatives. All the input data and output data are contained on separate worksheets and can be printed on single sheets of paper. Each major function of the spreadsheet is contained on separate worksheets and, for most analyses, should not require any changes. Similar to the original DHV sheet, once all the input data is in place, the only changes needed for each alternative in a corridor is the number and combination of lanes. The new spreadsheet also calculates the costs for both directions of a corridor, as well as impacts beyond the shoulder hours. The details of the spreadsheet are discussed more completely in the user's manual contained in Appendix C.

IV. TESTING THE REVISED METHODOLOGY

IDENTIFICATION OF TEST CORRIDORS

Researchers identified five corridors to test the revised SPM. The corridors shown in Table 2 were chosen because they are all expected to be relatively high volume traffic corridors in the future, and they represent a mix of facility types (e.g., radial versus circumferential, existing versus new facility). This section will report on the effect of including nonrecurrent congestion costs in the methodology and whether the recommendations in the original SPM (using year 2015 volumes) might have been different if those costs had been considered. It will also compare results from the revised SPM with toll options against recommendations from the NCTCOG Mobility 2020 report (using year 2020 volumes).

Table 2. Test Corridors

Corridor	Original SPM Recommendation	Mobility 2020 Recommendation
I-30 (SH 360 to I-35E)	GP/HOV	GP/HOV
I-30 (I-45 to Belt Line)	GP/HOV	GP/HOV
I-635 (SH 121 to US 75)	GP/HOV	GP/HOV/Toll
I-635 (US 75 to I-20)	GP/HOV	GP/HOV
SH 161 (IH 635 to I-20)	GP/HOV	GP/HOV/Toll

GP=General purpose freeway lanes / HOV=High occupancy vehicle lanes / Toll=Toll lanes

COMPARISON WITH ORIGINAL SPM RECOMMENDATIONS

The tabulated results compare the lowest public cost from the original SPM from 1992 to the current expanded methodology for the five selected corridors. In addition to nonrecurrent congestion costs, the expanded methodology includes energy and environmental costs, full construction costs, costs for peak period, off-peak direction traffic, as well as improvements to the HOV ridership estimation procedure, right-of-way costs, and recurrent congestion costs. The shaded cells in Tables 3 through 7 show the preferred alternatives for the original and revised methodologies. The addition of nonrecurrent congestion costs was not responsible for changing the lowest cost alternative in any of the five corridors. Three of the corridors showed no change at all, while the other two had a change in the number of general purpose lanes because of other modifications to the SPM process since its original implementation.

In general, the alternatives that had the highest total public cost with the original SPM methodology remain the most expensive, with the addition of nonrecurrent congestion costs. As can be expected, the alternatives with higher capital costs will have low recurrent congestion cost, and the nonrecurrent congestion cost for these alternatives will also be low. With the addition of nonrecurrent congestion cost, there is less of a balance between capital and congestion costs for most alternatives, i.e., the amount of congestion (sum of recurrent and nonrecurrent) becomes a more important factor in determining the alternative with the lowest public cost.

These results confirm the findings in the original SPM that there is a significant cost benefit in high volume corridors for alternatives that allow some congestion on general purpose lanes and provide HOV lanes to encourage a mode shift to carpools or transit. The addition of nonrecurrent costs which increase with congestion are not sufficient to argue for a policy shift away from HOV lanes.

Table 3. Testing the Effect of Nonrecurrent Congestion Interstate 30 from SH 360 to IH35E (in millions of $)

Alternative[1]	Original Public Cost[2]	Expanded Public Cost[3]	Nonrecurrent Congestion Cost[4]
1. GP: 6, 6, 6, 6, 6 (Existing / No Action)	$90.2	$371.2	$214.8
2. GP: 10, 10, 8, 8, 8 HOV: 1 lane reversible/at-grade (Proposed TxDOT)	$67.8	$111.2	$39.4
3. GP: 18, 16, 14, 16, 10 (All General Purpose)	$34.0	$71.9	$0.8
4. GP: 12, 10, 8, 8, 8 HOV: 1, 1, 1, 1 reversible/at-grade (NCTCOG Mobility 2010 Plan)[5]	$62.6	$97.9	$29.9
5. GP: 12, 10, 10, 10, 10 EXP: 3, 3, 2, 2 reversible/elevated	$27.9	$64.4	$1.2
6. GP: 12, 10, 10, 10, 8 EXP: 3, 2, 2, 2 reversible/elevated	$26.9	$63.4	$2.4
7. GP: 12, 10, 10, 8, 8 HOV: 2, 2, 2, 2 reversible/at-grade	$23.4	$58.5	$2.2
8. GP: 10, 10, 10, 8, 8 HOV: 2, 2, 2, 2 reversible/at-grade	$24.8	$58.7	$3.3
9. GP: 12, 10, 8, 8, 8 HOV: 2, 2, 2, 2 reversible/at-grade (NCTCOG Mobility 2010 Plan)[5]	$22.4	$56.9	$2.4

[1] GP=general purpose lanes; HOV=high occupancy vehicle lanes; EXP=express lanes with limited access; This facility is divided into five sections. If the number of lanes varies for a particular facility type, then the number of lanes is listed for each section from west to east.
[2]This is the public cost reported in the original System Plan Report. (*1*)
[3]This is the expanded public cost based on extensions of the methodology in two other research projects (*2,3*) and this project.
[4]This is the nonrecurrent congestion cost developed in this project and included in the expanded public cost.
[5]Alternatives #4 and #9 are both identified as a part of the NCTCOG Mobility 2010 Plan because the plan did not specify the number or operation of HOV lanes.

Table 4. Testing the Effect of Nonrecurrent Congestion
Interstate 30 from the Dallas CBD to Belt Line Road (in millions of $)

Alternative[1]	Original Public Cost	Expanded Public Cost	Non-recurrent Congestion Cost
1. GP: 10, 8, 8, 8, 6, 8 (Existing / No Action)	$58.2	$200.9	$116.6
2. GP: 10, 10, 10, 10, 6, 8 (TSM)	$53.1	$177.0	$99.6
3. GP: 18, 18, 18, 14, 10, 10 (All General Purpose)	$17.8	$58.4	$0.5
4. GP: 10, 10, 10, 10, 6, 8 EXP: 4, 4, 4, 4, 4 elevated HOV: 1, 1, 1, 1, 1 reversible/at-grade (NCTCOG Mobility 2010 Plan)	$23.1	$58.3	$1.0
5. GP: 12, 12, 12, 10, 6, 8 EXP: 2, 2, 2, 2, 2 reversible/at-grade	$15.7	$47.1	$1.7
6. GP: 10, 10, 10, 10, 6, 8 EXP: 3, 3, 3, 2, 2 reversible/at-grade	$14.8	$46.4	$1.9
7. GP: 10, 8, 8, 8, 6, 8 HOV: 2, 2, 2, 2, 1 reversible/at-grade	$8.5	**$39.0**	$1.5
8. GP: 10, 10, 8, 8, 6, 8 HOV: 2, 2, 2, 2, 1 reversible/at-grade	$8.9	$39.8	$1.5
9. GP: 10, 10, 10, 8, 6, 8 HOV: 2, 2, 2, 2, 1 reversible/at-grade	**$8.3**	$40.6	$1.2
10. GP: 10, 10, 10, 10, 6, 8 HOV: 2, 2, 2, 2, 1 reversible/at-grade	$18.0	$42.7	$1.0

[1] GP=general purpose lanes; HOV=high occupancy vehicle lanes; EXP=express lanes with limited access; This facility is divided into six sections. If the number of lanes varies for a particular facility type, then the number of lanes is listed for each section from west to east.

Table 5. Testing the Effect of Nonrecurrent Congestion
Interstate 635 from Royal Lane to US 75 (in millions of $)

Alternative[1]	Original Public Cost	Expanded Public Cost	Non-recurrent Congestion Cost
1. GP: 4, 6, 8, 8 (Existing / No Action)	$130.6	$492.9	$293.2
2. GP: 6, 10, 10, 10 EXP: 0,0,4,4 elevated HOV: 0, 1, 2, 2 at-grade (NCTCOG Mobility 2010 Plan)	$47.9	$96.4	$8.1
3. GP: 4, 12, 18, 18 (All General Purpose)	$42.3	$88.3	$2.1
4. GP: 4, 10, 12, 14 EXP: 0, 0, 4, 4 elevated	$41.0	$86.2	$4.1
5. GP: 4, 10, 12, 12 EXP: 0, 0, 4, 6 elevated	$40.9	$86.2	$4.0
6. GP: 4, 10, 10, 10 HOV: 0, 1, 4, 4 elevated	$35.9	$85.1	$11.1
7. GP: 4, 10, 10, 12 HOV: 0, 1, 4, 4 elevated	$31.2	$84.3	$8.3
8. GP: 4, 10, 10, 10 HOV: 0, 1, 4, 6 elevated	$32.6	$86.0	$10.0

[1] GP=general purpose lanes; HOV=high occupancy vehicle lanes; EXP=express lanes with limited access; This facility is divided into four sections. If the number of lanes varies for a particular facility type, then the number of lanes is listed for each section from west to east.

Table 6. Testing the Effect of Nonrecurrent Congestion Interstate 635 from US 75 to IH20 (in millions of $)

Alternative[1]	Original Public Cost	Expanded Public Cost	Non-recurrent Congestion Cost
1. GP: 8, 8, 8, 8, 8 (Existing / No Action)	$48.7	$197.0	$96.3
2. GP: 10, 10, 10, 10, 10 HOV: 2, 2, 2 reversible/at-grade (Proposed TxDOT)	$17.8	$86.0	$2.2
3. GP: 10, 10, 10, 10, 8 HOV: 1, 1, 1 reversible/at-grade (NCTCOG Mobility 2010 Plan)	$15.9	$83.4	$8.1
4. GP: 14, 12, 14, 10, 10 (All General Purpose)	$22.5	$86.8	$0.8
5. GP: 10, 8, 8, 10, 8 EXP: 2, 2, 2 reversible/at-grade	$11.2	$78.0	$5.4
6. GP: 10, 10, 10, 10, 8 EXP: 2, 2, 2 reversible/at-grade	$12.8	$80.5	$4.5
7. GP 8, 8, 8, 8, 8 HOV: 2, 1, 1 reversible/at-grade	$15.7	$80.4	$11.1
8. GP: 8, 8, 8, 8, 8 HOV: 2, 2, 2 reversible/at-grade	$13.6	$80.0	$10.5
9. GP: 10, 8, 8, 8, 8 HOV: 2, 2, 2 reversible/at-grade	$10.8	$72.2	$3.5
10. GP: 10, 10, 10, 10, 10 HOV: 2, 1, 1 reversible/at-grade (NCTCOG Mobility 2010 Plan)	$11.3	$76.6	$3.3
11. GP: 10, 10, 10, 10, 10 HOV: 2, 2, 2 reversible/at-grade	$12.2	$78.4	$2.9
12. GP 10, 10, 10, 10, 10 HOV: 1, 1, 1 reversible/at-grade	$15.8	$83.4	$8.1

[1] GP=general purpose lanes; HOV=high occupancy vehicle lanes; EXP=express lanes with limited access; This facility is divided into five sections. If the number of lanes varies for a particular facility type, then the number of lanes is listed for each section from west to east.

Table 7. Testing the Effect of Nonrecurrent Congestion
State Highway 161 from IH20 to IH635 (in millions of $)

Alternative[1]	Original Public Cost	Expanded Public Cost	Non-recurrent Congestion Cost
1. GP: 4, 8, 8, 8 (Proposed TxDOT)	$75.7	$119.6	$43.4
2. GP: 4, 8, 8, 10 HOV: 0,1,11 reversible/at-grade (NCTCOG Mobility 2010 Plan)	$48.9	$64.1	$1.9
3. GP: 4, 8, 8, 10 HOV: 0,2,2,2 reversible/at-grade (NCTCOG Mobility 2010 Plan)	$45.9	$65.2	$0.8
4. GP: 4, 12, 14, 16 (All General Purpose)	$50.5	$69.7	$0.3
5. GP: 4, 6, 8, 10 EXP: 0, 2, 2, 2 reversible/at-grade	$43.7	**$61.5**	$2.0
6. GP: 4, 6, 8, 10 EXP: 0, 2, 2, 2 reversible/elevated	$44.2	$61.8	$2.0
7. GP: 4, 6, 6, 8 HOV: 0, 2, 2, 2 reversible/at-grade	$42.0	$72.8	$11.8
8. GP: 4, 6, 6, 8 HOV: 0, 2, 2, 2 reversible/elevated	$42.1	$72.9	$11.8
9. GP: 4, 6, 8, 8 HOV: 0, 2, 2, 2 reversible/at-grade	$40.4	$65.2	$5.5
10. GP: 4, 6, 8, 8 HOV: 0, 2, 2, 2 reversible/elevated	**$40.8**	$65.4	$5.5

[1] GP=general purpose lanes; HOV=high occupancy vehicle lanes; EXP=express lanes with limited access; This facility is divided into four sections. If the number of lanes varies for a particular facility type, then the number of lanes is listed for each section from south to north.

PERFORMANCE OF TOLL LANE ALTERNATIVES

This section describes the performance of toll lane alternatives for the IH 30 corridor between SH 360 and IH 35E, west of downtown Dallas. The first option considered is an "all toll lane" alternative that would provide 10 to 12 lanes in this section. Table 8 compares this alternative with an all general purpose alternative and a combination of general purpose and HOT lanes.

Table 8. All Toll Lanes: Interstate 30 from SH 360 to IH35E

Alternative	Total Lanes	Peak Hour Occupancy	Congestion Cost (mil$)	Total Cost (mil$)
All Toll Lanes	10-12	1.24	$21.7	$75.2
All General Purpose Lanes	12-16	1.24	$0.6	$70.6
Combination General Purpose and HOT Lanes	8-10	1.45	$2.0	$54.1

Table 8 illustrates the following key points about "all toll lane" alternatives:

- "All toll lane" alternatives require fewer lanes than options with all free lanes because the tolls divert traffic to adjacent arterial routes. However, facilities with combinations of general purpose and HOT/HOV will generally require even fewer total lanes than one with all toll lanes.

- The "all toll lane" does not provide any mode shift to carpools or transit and generally results in higher congestion costs and total costs than other alternatives.

- This toll alternative will generate the highest revenue, but this is not an advantage within the context of the SPM because tolls are not counted in the calculation of total public cost.

The next toll lane alternative combines general purpose lanes with toll lanes. Table 9 summarizes the results of this analysis.

Table 9. General Purpose and Toll Lanes: Interstate 30 from SH 360 to IH35E

Alternative	Peak Hour Occupancy	Congestion Cost (mil$)	Total Cost (mil$)
Combination General Purpose and Toll Lanes	1.24	$7.8	$66.5
Combination General Purpose and HOV Lanes	1.45	$2.1	$54.2
Combination General Purpose and HOT Lanes	1.45	$2.1	$54.1

This table illustrates the following key points about combined general purpose lanes and toll lanes:

- Like the "all toll lane" alternative, this one provides no incentive for drivers to shift modes from single occupant vehicles to carpools or transit.
- Since the toll lanes operate below capacity (because of the price) and do not encourage higher occupancies, the general purpose lanes operate at higher levels of congestion. Consequently, this toll alternative will have higher congestion costs and total costs than alternatives with a combination of general purpose and HOV/HOT lanes.
- Toll revenue is only about 10 percent of the "all toll lane" alternative.

The last toll alternative involves a combination of general purpose lanes and HOT lanes. Table 10 shows the results of this analysis.

Table 10. General Purpose and HOT Lanes: Interstate 30 from SH 360 to IH35E

Alternative	General Purpose Lanes	HOV/ HOT Lanes	Congestion Cost (mil$)	Total Cost (mil$)
Combination General Purpose and HOV Lanes	8	1-2	$2.1	$54.2
Combination General Purpose and HOT Lanes	8	1-2	$2.1	$54.1
Combination General Purpose / New Lanes HOT	6	2-4	$2.5	$52.5

This table illustrates the following key points about combined general purpose lanes and HOT lanes:

- The HOT lane combination is very competitive with HOV options in congested corridors. Depending on the level of excess capacity in an HOV-only lane that is available to "sell" in the form of a toll, an HOT lane option should perform better than a comparable HOV alternative because it draws additional drivers out of the general purpose lanes and, therefore, decreases their congestion level.

- Building all "new" lanes as HOT lanes (no new general purpose lanes) may be best, but this will add congestion to the existing general purpose lanes. Adding some of the HOT lanes as reversible lanes helps offset this penalty with lower capital costs.

- Revenues are only about one percent of the "all toll lane" option.

COMPARISON WITH MOBILITY 2020 RECOMMENDATIONS

The regional transportation plan for the Dallas/Ft. Worth area was completed in late 1996 by the NCTCOG and is called the "Mobility 2020 Plan." The last step in this project was to use the revised System Planning Methodology to evaluate the five test corridors using year 2020 traffic volumes and compare the results of this analysis with the recommendation contained in the Mobility 2020 Plan.

Tables 11 through 15 summarize the results of this analysis for each of the five corridors -- the lowest cost alternative and the Mobility 2020 recommendation are highlighted in each table.

The Mobility 2020 recommendations performed well in four out of five corridors; although none of its recommendations was the lowest total cost alternative. Only the SH 161 recommendation that included use of toll lanes in the northern segments was significantly higher, more than double, the lowest total cost alternative. The SPM generally preferred alternatives that included HOT lanes, with HOV combinations only slightly more costly. In some cases, the number of general purpose lanes needed was reduced under the SPM recommendation. The results of the SPM in these corridors would be helpful in refining plans for these corridors. Naturally, many other factors would come into play that might make a higher cost alternative the "best" one in a particular case.

Table 11. Application of Revised System Planning Methodology Interstate 30 from SH 360 to IH35E (in millions of $)

Alternative[1]	Total Public Cost
1. GP: 6, 6, 6, 6, 6 (Existing / No Action)	$356.0
2. GP: 16, 14, 14, 14, 12 (All General Purpose)	$70.6
3. GP: 10, 10, 8, 8, 8 HOV: 2, 2, 2, 2, 1 reversible/at-grade (NCTCOG Mobility 2020 Plan)	**$58.3**
4. GP: 10, 8, 8, 8, 6 EXP: 2, 2 reversible/at-grade 2, 3, 2 reversible/elevated (General Purpose & Express)	$62.2
5. GP: 10, 8, 8, 8, 6 TOLL: 2, 2 reversible/at-grade 2, 3, 2 reversible/elevated (General Purpose & Toll)	$66.5
6. GP: 8, 8, 8, 8, 8 HOV: 2, 2, 2, 2, 1 reversible/at-grade (General Purpose & HOV)	$54.2
7. GP: 8, 8, 8, 8, 6 HOT: 2, 2, 2, 2, 2 reversible/at-grade (General Purpose & HOT)	**$54.1**

[1] GP=general purpose lanes; HOV=high occupancy vehicle lanes; EXP=express lanes with limited access; TOLL=toll lanes; HOT=high occupancy/toll lanes. This facility is divided into five sections. If the number of lanes varies for a particular facility type, then the number of lanes is listed for each section from west to east.

Table 12. Application of Revised System Planning Methodology Interstate 30 from Dallas CBD to Belt Line Road (in millions of $)

Alternative[1]	Total Public Cost
1. GP: 10, 8, 8, 8, 6, 8 (Existing / No Action)	$364.1
2. GP: 18, 18, 18, 18, 14, 16 (All General Purpose)	$83.1
3. GP: 10, 10, 10, 10, 8, 8 HOV: 2, 2, 2, 2 reversible/elevated, 2, 2 reversible/at grade (NCTCOG Mobility 2020 Plan)	**$71.6**
4. GP: 10, 10, 10, 10, 8, 8 EXP: 3, 3, 3, 3 reversible/elevated, 2, 2 reversible/at grade (General Purpose & Express)	$75.21
5. GP: 10, 10, 10, 10, 8, 8 TOLL: 3, 3, 3, 3 reversible/elevated, 2, 3 reversible/at grade (General Purpose & Toll)	$78.75
6. GP: 10. 10, 10, 10, 8, 8 HOT: 3, 3, 3, 3 reversible/elevated, 2, 3 reversible/at grade (General Purpose & HOT)	**$67.1**

[1] GP=general purpose lanes; HOV=high occupancy vehicle lanes; EXP=express lanes with limited access; TOLL=toll lanes; HOT=high occupancy/toll lanes. This facility is divided into six sections. If the number of lanes varies for a particular facility type, then the number of lanes is listed for each section from west to east.

Table 13. Application of Revised System Planning Methodology Interstate 635 from Royal Lane to US 75 (in millions of $)

Alternative[1]	Total Public Cost
1. GP: 4, 10, 8, 8 (Existing / No Action)	$562.5
2. GP: 8, 14, 14, 16 (All General Purpose)	$98.9
3. GP: 6, 10, 8, 8 HOV: 0, 2, 0, 0 bi-directional/at-grade HOT: 0, 0, 6, 6 bi-directional/at-grade (NCTCOG Mobility 2020 Plan)	**$89.9**
4. GP: 6, 10, 10, 10 EXP: 2, 2 reversible/at-grade, 4, 4 bi-directional/elevated (General Purpose & Express)	$100.8
5. GP: 6, 10, 10, 10 TOLL: 2, 2 reversible/at-grade, 4, 4 bi-directional/elevated (General Purpose & Toll)	$106.9
6. GP: 6, 10, 8, 8 HOV: 1, 1 reversible/at-grade, 4, 4 bi-directional/elevated (General Purpose & HOV)	**$86.4**
7. GP: 6, 8, 8, 8 HOT: 1, 2 reversible/at-grade, 4, 6 bi-directional/elevated (General Purpose & HOT)	$86.6

[1] GP=general purpose lanes; HOV=high occupancy vehicle lanes; EXP=express lanes with limited access; TOLL=toll lanes; HOT=high occupancy/toll lanes. This facility is divided into four sections. If the number of lanes varies for a particular facility type, then the number of lanes is listed for each section from west to east.

Table 14. Application of Revised System Planning Methodology
Interstate 635 from US 75 to IH20 (in millions of $)

Alternative[1]	Total Public Cost
1. GP: 8, 8, 8, 8, 8 (Existing / No Action)	$368.6
2. GP: 14, 16, 16, 12, 12 (All General Purpose)	$117.8
3. GP: 10, 10, 10, 10, 8 HOV: 4 bi-directional/at-grade, 2, 2 reversible/at-grade (NCTCOG Mobility 2020 Plan)	**$101.8**
4. GP: 10, 10, 10, 10, 10 EXP: 4 bi-directional/at-grade, 2, 2, 2 reversible/at-grade (General Purpose & Express)	$110.1
5. GP: 10, 10, 10, 10, 10 TOLL: 4 bi-directional/at-grade, 2, 2, 2 reversible/at-grade (General Purpose & Toll)	$113.4
6. GP: 8, 8, 8, 8, 8 HOV: 4 bi-directional/at grade, 2 reversible/at-grade, 3 bi-directional/at-grade (General Purpose & HOV)	$94.7
7. GP: 8, 8, 8, 8, 8 HOT: 4 bi-directional/at-grade, 2, 2 reversible/at-grade (General Purpose & HOT)	**$93.6**

[1] GP=general purpose lanes; HOV=high occupancy vehicle lanes; EXP=express lanes with limited access; TOLL=toll lanes; HOT=high occupancy/toll lanes. This facility is divided into five sections. If the number of lanes varies for a particular facility type, then the number of lanes is listed for each section from west to east.

Table 15. Application of Revised System Planning Methodology State Highway 161 from IH20 to IH635 (in millions of $)

Alternative[1]	Total Public Cost
1. GP: 4, 8, 8, 8, 8 (Proposed TxDOT)	$144.2
2. GP: 8, 10, 10, 12, 14 (All General Purpose)	$74.3
3. GP: 4, 6, 0, 0, 0 TOLL: 0, 0, 6, 8, 8 HOV: 0, 0, 2, 2, 2 bi-directional/at-grade (NCTCOG Mobility 2020 Plan)	**$151.9**
4. GP: 4, 6, 8, 8, 8 EXP: 2, 2, 2, 2 reversible/at-grade, 4 bi-directional/at-grade (General Purpose & Express)	$69.1
5. GP: 4, 6, 6, 8, 8 TOLL: 2, 2 reversible/at-grade 4, 4, 4 bi-directional/at-grade (General Purpose & Toll)	$75.4
6. GP: 4, 6, 6, 8, 8 HOV: 1, 1 reversible/at-grade, 2, 2, 2 bi-directional/at-grade (General Purpose & HOV)	$64.0
7. GP: 4, 6, 6, 6, 6 HOT: 1, 2 reversible/at-grade, 3, 4, 4 bi-directional/at-grade (General Purpose & HOT)	**$63.2**

[1] GP=general purpose lanes; HOV=high occupancy vehicle lanes; EXP=express lanes with limited access; TOLL=toll lanes; HOT=high occupancy/toll lanes. This facility is divided into four sections. If the number of lanes varies for a particular facility type, then the number of lanes is listed for each section from south to north.

V. RECOMMENDATIONS/CONCLUSIONS

RESULTS OF INCLUDING NONRECURRENT COSTS AND TOLL LANES

This research has extended the SPM by correcting some problems associated with the spreadsheet's handling of nonrecurrent congestion costs and adding the option of examining toll lanes in the mix of alternative cross sections for a corridor. Application of the SPM prior to this study had concluded that, in practice, the outcomes of corridor analysis depended largely on travel demand. For example (*1*):

1) Corridors with low demand can typically be served by the existing design or by the existing design with some capacity improvements to the general purpose lanes.

2) Corridors with moderate demand can typically be served by the existing design (sometimes with capacity improvements to the general purpose lanes) and additional express lanes to serve the long distance trips.

3) Corridors with high demand are best served by the existing design with some capacity improvements to the general purpose lanes and an HOV facility. If a travel time advantage over the general purpose lanes is created for HOVs, an HOV lane will reduce the total number of vehicle trips in the corridor because of the mode shift to high occupancy vehicles.

The results of this project do not alter the initial findings as described under (1) and (2) above for low and moderate demand facilities.

It was thought that the introduction of nonrecurrent costs might cause the addition of general purpose lanes to become the preferred alternative for high demand corridors, but results from the test corridors showed that HOV lanes continue to be part of the best solution. It is generally believed that more than half of total freeway congestion in urban areas is the result of nonrecurrent congestion (*2*)

.The estimation of nonrecurrent congestion costs, as implemented by this project is showing nonrecurrent congestion levels ranging from 1.5 to 5 times the level of recurrent congestion. While these levels may be somewhat high, corridors that have multiple, barrier-separated facilities may be subject to greater congestion impacts from incidents. The absolute value of recurrent congestion estimated by the model could be modified by altering some of the assumptions regarding time required to remove an incident or the capacity reduction assumed per incident. For the purposes of this project, it was assumed that higher levels of nonrecurrent congestion indicated a conservative approach since the additional costs did not alter recommendations in the test corridors. It should also be noted that the high estimated costs associated with nonrecurrent congestion may suggest that the effect of incidents on traffic flow could be greater than generally assumed. This would support continued efforts to provide effective incident detection and response programs in heavily congested areas.

The evaluation of toll lanes in the test corridors showed that congested corridors with all toll lane or general purpose/toll lane combinations did not perform as well as alternatives that included a combination of general purpose and HOV lanes based on the lowest total public cost criteria. However, alternatives that combined general purpose lanes with HOT lanes tended to perform as well as and slightly better, in some cases, than HOV lanes. This is understandable since the model simply allows excess capacity in the HOV lanes (not used by HOVs) to be absorbed by SOVs willing to pay a toll. Congestion costs in the general purpose lanes are reduced somewhat, depending on the amount of capacity available in the HOV lanes and the number of SOVs who are willing to pay the toll. In general, the SPM suggests that any lanes added to an existing, high demand facility should be either HOT or HOV lanes. This recommendation must be tempered by the fact that HOT lanes represent a new approach to serving travel demand, and there are many public policy, implementation, and operations issues that need to be examined before HOT lanes can be given an unqualified endorsement.

From a revenue producing standpoint, an all toll facility will generate the highest level of toll revenue, followed by general purpose/toll lane combinations, and general purpose/HOT lane combinations, respectively. This study clearly shows that HOT lanes (permitting 2+ HOV to ride free) should not be viewed as a major source of revenue to help pay for the construction or reconstruction of a facility. Revenue estimates indicate that a HOT lane will produce less than one percent of the revenue that an all toll lane facility would produce, depending on the amount of excess capacity that is available for single occupant vehicles in the HOT lane.

APPLICATION IN TRANSPORTATION PLANNING PROCESS

The original application of the SPM was done in conjunction with the NCTCOG Mobility 2010 Update completed in 1992. The results from the System Plan were used as an input to the decision making process for that study. The System Plan was not updated for use with the recently completed NCTCOG Mobility 2020 Plan largely because of the tight schedule followed by the MPO in developing alternative networks and design year forecasts, and seeking approval of a recommended plan. Discussions with representatives of the NCTCOG and TxDOT Dallas District during the course of this project point toward the application of the SPM as a tool in analyzing projects during their feasibility studies, i.e., major investment studies and corridor studies. This has several advantages, including:

1) time to develop input data to a greater level of detail and test the sensitivity of the model to variations in the inputs;

2) MISs and corridor studies are part of TxDOT's feasibility phase of project development and are requiring higher levels of public involvement -- they provide a link between macro-level regional transportation planning and micro-level schematic design; and

3) results from these studies can be used as an input into the regional transportation plan that must be updated every three years.

FUTURE ENHANCEMENT TO THE SYSTEM PLANNING METHODOLOGY

HOT lanes are receiving a lot of attention around the country as a facility option that can increase person movement through its high occupancy component and revenue through its toll component. The current project has not attempted to evaluate every way that HOT lanes could be implemented. In particular, options that involve 3+ carpools riding free and single occupant vehicles and/or 2+ carpools paying a toll has not been examined because there is limited information available about factors that affect the formation of 3+ carpools. The SR91 project in Los Angeles is the first operating HOT lane that allows 3+ carpools to drive free while all other vehicles pay a toll. Data from this project should be available in the coming months and may provide the basis for a new research project that would extend the SPM so that it can effectively evaluate additional HOT lane options.

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APPENDIX A
OUTPUT COMPARING REVISED SPM WITH ORIGINAL SPM

System Plan Corridor Critical Lane Volume and Public Cost Analysis Output

System of Units: US

17-Jul-97

Corridor: Interstate 30 West **Design Year:** 2015

Alternative: 9 Mobility Plan 2

Freeway Section:	1	2	3	4	5	6	7	8	
Section Limits:	360 - 161	161 - Lp12	Lp12-Ham.	Ham.-Trin.	Trin.-IH35E	0	0	0	
Length (Miles)									
Length At-Grade	1.75	6.39	2.95	1.9	0	0	0	0	
Length Elevated	0.2	0.31	0.26	0.34	0.34	0	0	0	
Traffic Inputs:									
Freeway ADT	311,172	232,989	211,950	237,453	139,375	0	0	0	
HOV ADT	13,186	10,847	9,621	8,582	2,253	0	0	0	
AD Transit Riders	0	1,421	2,898	4,098	4,098	0	0	0	
Freeway K	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	
Freeway D	0.60	0.65	0.65	0.65	0.65	0.57	0.57	0.57	
Carpool Occupancy	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	
GP Occupancy	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	
Lane Inputs:									
Existing Lanes	6	6	6	6	6	0	0	0	
Proposed Lanes:									
General Purpose Free	12	10	8	8	8	0	0	0	
General Purpose Toll	0	0	0	0	0	0	0	0	
Express Reversible	0	0	0	0	0	0	0	0	
Express Bi-directional	0	0	0	0	0	0	0	0	
Toll Reversible	0	0	0	0	0	0	0	0	
Toll Bi-directional	0	0	0	0	0	0	0	0	
HOV Reversible	2	2	2	2	0	0	0	0	
HOV Bi-directional	0	0	0	0	0	0	0	0	
HOT Reversible	0	0	0	0	0	0	0	0	
HOT Bi-directional	0	0	0	0	0	0	0	0	
Peak Hour Peak Direction Volume per Lane:									
General Purpose	1,763	1,530	1,644	2,000	1,638	0	0	0	
Express/Toll	0	0	0	0	0	0	0	0	
HOV/HOT	2,000	2,000	1,909	1,700	0	0	0	0	
Transit Riders (Persons)	0	528	1,077	1,523	1,523	0	0	0	
Occupancy	1.64	1.70	1.76	1.71	1.58	0.00	0.00	0.00	
Veh Distance of Travel	28,423	78,069	33,360	25,537	2,228	0	0	0	
Peak Hour Off Peak Direction Volume per Lane:									
General Purpose	1,763	1,386	1,576	1,766	1,037	0	0	0	
Express/Toll	0	0	0	0	0	0	0	0	
HOV/HOT	0	0	0	0	0	0	0	0	
Transit Riders (Persons)	0	0	0	0	0	0	0	0	
Occupancy	1.05	1.05	1.05	1.05	1.05	0.00	0.00	0.00	
Veh Distance of Travel	20,631	46,441	20,241	15,824	1,410	0	0	0	
Costs ($Million):									**Subtotals**
Construction Cost	$4.87	$14.20	$5.83	$4.18	$0.62	$0.00	$0.00	$0.00	$29.71
Right of Way Cost	$0.66	$2.26	$0.54	$0.38	$0.00	$0.00	$0.00	$0.00	$3.84
Operations Cost	$0.35	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.35
Pk Hr Recrnt Congstn Cost	$0.07	$0.24	$0.04	$0.09	$0.00	$0.00	$0.00	$0.00	$0.44
Recrnt Congstn Cost	$0.07	$0.24	$0.04	$0.09	$0.00	$0.00	$0.00	$0.00	$0.44
Subtotal Costs									$34.78
Nonrecrnt Congstn Cost	$0.44	$1.23	$0.39	$0.33	$0.00	$0.00	$0.00	$0.00	$2.39
Emissions Cost	$2.58	$6.36	$2.73	$2.11	$0.21	$0.00	$0.00	$0.00	$13.98
Fuel Consumption Cost	$1.14	$2.79	$1.19	$0.94	$0.09	$0.00	$0.00	$0.00	$6.17
Total Costs ($M)	$10.11	$27.09	$10.73	$8.03	$0.93	$0.00	$0.00	$0.00	$56.88

ALTERNATIVE	SECTION	LENGTH (MI) A-G	LENGTH (MI) ELEV	EXIST LANES	PROPOSED LANES GEN PUR	PROPOSED LANES EXPRESS AG	PROPOSED LANES EXPRESS ELEV	PROPOSED LANES HOV AG	PROPOSED LANES HOV ELEV	CRITICAL LANE VOL GEN.PUR.	CRITICAL LANE VOL EXP	CRITICAL LANE VOL HOV	TRANSIT RIDERSHIP (PERSONS)	CONSTR COST ($ M)	R.O.W. COST ($ M)	O&M COSTS ($ M)	PK HOUR GEN-PURP CONGEST COST ($ M)	TOTAL GEN-PURP CONGEST COST ($ M)	TRANSIT CONGEST COST ($M)	TOTAL COST ($ M)
9 Mobility	360-161	1.75	.20	6	12	0	0	2	0	2052	0	2000	0	$3.0	$.4	$.4	$.9	$.9	$.0	$4.6
Plan 2	161-LP12	6.39	.31	6	10	0	0	2	0	2062	0	1626	425	$7.7	$1.4	$.0	$2.0	$2.0	$.0	$11.0
Gen. Purp.	LP12-HAMP	2.95	.26	6	8	0	0	2	0	2031	0	1723	925	$2.7	$.3	$.0	$.7	$.7	$.0	$3.8
& HOV 2+	HAMP-TRIN	1.90	.34	6	8	0	0	2	0	2059	0	1885	1441	$2.0	$.2	$.0	$.6	$.6	$.0	$2.8
	TRIN-135E	.00	.34	6	8	0	0	0	0	1770	0	0	1441	$.2	$.0	$.0	$.0	$.0	$.0	$.2
		14.44											SUBTOTAL	$15.6	$2.3	$.4	$4.2	$4.2	$.0	$22.4
															$18.2			$4.2		

I-30 from SH 360 to I-35E

System Plan Corridor Critical Lane Volume and Public Cost Analysis Output

System of Units: US

18-Jul-97

Corridor: Interstate 30 ERLT **Design Year:** 2015

Alternative: 7 GP & HOV 2+

Freeway Section:	1	2	3	4	5	6	7	8
Section Limits:	CBD-Peak.	Peak.-Grn	Grn.-Ferg.	Ferg-US80	US80-LBJ	LBJ-Bltl.	0	0
Length (Miles)								
Length At-Grade	0	1.3	1	2.6	3.4	2.5	0	0
Length Elevated	1	0	0.5	0	0	0	0	0
Traffic Inputs:								
Freeway ADT	259,464	252,397	250,299	216,514	143,754	131,277	0	0
HOV ADT	9,527	9,527	9,527	6,132	5,636	3,693	0	0
AD Transit Riders	11,575	11,575	11,575	4,550	4,550	2,295	0	0
Freeway K	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Freeway D	0.69	0.69	0.69	0.69	0.69	0.69	0.57	0.57
Carpool Occupancy	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20
GP Occupancy	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05
Lane Inputs:								
Existing Lanes	10	8	8	8	6	8	0	0
Proposed Lanes:								
General Purpose Free	8	8	8	8	6	8	0	0
General Purpose Toll	0	0	0	0	0	0	0	0
Express Reversible	1	0	0	0	0	0	0	0
Express Bi-directional	0	0	0	0	0	0	0	0
Toll Reversible	0	0	0	0	0	0	0	0
Toll Bi-directional	0	0	0	0	0	0	0	0
HOV Reversible	2	2	2	2	1	0	0	0
HOV Bi-directional	0	0	0	0	0	0	0	0
HOT Reversible	0	0	0	0	0	0	0	0
HOT Bi-directional	0	0	0	0	0	0	0	0
Peak Hour Peak Direction Volume per Lane:								
General Purpose	1,679	1,864	1,867	1,939	1,702	1,648	0	0
Express/Toll	1,679	0	0	0	0	0	0	0
HOV/HOT	1,956	1,952	1,952	1,470	1,800	0	0	0
Transit Riders (Persons)	4,371	4,819	4,819	1,894	1,894	955	0	0
Occupancy	1.96	2.08	2.07	1.67	1.90	1.62	0.00	0.00
Veh Distance of Travel	12,307	14,770	17,060	27,807	23,481	16,483	0	0
Peak Hour Off Peak Direction Volume per Lane:								
General Purpose	1,709	1,663	1,649	1,426	1,263	865	0	0
Express/Toll	0	0	0	0	0	0	0	0
HOV/HOT	0	0	0	0	0	0	0	0
Transit Riders (Persons)	0	0	0	0	0	0	0	0
Occupancy	1.05	1.05	1.05	1.05	1.05	1.05	0.00	0.00
Veh Distance of Travel	6,837	8,646	9,893	14,833	12,879	8,648	0	0

Costs ($Million):	1	2	3	4	5	6	7	8	Subtotals
Construction Cost	$3.01	$2.29	$2.99	$7.07	$4.46	$3.28	$0.00	$0.00	$23.10
Right of Way Cost	$0.24	$0.21	$0.24	$0.11	$0.00	$0.00	$0.00	$0.00	$0.80
Operations Cost	$0.35	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.35
Pk Hr Recrnt Congstn Cost	$0.02	$0.04	$0.04	$0.06	$0.00	$0.00	$0.00	$0.00	$0.16
Recrnt Congstn Cost	$0.02	$0.04	$0.04	$0.06	$0.00	$0.00	$0.00	$0.00	$0.16
Subtotal Costs									$24.58
Nonrecrnt Congstn Cost	$0.29	$0.39	$0.46	$0.17	$0.18	$0.04	$0.00	$0.00	$1.53
Emissions Cost	$0.96	$1.19	$1.37	$2.19	$1.92	$1.43	$0.00	$0.00	$9.05
Fuel Consumption Cost	$0.42	$0.52	$0.60	$0.98	$0.84	$0.65	$0.00	$0.00	$4.02
Total Costs ($M)	$5.30	$4.64	$5.70	$10.57	$7.41	$5.40	$0.00	$0.00	$39.02

ALTERNATIVE	SECTION	LENGTH (MI) A-G	LENGTH (MI) ELEV	EXIST LANES	PROPOSED LANES GEN PUR	PROPOSED LANES EXPRESS AG	PROPOSED LANES EXPRESS ELEV	PROPOSED LANES HOV AG	PROPOSED LANES HOV ELEV	CRITICAL LANE VOL GEN.PUR.	CRITICAL LANE VOL EXP	CRITICAL LANE VOL HOV	TRANSIT RIDERSHIP (PERSONS)	CONSTR COST ($ M)	R.O.W. COST ($ M)	O&M COSTS ($ M)	PK HOUR GEN-PURP CONGEST COST ($ M)	TOTAL GEN-PURP CONGEST COST ($ M)	TRANSIT CONGEST COST ($M)	TOTAL COST ($ M)
9 Gen. Purp.	CBD-PEAK	.00	1.00	10	8	0	0	1	0	1995	0	1942	4256	$.5	$.0	$.4	$.1	$.1	$.0	$.9
& HOV (2+)	PEAK-GRAN	1.30	.00	8	10	0	0	2	0	1932	0	1942	4256	$1.0	$.3	$.0	$.2	$.2	$.0	$1.5
	GRAND-FER	1.00	.50	8	10	0	0	2	0	1913	0	1942	4256	$1.5	$.4	$.0	$.2	$.2	$.0	$2.0
	FERG-US80	2.60	.00	8	8	0	0	2	0	2128	0	1595	1599	$1.2	$.0	$.0	$.6	$.6	$.0	$1.9
	US80-LBJ	3.40	.00	6	6	0	0	1	0	2069	0	1820	1441	$1.2	$.0	$.0	$.6	$.6	$.0	$1.8
	LBJ-BLTLN	2.50	.00	8	8	0	0	0	0	1759	0	0	674	$.1	$.0	$.0	$.0	$.0	$.0	$.1
		12.30											SUBTOTAL	$5.5	$.7	$.4	$1.7	$1.7	$.0	$8.3
															$6.6			$1.7		

I-30 from the Dallas CBD to Belt Line Road

System Plan Corridor Critical Lane Volume and Public Cost Analysis Output

System of Units: US

18-Jul-97

Corridor: Interstate 635 LBJ **Design Year:** 2015

Alternative: 7 GP & HOV 2+

Freeway Section:	1	2	3	4	5	6	7	8	
Section Limits:	Ryl.- 190	190 - I35E	I35E-DNT	DNT-US75	0	0	0	0	
Length (Miles)									
Length At-Grade	5.64	1.63	4.07	3.18	0	0	0	0	
Length Elevated	0	0.95	0.67	0.28	0	0	0	0	
Traffic Inputs:									
Freeway ADT	62,088	202,610	395,492	422,919	0	0	0	0	
HOV ADT	1,184	10,847	12,262	10,895	0	0	0	0	
AD Transit Riders	0	389	1,276	1,481	0	0	0	0	
Freeway K	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	
Freeway D	0.60	0.60	0.50	0.50	0.65	0.57	0.57	0.57	
Carpool Occupancy	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	
GP Occupancy	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	
Lane Inputs:									
Existing Lanes	4	6	8	8	0	0	0	0	
Proposed Lanes:									
General Purpose Free	4	10	10	12	0	0	0	0	
General Purpose Toll	0	0	0	0	0	0	0	0	
Express Reversible	0	0	0	0	0	0	0	0	
Express Bi-directional	0	0	0	0	0	0	0	0	
Toll Reversible	0	0	0	0	0	0	0	0	
Toll Bi-directional	0	0	0	0	0	0	0	0	
HOV Reversible	0	1	0	0	0	0	0	0	
HOV Bi-directional	0	0	4	4	0	0	0	0	
HOT Reversible	0	0	0	0	0	0	0	0	
HOT Bi-directional	0	0	0	0	0	0	0	0	
Peak Hour Peak Direction Volume per Lane:									
General Purpose	1,359	1,428	2,158	1,945	0	0	0	0	
Express/Toll	0	0	0	0	0	0	0	0	
HOV/HOT	0	1,800	1,795	1,873	0	0	0	0	
Transit Riders (Persons)	0	97	0	0	0	0	0	0	
Occupancy	1.32	1.65	1.40	1.34	0.00	0.00	0.00	0.00	
Veh Distance of Travel	15,328	23,059	68,163	53,336	0	0	0	0	
Peak Hour Off Peak Direction Volume per Lane:									
General Purpose	933	1,213	2,256	2,009	0	0	0	0	
Express/Toll	0	0	0	0	0	0	0	0	
HOV/HOT	0	0	1,585	1,685	0	0	0	0	
Transit Riders (Persons)	0	0	685	795	0	0	0	0	
Occupancy	1.23	1.37	1.39	1.38	0.00	0.00	0.00	0.00	
Veh Distance of Travel	10,521	15,649	68,481	53,360	0	0	0	0	
Costs ($Million):									**Subtotals**
Construction Cost	$3.79	$8.24	$18.79	$14.72	$0.00	$0.00	$0.00	$0.00	$45.54
Right of Way Cost	$0.00	$0.00	$1.92	$2.81	$0.00	$0.00	$0.00	$0.00	$4.73
Operations Cost	$0.35	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.35
Pk Hr Recrnt Congstn Cost	$0.00	$0.00	$2.48	$0.36	$0.00	$0.00	$0.00	$0.00	$2.84
Recrnt Congstn Cost	$0.00	$0.00	$2.48	$0.36	$0.00	$0.00	$0.00	$0.00	$2.84
Subtotal Costs									$56.30
Nonrecrnt Congstn Cost	$0.00	$0.07	$7.08	$1.12	$0.00	$0.00	$0.00	$0.00	$8.28
Emissions Cost	$1.47	$2.09	$6.87	$5.19	$0.00	$0.00	$0.00	$0.00	$15.62
Fuel Consumption Cost	$0.67	$0.93	$3.03	$2.34	$0.00	$0.00	$0.00	$0.00	$6.96
Total Costs ($M)	$6.28	$11.34	$40.17	$26.53	$0.00	$0.00	$0.00	$0.00	$84.32

ALTERNATIVE	SECTION	LENGTH (MI) A-G	LENGTH (MI) ELEV	EXIST LANES	PROPOSED LANES GEN PUR	PROPOSED LANES EXPRESS AG	PROPOSED LANES EXPRESS ELEV	PROPOSED LANES HOV AG	PROPOSED LANES HOV ELEV	CRITICAL LANE VOL GEN.PUR.	CRITICAL LANE VOL EXP	CRITICAL LANE VOL HOV	TRANSIT RIDERSHIP (PERSONS)	CONSTR COST ($ M)	R.O.W. COST ($ M)	O&M COSTS ($ M)	PK HOUR GEN-PURP CONGEST COST ($ M)	TOTAL GEN-PURP CONGEST COST ($ M)	TRANSIT CONGEST COST ($M)	TOTAL COST ($ M)
7 Gen. Purp.	RYL-SH190	5.64	.00	4	4	0	0	0	0	1307	0	0	0	$.2	$.0	$.4	$.0	$.0	$.0	$.5
& HOV (2+)	190-135E	1.63	.95	6	10	0	0	1	0	1608	0	1200	97	$2.9	$.0	$.0	$.0	$.0	$.0	$2.9
(Elevated)	135E-DNT	4.07	.67	8	10	0	0	0	4	1960	0	2000	0	$12.4	$1.0	$.0	$1.0	$1.0	$.0	$14.3
	DNT-US75	3.18	.28	8	10	0	0	0	4	2000	0	2000	0	$9.0	$.7	$.0	$1.4	$1.4	$.0	$11.1
		14.52											SUBTOTAL	$24.5	$1.7	$.4	$2.4	$2.4	$.0	$28.9
															$26.5		EB	$2.4		
																	WB	$2.4		$2.4
																	TOTAL	$4.7		$31.2

I-635 from Royal Lane to US 75

System Plan Corridor Critical Lane Volume and Public Cost Analysis Output

System of Units: US

18-Jul-97

Corridor: Interstate 635 LBJ **Design Year:** 2015

Alternative: 9 GP & HOV 2+

Freeway Section:	1	2	3	4	5	6	7	8	
Section Limits:	75-Skmn.	Skl.-Gar	Gar - IH30	IH30-US80	US80-IH20	0	0	0	
Length (Miles)									
Length At-Grade	3.2	3.2	3.5	2	6	0	0	0	
Length Elevated	0	0.5	0.4	0	0.5	0	0	0	
Traffic Inputs:									
Freeway ADT	300,236	195,092	212,454	178,744	165,759	0	0	0	
HOV ADT	4,257	4,748	5,824	3,775	3,821	0	0	0	
AD Transit Riders	86	86	1,800	0	0	0	0	0	
Freeway K	0.08	0.09	0.09	0.09	0.09	0.09	0.09	0.09	
Freeway D	0.55	0.65	0.65	0.60	0.60	0.69	0.57	0.57	
Carpool Occupancy	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	
GP Occupancy	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	
Lane Inputs:									
Existing Lanes	8	8	8	8	8	0	0	0	
Proposed Lanes:									
General Purpose Free	10	8	8	8	8	0	0	0	
General Purpose Toll	0	0	0	0	0	0	0	0	
Express Reversible	0	0	0	0	0	0	0	0	
Express Bi-directional	0	0	0	0	0	0	0	0	
Toll Reversible	0	0	0	0	0	0	0	0	
Toll Bi-directional	0	0	0	0	0	0	0	0	
HOV Reversible	2	2	2	0	0	0	0	0	
HOV Bi-directional	0	0	0	0	0	0	0	0	
HOT Reversible	0	0	0	0	0	0	0	0	
HOT Bi-directional	0	0	0	0	0	0	0	0	
Peak Hour Peak Direction Volume per Lane:									
General Purpose	1,891	1,906	1,993	2,097	1,943	0	0	0	
Express/Toll	0	0	0	0	0	0	0	0	
HOV/HOT	1,348	1,130	1,247	0	0	0	0	0	
Transit Riders (Persons)	50	50	770	0	0	0	0	0	
Occupancy	1.34	1.41	1.53	1.39	1.41	0.00	0.00	0.00	
Veh Distance of Travel	38,876	36,575	40,816	16,776	50,523	0	0	0	
Peak Hour Off Peak Direction Volume per Lane:									
General Purpose	2,162	1,451	1,580	1,519	1,409	0	0	0	
Express/Toll	0	0	0	0	0	0	0	0	
HOV/HOT	0	0	0	0	0	0	0	0	
Transit Riders (Persons)	0	0	0	0	0	0	0	0	
Occupancy	1.05	1.05	1.05	1.05	1.05	0.00	0.00	0.00	
Veh Distance of Travel	34,587	21,475	24,650	12,155	36,633	0	0	0	
Costs ($Million):									**Subtotals**
Construction Cost	$9.73	$10.42	$10.89	$2.62	$8.79	$0.00	$0.00	$0.00	$42.45
Right of Way Cost	$0.52	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.52
Operations Cost	$0.35	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.35
Pk Hr Recrnt Congstn Cost	$0.42	$0.05	$0.15	$0.17	$0.20	$0.00	$0.00	$0.00	$0.99
Recrnt Congstn Cost	$0.42	$0.05	$0.15	$0.17	$0.20	$0.00	$0.00	$0.00	$0.99
Subtotal Costs									$45.30
Nonrecrnt Congstn Cost	$1.86	$0.18	$0.37	$0.59	$0.52	$0.00	$0.00	$0.00	$3.52
Emissions Cost	$3.86	$3.04	$3.39	$1.61	$4.84	$0.00	$0.00	$0.00	$16.74
Fuel Consumption Cost	$1.75	$1.36	$1.52	$0.74	$2.23	$0.00	$0.00	$0.00	$7.60
Total Costs ($M)	$18.48	$15.05	$16.32	$5.73	$16.58	$0.00	$0.00	$0.00	$72.17

ALTERNATIVE	SECTION	LENGTH (MI) A-G	LENGTH (MI) ELEV	EXIST LANES	PROPOSED LANES GEN PUR	PROPOSED LANES EXPRESS AG	PROPOSED LANES EXPRESS ELEV	PROPOSED LANES HOV AG	PROPOSED LANES HOV ELEV	CRITICAL LANE VOL GEN.PUR.	CRITICAL LANE VOL EXP	CRITICAL LANE VOL HOV	TRANSIT RIDERSHIP (PERSONS)	CONSTR COST ($ M)	R.O.W. COST ($ M)	O&M COSTS ($ M)	PK HOUR GEN-PURP CONGEST COST ($ M)	TOTAL GEN-PURP CONGEST COST ($ M)	TRANSIT CONGEST COST ($M)	TOTAL COST ($ M)
9 Gen. Purp.	US75-SKMN	3.20	.00	8	10	0	0	2	0	1976	0	1352	63	$2.6	$.0	$.4	$.3	$.3	$.0	$3.2
& HOV 2+	SKMN-GRLD	3.20	.50	8	8	0	0	2	0	1993	0	1133	63	$2.0	$.0	$.0	$.3	$.3	$.0	$2.3
(At-grade)	GRLD-IH30	3.50	.40	8	8	0	0	2	0	2171	0	1248	450	$2.1	$.0	$.0	$1.0	$1.0	$.0	$3.0
	IH30-US80	2.00	.00	8	8	0	0	0	0	2173	0	0	0	$.1	$.0	$.0	$.5	$.5	$.0	$.6
	US80-IH20	6.00	.50	8	8	0	0	0	0	2014	0	0	0	$.2	$.0	$.0	$1.5	$1.5	$.0	$1.7
		17.90											SUBTOTAL	$6.9	$.0	$.4	$3.5	$3.5	$.0	$10.8
															$7.2			$3.5		

I-635 from US 75 to I-20

System Plan Corridor Critical Lane Volume and Public Cost Analysis Output

System of Units: US

17-Jul-97

Corridor: State Highway 161 **Design Year:** 2015

Alternative: 5 GP & Express

Freeway Section:	1	2	3	4	5	6	7	8	
Section Limits:	IH30-IH20	IH30-183	183-Belt.	Belt-IH635	0	0	0	0	
Length (Miles)									
Length At-Grade	5.5	5.83	3	2.14	0	0	0	0	
Length Elevated	0.45	0.17	0.3	0.17	0	0	0	0	
Traffic Inputs:									
Freeway ADT	61,889	151,962	171,307	215,338	0	0	0	0	
HOV ADT	1	8,337	12,063	12,280	0	0	0	0	
AD Transit Riders	0	0	0	0	0	0	0	0	
Freeway K	0.095	0.095	0.095	0.095	0.085	0.09	0.09	0.09	
Freeway D	0.65	0.6	0.55	0.55	0.65	0.57	0.57	0.57	
Carpool Occupancy	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	
GP Occupancy	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	
Lane Inputs:									
Existing Lanes	0	0	0	0	0	0	0	0	
Proposed Lanes:									
General Purpose Free	4	6	8	10	0	0	0	0	
General Purpose Toll	0	0	0	0	0	0	0	0	
Express Reversible	0	2	2	2	0	0	0	0	
Express Bi-directional	0	0	0	0	0	0	0	0	
Toll Reversible	0	0	0	0	0	0	0	0	
Toll Bi-directional	0	0	0	0	0	0	0	0	
HOV Reversible	0	0	0	0	0	0	0	0	
HOV Bi-directional	0	0	0	0	0	0	0	0	
HOT Reversible	0	0	0	0	0	0	0	0	
HOT Bi-directional	0	0	0	0	0	0	0	0	
Peak Hour Peak Direction Volume per Lane:									
General Purpose	1,911	1,869	1,734	1,779	0	0	0	0	
Express/Toll	0	1,869	1,734	1,779	0	0	0	0	
HOV/HOT	0	0	0	0	0	0	0	0	
Transit Riders (Persons)	0	0	0	0	0	0	0	0	
Occupancy	1.05	1.46	1.54	1.49	0.00	0.00	0.00	0.00	
Veh Distance of Travel	22,739	56,064	34,336	28,766	0	0	0	0	
Peak Hour Off Peak Direction Volume per Lane:									
General Purpose	1,029	1,925	1,831	1,841	0	0	0	0	
Express/Toll	0	0	0	0	0	0	0	0	
HOV/HOT	0	0	0	0	0	0	0	0	
Transit Riders (Persons)	0	0	0	0	0	0	0	0	
Occupancy	1.05	1.05	1.05	1.05	0.00	0.00	0.00	0.00	
Veh Distance of Travel	12,244	34,647	24,167	21,265	0	0	0	0	
Costs ($Million):									**Subtotals**
Construction Cost	$7.92	$14.12	$8.98	$7.02	$0.00	$0.00	$0.00	$0.00	$38.03
Right of Way Cost	$0.00	$0.57	$0.85	$0.97	$0.00	$0.00	$0.00	$0.00	$2.38
Operations Cost	$0.30	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.30
Pk Hr Recrnt Congstn Cost	$0.05	$0.13	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.18
Recrnt Congstn Cost	$0.05	$0.13	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.18
Subtotal Costs									$41.07
Nonrecrnt Congstn Cost	$0.34	$1.07	$0.30	$0.31	$0.00	$0.00	$0.00	$0.00	$2.03
Emissions Cost	$1.96	$4.83	$3.19	$2.75	$0.00	$0.00	$0.00	$0.00	$12.73
Fuel Consumption Cost	$0.90	$2.22	$1.44	$1.25	$0.00	$0.00	$0.00	$0.00	$5.81
Total Costs ($M)	$11.47	$22.95	$14.76	$12.29	$0.00	$0.00	$0.00	$0.00	$61.46

ALTERNATIVE	SECTION	LENGTH (MI) A-G	LENGTH (MI) ELEV	EXIST LANES	PROPOSED LANES GEN PUR	PROPOSED LANES EXPRESS AG	PROPOSED LANES EXPRESS ELEV	PROPOSED LANES HOV AG	PROPOSED LANES HOV ELEV	CRITICAL LANE VOL GEN.PUR.	CRITICAL LANE VOL EXP	CRITICAL LANE VOL HOV	TRANSIT RIDERSHIP (PERSONS)	CONSTR COST ($ M)	R.O.W. COST ($ M)	O&M COSTS ($ M)	PK HOUR GEN-PURP CONGEST COST ($ M)	TOTAL GEN-PURP CONGEST COST ($ M)	TRANSIT CONGEST COST ($M)	TOTAL COST ($ M)
10 Gen. Purp.	IH20-IH30	5.50	.45	0	4	0	0	0	0	1661	0	0	0	$7.9	$.0	$.4	$.0	$.0	$.0	$8.3
HOV 2+	IH30-183	5.83	.17	0	6	0	0	2	0	1945	0	1436	0	$14.5	$.0	$.0	$.3	$.3	$.0	$14.9
(Elevated)	183-BLTLN	3.00	.30	0	8	0	0	0	2	1813	0	1597	0	$9.8	$.3	$.0	$.0	$.0	$.0	$10.0
	BLTLN-635	2.14	.17	0	8	0	0	0	2	2023	0	1913	0	$6.8	$.2	$.0	$.6	$.6	$.0	$7.6
		.00	.00	0	0	0	0	0	0	0	0	0	0	$.0	$.0	$.0	$.0	$.0	$.0	$.0
		.00	.00	0	0	0	0	0	0	0	0	0	0	$.0	$.0	$.0	$.0	$.0	$.0	$.0
		16.47											SUBTOTAL	$39.0	$.5	$.4	$.9	$.9	$.0	$40.8
															$39.9			$.9		

SH 161 from I-20 to I-635

APPENDIX B
OUTPUT TESTING REVISED SPM AGAINST MOBILITY 2010

System Plan Corridor Critical Lane Volume and Public Cost Analysis Output

System of Units: US

9-Sep-97

Corridor: Interstate 30 West of CBD **Design Year:** 2020

Alternative: 3 Mobility Plan

Freeway Section:	1	2	3	4	5	6	7	8
Section Limits:	360 - 161	161 - Lp12	Lp12-Ham	Ham-Trin	Trin-I35E	0	0	0
Length (Miles)								
Length At-Grade	1.75	6.39	2.95	1.9	0	0	0	0
Length Elevated	0.2	0.31	0.26	0.34	0.34	0	0	0
Traffic Inputs:								
Freeway ADT	226,191	196,516	189,372	211,582	153,713	0	0	0
HOV ADT	11,148	10,366	10,977	10,877	8,488	0	0	0
AD Transit Riders	0	0	0	0	0	0	0	0
Freeway K	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Freeway D	0.60	0.65	0.65	0.65	0.65	0.60	0.60	0.60
Carpool Occupancy	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20
GP Occupancy	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05
Lane Inputs:								
Existing Lanes	6	6	6	6	6	0	0	0
Proposed Lanes:								
General Purpose Free	10	10	8	8	8	0	0	0
General Purpose Toll	0	0	0	0	0	0	0	0
Express Rev At-Grade	0	0	0	0	0	0	0	0
Express Rev Elevated	0	0	0	0	0	0	0	0
Express Bi-drct At-Grade	0	0	0	0	0	0	0	0
Express Bi-drct Elevated	0	0	0	0	0	0	0	0
Toll Rev At-Grade	0	0	0	0	0	0	0	0
Toll Rev Elevated	0	0	0	0	0	0	0	0
Toll Bi-drct At-Grade	0	0	0	0	0	0	0	0
Toll Bi-drct Elevated	0	0	0	0	0	0	0	0
HOV Rev At-Grade	2	2	2	2	1	0	0	0
HOV Rev Elevated	0	0	0	0	0	0	0	0
HOV Bi-drct At-Grade	0	0	0	0	0	0	0	0
HOV Bi-drct Elevated	0	0	0	0	0	0	0	0
HOT Rev At-Grade	0	0	0	0	0	0	0	0
HOT Rev Elevated	0	0	0	0	0	0	0	0
HOT Bi-drct At-Grade	0	0	0	0	0	0	0	0
HOT Bi-drct Elevated	0	0	0	0	0	0	0	0
Peak Hour Peak Direction Volume per Lane:								
General Purpose	1,444	1,440	1,693	2,000	1,657	0	0	0
Express/Toll	0	0	0	0	0	0	0	0
HOV/HOT	2,000	1,772	1,641	1,641	1,800	0	0	0
Transit Riders (Persons)	0	0	0	0	0	0	0	0
Occupancy Rate	1.46	1.43	1.43	1.38	1.53	0.00	0.00	0.00
Peak Hour Off Peak Direction Volume per Lane:								
General Purpose	1,574	1,211	1,560	1,725	1,107	0	0	0
Express/Toll	0	0	0	0	0	0	0	0
HOV/HOT	0	0	0	0	0	0	0	0
Transit Riders (Persons)	0	0	0	0	0	0	0	0
Occupancy Rate	1.13	1.15	1.22	1.21	1.08	0.00	0.00	0.00

Costs ($Million):									Subtotals
Construction Cost	$4.44	$14.93	$6.13	$4.40	$0.81	$0.00	$0.00	$0.00	$30.71
Right of Way Cost	$0.24	$2.26	$0.51	$0.36	$0.07	$0.00	$0.00	$0.00	$3.45
Operations Cost	$0.35	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.35
Pk Hr Recrnt Congstn Cost	$0.09	$0.00	$0.00	$0.10	$0.00	$0.00	$0.00	$0.00	$0.19
Recrnt Congstn Cost	$0.09	$0.00	$0.00	$0.10	$0.00	$0.00	$0.00	$0.00	$0.19
Subtotal Costs									$34.70
Nonrecrnt Congstn Cost	$0.38	$0.25	$0.10	$0.35	$0.01	$0.00	$0.00	$0.00	$1.09
Emissions Cost	$2.30	$6.95	$3.17	$2.50	$0.28	$0.00	$0.00	$0.00	$15.19
Fuel Consumption Cost	$1.12	$3.34	$1.53	$1.22	$0.14	$0.00	$0.00	$0.00	$7.35
Toll Cost	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Toll Revenue (-$M)	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Total Costs ($M)	$8.91	$27.72	$11.45	$8.93	$1.32	$0.00	$0.00	$0.00	$58.33

Toll Costs	($/veh-mile)
Peak Hour	$0.05
Peak Period Shoulder Hours	$0.04
Off Peak Period Hours	$0.02

System Plan Corridor Critical Lane Volume and Public Cost Analysis Output

System of Units: US

9-Sep-97

Corridor: Interstate 30 West of CBD **Design Year:** 2020

Alternative: 7 GP & HOT

Freeway Section:	1	2	3	4	5	6	7	8
Section Limits:	360 - 161	161 - Lp12	Lp12-Ham	Ham-Trin	Trin-I35E	0	0	0
Length (Miles)								
Length At-Grade	1.75	6.39	2.95	1.9	0	0	0	0
Length Elevated	0.2	0.31	0.26	0.34	0.34	0	0	0
Traffic Inputs:								
Freeway ADT	226,191	196,516	189,372	211,582	153,713	0	0	0
HOV ADT	11,148	10,366	10,977	10,977	8,488	0	0	0
AD Transit Riders	0	0	0	0	0	0	0	0
Freeway K	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Freeway D	0.60	0.65	0.65	0.65	0.65	0.60	0.60	0.60
Carpool Occupancy	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20
GP Occupancy	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05
Lane Inputs:								
Existing Lanes	6	6	6	6	6	0	0	0
Proposed Lanes:								
General Purpose Free	8	8	8	8	6	0	0	0
General Purpose Toll	0	0	0	0	0	0	0	0
Express Rev At-Grade	0	0	0	0	0	0	0	0
Express Rev Elevated	0	0	0	0	0	0	0	0
Express Bi-drct At-Grade	0	0	0	0	0	0	0	0
Express Bi-drct Elevated	0	0	0	0	0	0	0	0
Toll Rev At-Grade	0	0	0	0	0	0	0	0
Toll Rev Elevated	0	0	0	0	0	0	0	0
Toll Bi-drct At-Grade	0	0	0	0	0	0	0	0
Toll Bi-drct Elevated	0	0	0	0	0	0	0	0
HOV Rev At-Grade	0	0	0	0	0	0	0	0
HOV Rev Elevated	0	0	0	0	0	0	0	0
HOV Bi-drct At-Grade	0	0	0	0	0	0	0	0
HOV Bi-drct Elevated	0	0	0	0	0	0	0	0
HOT Rev At-Grade	2	2	2	2	2	0	0	0
HOT Rev Elevated	0	0	0	0	0	0	0	0
HOT Bi-drct At-Grade	0	0	0	0	0	0	0	0
HOT Bi-drct Elevated	0	0	0	0	0	0	0	0
Peak Hour Peak Direction Volume per Lane:								
General Purpose	1,803	1,689	1,693	1,882	1,531	0	0	0
Express/Toll	0	0	0	0	0	0	0	0
HOV/HOT	2,000	1,879	1,641	1,877	1,827	0	0	0
Transit Riders (Persons)	0	0	0	0	0	0	0	0
Occupancy Rate	1.46	1.46	1.43	1.38	1.56	0.00	0.00	0.00
Peak Hour Off Peak Direction Volume per Lane:								
General Purpose	1,967	1,514	1,560	1,725	1,476	0	0	0
Express/Toll	0	0	0	0	0	0	0	0
HOV/HOT	0	0	0	0	0	0	0	0
Transit Riders (Persons)	0	0	0	0	0	0	0	0
Occupancy Rate	1.13	1.15	1.22	1.21	1.08	0.00	0.00	0.00

Costs ($Million):	1	2	3	4	5	6	7	8	Subtotals
Construction Cost	$3.76	$12.63	$6.13	$4.40	$0.72	$0.00	$0.00	$0.00	$27.64
Right of Way Cost	$0.00	$0.83	$0.51	$0.36	$0.04	$0.00	$0.00	$0.00	$1.75
Operations Cost	$0.35	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.35
Pk Hr Recrnt Congstn Cost	$0.16	$0.05	$0.00	$0.04	$0.00	$0.00	$0.00	$0.00	$0.25
Recrnt Congstn Cost	$0.16	$0.05	$0.00	$0.04	$0.00	$0.00	$0.00	$0.00	$0.25
Subtotal Costs									$29.99
Nonrecrnt Congstn Cost	$0.63	$0.69	$0.10	$0.37	$0.02	$0.00	$0.00	$0.00	$1.81
Emissions Cost	$2.25	$6.77	$3.17	$2.52	$0.25	$0.00	$0.00	$0.00	$14.97
Fuel Consumption Cost	$1.11	$3.26	$1.53	$1.23	$0.12	$0.00	$0.00	$0.00	$7.25
Toll Cost	$0.00	$0.00	$0.00	$0.02	$0.00	$0.00	$0.00	$0.00	$0.02
Toll Revenue (-$M)	$0.00	$0.00	$0.00	$0.02	$0.00	$0.00	$0.00	$0.00	$0.02
Total Costs ($M)	$8.25	$24.23	$11.45	$8.92	$1.16	$0.00	$0.00	$0.00	$54.01

Toll Costs	($/veh-mile)
Peak Hour	$0.05
Peak Period Shoulder Hours	$0.04
Off Peak Period Hours	$0.02

System Plan Corridor Critical Lane Volume and Public Cost Analysis Output

System of Units: US

5-Sep-97

Corridor: Interstate 30 ERLT **Design Year:** 2020

Alternative: 3 Mobility Plan

Freeway Section:	1	2	3	4	5	6	7	8	
Section Limits:	CBD-Peak	Peak-Grnd	Grnd-Ferg	Ferg-US80	US80-LBJ	LBJ-Beltln	0	0	
Length (Miles)									
Length At-Grade	0	1.3	1	2.6	3.4	2.5	0	0	
Length Elevated	1	0	0.5	0	0	0	0	0	
Traffic Inputs:									
Freeway ADT	220,354	237,829	249,622	227,719	176,001	192,469	0	0	
HOV ADT	17,094	13,793	13,217	13,217	9,076	11,010	0	0	
AD Transit Riders	2,598	2,598	2,598	3,383	3,196	0	0	0	
Freeway K	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	
Freeway D	0.69	0.69	0.69	0.69	0.69	0.69	0.60	0.60	
Carpool Occupancy	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	
GP Occupancy	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	
Lane Inputs:									
Existing Lanes	10	8	8	8	6	8	0	0	
Proposed Lanes:									
General Purpose Free	10	10	10	10	8	8	0	0	
General Purpose Toll	0	0	0	0	0	0	0	0	
Express Rev At-Grade	0	0	0	0	0	0	0	0	
Express Rev Elevated	0	0	0	0	0	0	0	0	
Express Bi-drct At-Grade	0	0	0	0	0	0	0	0	
Express Bi-drct Elevated	0	0	0	0	0	0	0	0	
Toll Rev At-Grade	0	0	0	0	0	0	0	0	
Toll Rev Elevated	0	0	0	0	0	0	0	0	
Toll Bi-drct At-Grade	0	0	0	0	0	0	0	0	
Toll Bi-drct Elevated	0	0	0	0	0	0	0	0	
HOV Rev At-Grade	0	0	0	0	2	2	0	0	
HOV Rev Elevated	2	2	2	2	0	0	0	0	
HOV Bi-drct At-Grade	0	0	0	0	0	0	0	0	
HOV Bi-drct Elevated	0	0	0	0	0	0	0	0	
HOT Rev At-Grade	0	0	0	0	0	0	0	0	
HOT Rev Elevated	0	0	0	0	0	0	0	0	
HOT Bi-drct At-Grade	0	0	0	0	0	0	0	0	
HOT Bi-drct Elevated	0	0	0	0	0	0	0	0	
Peak Hour Peak Direction Volume per Lane:									
General Purpose	1,993	2,172	2,319	2,063	2,016	2,181	0	0	
Express/Toll	0	0	0	0	0	0	0	0	
HOV/HOT	2,000	1,948	1,934	1,936	1,458	1,697	0	0	
Transit Riders (Persons)	546	546	546	569	569	0	0	0	
Occupancy Rate	1.44	1.39	1.37	1.40	1.40	1.37	0.00	0.00	
Peak Hour Off Peak Direction Volume per Lane:									
General Purpose	1,277	1,306	1,346	1,231	1,141	1,264	0	0	
Express/Toll	0	0	0	0	0	0	0	0	
HOV/HOT	0	0	0	0	0	0	0	0	
Transit Riders (Persons)	180	180	180	353	306	0	0	0	
Occupancy Rate	1.26	1.19	1.16	1.20	1.15	1.11	0.00	0.00	
Costs ($Million):									Subtotals
Construction Cost	$3.06	$3.11	$3.92	$8.84	$9.72	$7.15	$0.00	$0.00	$35.80
Right of Way Cost	$0.21	$0.28	$0.32	$0.22	$0.07	$0.05	$0.00	$0.00	$1.16
Operations Cost	$0.35	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.35
Pk Hr Recrnt Congstn Cost	$0.10	$0.21	$1.40	$0.29	$0.18	$0.28	$0.00	$0.00	$2.46
Recrnt Congstn Cost	$0.10	$0.21	$1.41	$0.29	$0.18	$0.28	$0.00	$0.00	$2.47
Subtotal Costs									$39.77
Nonrecrnt Congstn Cost	$0.35	$1.00	$2.85	$0.97	$0.47	$1.43	$0.00	$0.00	$7.07
Emissions Cost	$1.43	$1.98	$2.50	$3.76	$3.80	$3.10	$0.00	$0.00	$16.58
Fuel Consumption Cost	$0.71	$0.98	$1.22	$1.86	$1.87	$1.51	$0.00	$0.00	$8.15
Toll Cost	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Toll Revenue (-$M)	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Total Costs ($M)	$6.21	$7.56	$12.22	$15.94	$16.12	$13.52	$0.00	$0.00	$71.57

Toll Costs	($/veh-mile)
Peak Hour	$0.05
Peak Period Shoulder Hours	$0.04
Off Peak Period Hours	$0.02

System Plan Corridor Critical Lane Volume and Public Cost Analysis Output

System of Units: US

5-Sep-97

Corridor: Interstate 30 ERLT **Design Year:** 2020

Alternative: 7 GP & HOT

Freeway Section:	1	2	3	4	5	6	7	8
Section Limits:	CBD-Peak	Peak-Grnd	Grnd-Ferg	Ferg-US80	US80-LBJ	LBJ-Beltln	0	0
Length (Miles)								
Length At-Grade	0	1.3	1	2.6	3.4	2.5	0	0
Length Elevated	1	0	0.5	0	0	0	0	0
Traffic Inputs:								
Freeway ADT	220,354	237,829	249,622	227,719	176,001	192,469	0	0
HOV ADT	17,094	13,793	13,217	13,217	9,076	11,010	0	0
AD Transit Riders	2,598	2,598	2,598	3,383	3,196	0	0	0
Freeway K	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Freeway D	0.69	0.69	0.69	0.69	0.69	0.69	0.60	0.60
Carpool Occupancy	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20
GP Occupancy	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05
Lane Inputs:								
Existing Lanes	10	8	8	8	6	8	0	0
Proposed Lanes:								
General Purpose Free	10	10	10	10	8	8	0	0
General Purpose Toll	0	0	0	0	0	0	0	0
Express Rev At-Grade	0	0	0	0	0	0	0	0
Express Rev Elevated	0	0	0	0	0	0	0	0
Express Bi-drct At-Grade	0	0	0	0	0	0	0	0
Express Bi-drct Elevated	0	0	0	0	0	0	0	0
Toll Rev At-Grade	0	0	0	0	0	0	0	0
Toll Rev Elevated	0	0	0	0	0	0	0	0
Toll Bi-drct At-Grade	0	0	0	0	0	0	0	0
Toll Bi-drct Elevated	0	0	0	0	0	0	0	0
HOV Rev At-Grade	0	0	0	0	0	0	0	0
HOV Rev Elevated	0	0	0	0	0	0	0	0
HOV Bi-drct At-Grade	0	0	0	0	0	0	0	0
HOV Bi-drct Elevated	0	0	0	0	0	0	0	0
HOT Rev At-Grade	0	0	0	0	2	3	0	0
HOT Rev Elevated	3	3	3	3	0	0	0	0
HOT Bi-drct At-Grade	0	0	0	0	0	0	0	0
HOT Bi-drct Elevated	0	0	0	0	0	0	0	0
Peak Hour Peak Direction Volume per Lane:								
General Purpose	1,874	1,903	1,944	1,885	1,883	1,896	0	0
Express/Toll	0	0	0	0	0	0	0	0
HOV/HOT	1,532	1,746	1,914	1,586	1,725	1,511	0	0
Transit Riders (Persons)	546	546	546	569	569	0	0	0
Occupancy Rate	1.44	1.39	1.37	1.40	1.40	1.37	0.00	0.00
Peak Hour Off Peak Direction Volume per Lane:								
General Purpose	1,277	1,306	1,346	1,231	1,141	1,264	0	0
Express/Toll	0	0	0	0	0	0	0	0
HOV/HOT	0	0	0	0	0	0	0	0
Transit Riders (Persons)	180	180	180	353	306	0	0	0
Occupancy Rate	1.26	1.19	1.16	1.20	1.15	1.11	0.00	0.00

Costs ($Million):	1	2	3	4	5	6	7	8	Subtotals
Construction Cost	$3.40	$3.54	$4.42	$9.71	$9.72	$7.74	$0.00	$0.00	$38.54
Right of Way Cost	$0.21	$0.28	$0.32	$0.22	$0.07	$0.37	$0.00	$0.00	$1.48
Operations Cost	$0.35	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.35
Pk Hr Recrnt Congstn Cost	$0.01	$0.03	$0.10	$0.03	$0.03	$0.03	$0.00	$0.00	$0.23
Recrnt Congstn Cost	$0.01	$0.03	$0.10	$0.03	$0.03	$0.03	$0.00	$0.00	$0.23
Subtotal Costs									$40.60
Nonrecrnt Congstn Cost	$0.07	$0.22	$0.47	$0.24	$0.31	$0.25	$0.00	$0.00	$1.56
Emissions Cost	$1.47	$2.02	$2.45	$3.86	$3.87	$3.13	$0.00	$0.00	$16.80
Fuel Consumption Cost	$0.71	$0.98	$1.21	$1.87	$1.88	$1.51	$0.00	$0.00	$8.17
Toll Cost	$0.00	$0.01	$0.01	$0.01	$0.01	$0.01	$0.00	$0.00	$0.04
Toll Revenue (-$M)	$0.00	$0.01	$0.01	$0.01	$0.01	$0.01	$0.00	$0.00	$0.04
Total Costs ($M)	$6.22	$7.06	$8.97	$15.94	$15.88	$13.05	$0.00	$0.00	$67.13

Toll Costs	($/veh-mile)
Peak Hour	$0.05
Peak Period Shoulder Hours	$0.04
Off Peak Period Hours	$0.02

System Plan Corridor Critical Lane Volume and Public Cost Analysis Output

System of Units: US

27-Aug-97

Corridor: Interstate 635 LBJ **Design Year:** 2020

Alternative: 3 Mobility Plan

Freeway Section:	1	2	3	4	5	6	7	8	
Section Limits:	Ryl.-S190	S190-I35E	I35E-DNT	DNT-US75	0	0	0	0	
Length (Miles)									
Length At-Grade	5.64	1.63	4.07	3.18	0	0	0	0	
Length Elevated	0	0.95	0.67	0.28	0	0	0	0	
Traffic Inputs:									
Freeway ADT	145,350	232,121	290,453	321,062	0	0	0	0	
HOV ADT	2,772	6,548	15,289	13,849	0	0	0	0	
AD Transit Riders	0	429	1,409	1,635	0	0	0	0	
Freeway K	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09	
Freeway D	0.60	0.60	0.50	0.50	0.60	0.60	0.60	0.60	
Carpool Occupancy	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	
GP Occupancy	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	
Lane Inputs:									
Existing Lanes	4	10	8	8	0	0	0	0	
Proposed Lanes:									
General Purpose Free	6	10	8	8	0	0	0	0	
General Purpose Toll	0	0	0	0	0	0	0	0	
Express Rev At-Grade	0	0	0	0	0	0	0	0	
Express Rev Elevated	0	0	0	0	0	0	0	0	
Express Bi-drct At-Grade	0	0	0	0	0	0	0	0	
Express Bi-drct Elevated	0	0	0	0	0	0	0	0	
Toll Rev At-Grade	0	0	0	0	0	0	0	0	
Toll Rev Elevated	0	0	0	0	0	0	0	0	
Toll Bi-drct At-Grade	0	0	0	0	0	0	0	0	
Toll Bi-drct Elevated	0	0	0	0	0	0	0	0	
HOV Rev At-Grade	0	0	0	0	0	0	0	0	
HOV Rev Elevated	0	0	0	0	0	0	0	0	
HOV Bi-drct At-Grade	0	2	0	0	0	0	0	0	
HOV Bi-drct Elevated	0	0	0	0	0	0	0	0	
HOT Rev At-Grade	0	0	0	0	0	0	0	0	
HOT Rev Elevated	0	0	0	0	0	0	0	0	
HOT Bi-drct At-Grade	0	0	0	0	0	0	0	0	
HOT Bi-drct Elevated	0	0	6	6	0	0	0	0	
Peak Hour Peak Direction Volume per Lane:									
General Purpose	2,038	1,631	1,758	1,875	0	0	0	0	
Express/Toll	0	0	0	0	0	0	0	0	
HOV/HOT	0	1,800	1,278	1,485	0	0	0	0	
Transit Riders (Persons)	0	135	133	167	0	0	0	0	
Occupancy Rate	1.33	1.37	1.47	1.41	0.00	0.00	0.00	0.00	
Peak Hour Off Peak Direction Volume per Lane:									
General Purpose	1,359	970	1,765	1,876	0	0	0	0	
Express/Toll	0	0	0	0	0	0	0	0	
HOV/HOT	0	1,800	1,278	1,492	0	0	0	0	
Transit Riders (Persons)	0	0	105	140	0	0	0	0	
Occupancy Rate	1.33	1.36	1.46	1.41	0.00	0.00	0.00	0.00	
Costs ($Million):									Subtotals
Construction Cost	$5.88	$9.66	$21.26	$15.40	$0.00	$0.00	$0.00	$0.00	$52.21
Right of Way Cost	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Operations Cost	$0.30	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.30
Pk Hr Recrnt Congstn Cost	$0.31	$0.00	$0.00	$0.05	$0.00	$0.00	$0.00	$0.00	$0.36
Recrnt Congstn Cost	$0.31	$0.00	$0.00	$0.05	$0.00	$0.00	$0.00	$0.00	$0.36
Subtotal Costs									$52.86
Nonrecrnt Congstn Cost	$1.02	$0.19	$0.25	$0.42	$0.00	$0.00	$0.00	$0.00	$1.88
Emissions Cost	$5.23	$3.65	$8.20	$6.63	$0.00	$0.00	$0.00	$0.00	$23.71
Fuel Consumption Cost	$2.62	$1.77	$3.91	$3.18	$0.00	$0.00	$0.00	$0.00	$11.47
Toll Cost	$0.00	$0.00	$0.00	$0.01	$0.00	$0.00	$0.00	$0.00	$0.01
Toll Revenue (-$M)	$0.00	$0.00	$0.00	$0.01	$0.00	$0.00	$0.00	$0.00	$0.01
Total Costs ($M)	$15.37	$15.27	$33.61	$25.68	$0.00	$0.00	$0.00	$0.00	$89.93

Toll Costs	($/veh-mile)
Peak Hour	$0.05
Peak Period Shoulder Hours	$0.04
Off Peak Period Hours	$0.02

System Plan Corridor Critical Lane Volume and Public Cost Analysis Output

System of Units: US

27-Aug-97

Corridor: Interstate 635 LBJ **Design Year:** 2020

Alternative: 6 GP & HOV

Freeway Section:	1	2	3	4	5	6	7	8
Section Limits:	Ryl.-S190	S190-I35E	I35E-DNT	DNT-US75	0	0	0	0
Length (Miles)								
Length At-Grade	5.64	1.63	4.07	3.18	0	0	0	0
Length Elevated	0	0.95	0.67	0.28	0	0	0	0
Traffic Inputs:								
Freeway ADT	145,350	232,121	290,453	321,062	0	0	0	0
HOV ADT	2,772	6,548	15,289	13,849	0	0	0	0
AD Transit Riders	0	429	1,409	1,635	0	0	0	0
Freeway K	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.09
Freeway D	0.60	0.60	0.50	0.50	0.60	0.60	0.60	0.60
Carpool Occupancy	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20
GP Occupancy	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05
Lane Inputs:								
Existing Lanes	4	10	8	8	0	0	0	0
Proposed Lanes:								
General Purpose Free	6	10	8	8	0	0	0	0
General Purpose Toll	0	0	0	0	0	0	0	0
Express Rev At-Grade	0	0	0	0	0	0	0	0
Express Rev Elevated	0	0	0	0	0	0	0	0
Express Bi-drct At-Grade	0	0	0	0	0	0	0	0
Express Bi-drct Elevated	0	0	0	0	0	0	0	0
Toll Rev At-Grade	0	0	0	0	0	0	0	0
Toll Rev Elevated	0	0	0	0	0	0	0	0
Toll Bi-drct At-Grade	0	0	0	0	0	0	0	0
Toll Bi-drct Elevated	0	0	0	0	0	0	0	0
HOV Rev At-Grade	1	1	0	0	0	0	0	0
HOV Rev Elevated	0	0	0	0	0	0	0	0
HOV Bi-drct At-Grade	0	0	0	0	0	0	0	0
HOV Bi-drct Elevated	0	0	4	4	0	0	0	0
HOT Rev At-Grade	0	0	0	0	0	0	0	0
HOT Rev Elevated	0	0	0	0	0	0	0	0
HOT Bi-drct At-Grade	0	0	0	0	0	0	0	0
HOT Bi-drct Elevated	0	0	0	0	0	0	0	0
Peak Hour Peak Direction Volume per Lane:								
General Purpose	1,439	1,630	1,739	2,000	0	0	0	0
Express/Toll	0	0	0	0	0	0	0	0
HOV/HOT	1,800	1,800	1,916	1,924	0	0	0	0
Transit Riders (Persons)	0	145	222	276	0	0	0	0
Occupancy Rate	1.32	1.37	1.48	1.43	0.00	0.00	0.00	0.00
Peak Hour Off Peak Direction Volume per Lane:								
General Purpose	1,359	1,331	1,739	2,000	0	0	0	0
Express/Toll	0	0	0	0	0	0	0	0
HOV/HOT	0	0	1,916	1,924	0	0	0	0
Transit Riders (Persons)	0	0	222	276	0	0	0	0
Occupancy Rate	1.32	1.36	1.48	1.43	0.00	0.00	0.00	0.00

Costs ($Million):	1	2	3	4	5	6	7	8	Subtotals
Construction Cost	$7.78	$8.67	$18.07	$13.07	$0.00	$0.00	$0.00	$0.00	$47.59
Right of Way Cost	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Operations Cost	$0.35	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.35
Pk Hr Recrnt Congstn Cost	$0.00	$0.00	$0.18	$0.47	$0.00	$0.00	$0.00	$0.00	$0.65
Recrnt Congstn Cost	$0.00	$0.00	$0.18	$0.47	$0.00	$0.00	$0.00	$0.00	$0.65
Subtotal Costs									$48.59
Nonrecrnt Congstn Cost	$0.19	$0.10	$1.34	$1.69	$0.00	$0.00	$0.00	$0.00	$3.32
Emissions Cost	$4.99	$3.80	$8.07	$6.37	$0.00	$0.00	$0.00	$0.00	$23.22
Fuel Consumption Cost	$2.43	$1.86	$3.88	$3.13	$0.00	$0.00	$0.00	$0.00	$11.30
Toll Cost	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Toll Revenue (-$M)	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Total Costs ($M)	$15.73	$14.43	$31.53	$24.73	$0.00	$0.00	$0.00	$0.00	$86.43

Toll Costs	($/veh-mile)
Peak Hour	$0.05
Peak Period Shoulder Hours	$0.04
Off Peak Period Hours	$0.02

System Plan Corridor Critical Lane Volume and Public Cost Analysis Output

System of Units: US

26-Aug-97

Corridor: Interstate 635 LBJ **Design Year:** 2020

Alternative: 3 Mobility Plan

Freeway Section:	1	2	3	4	5	6	7	8
Section Limits:	US75 - Skl.	Skl. - Gar.	Gar. - IH30	IH30-US80	US80-IH20	0	0	0
Length (Miles)								
Length At-Grade	3.2	3.2	3.5	2	6	0	0	0
Length Elevated	0	0.5	0.4	0	0.5	0	0	0

Traffic Inputs:

Freeway ADT	258,522	226,849	226,243	201,982	178,000	0	0	0
HOV ADT	6,767	8,127	7,666	4,266	4,103	0	0	0
AD Transit Riders	95	95	1,987	0	0	0	0	0
Freeway K	0.08	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Freeway D	0.55	0.65	0.65	0.60	0.60	0.60	0.60	0.60
Carpool Occupancy	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20
GP Occupancy	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05

Lane Inputs:

Existing Lanes	8	8	8	8	8	0	0	0
Proposed Lanes:								
General Purpose Free	10	10	10	10	8	0	0	0
General Purpose Toll	0	0	0	0	0	0	0	0
Express Rev At-Grade	0	0	0	0	0	0	0	0
Express Rev Elevated	0	0	0	0	0	0	0	0
Express Bi-drct At-Grade	0	0	0	0	0	0	0	0
Express Bi-drct Elevated	0	0	0	0	0	0	0	0
Toll Rev At-Grade	0	0	0	0	0	0	0	0
Toll Rev Elevated	0	0	0	0	0	0	0	0
Toll Bi-drct At-Grade	0	0	0	0	0	0	0	0
Toll Bi-drct Elevated	0	0	0	0	0	0	0	0
HOV Rev At-Grade	0	2	2	0	0	0	0	0
HOV Rev Elevated	0	0	0	0	0	0	0	0
HOV Bi-drct At-Grade	4	0	0	0	0	0	0	0
HOV Bi-drct Elevated	0	0	0	0	0	0	0	0
HOT Rev At-Grade	0	0	0	0	0	0	0	0
HOT Rev Elevated	0	0	0	0	0	0	0	0
HOT Bi-drct At-Grade	0	0	0	0	0	0	0	0
HOT Bi-drct Elevated	0	0	0	0	0	0	0	0

Peak Hour Peak Direction Volume per Lane:

General Purpose	1,748	2,000	1,979	1,976	2,185	0	0	0
Express/Toll	0	0	0	0	0	0	0	0
HOV/HOT	1,223	1,347	1,343	0	0	0	0	0
Transit Riders (Persons)	32	32	0	0	0	0	0	0
Occupancy Rate	1.25	1.29	1.28	1.21	1.22	0.00	0.00	0.00

Peak Hour Off Peak Direction Volume per Lane:

General Purpose	1,681	1,379	1,380	1,430	1,581	0	0	0
Express/Toll	0	0	0	0	0	0	0	0
HOV/HOT	651	0	0	0	0	0	0	0
Transit Riders (Persons)	0	0	497	0	0	0	0	0
Occupancy Rate	1.13	1.11	1.18	1.12	1.12	0.00	0.00	0.00

Costs ($Million):

									Subtotals
Construction Cost	$11.74	$12.27	$12.82	$5.45	$9.24	$0.00	$0.00	$0.00	$51.51
Right of Way Cost	$1.77	$0.55	$0.58	$0.00	$0.00	$0.00	$0.00	$0.00	$2.91
Operations Cost	$0.35	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.35
Pk Hr Recrnt Congstn Cost	$0.00	$0.22	$0.19	$0.11	$0.84	$0.00	$0.00	$0.00	$1.36
Recrnt Congstn Cost	$0.00	$0.22	$0.19	$0.11	$0.84	$0.00	$0.00	$0.00	$1.36
Subtotal Costs									$56.12
Nonrecrnt Congstn Cost	$0.14	$0.50	$0.45	$0.26	$4.21	$0.00	$0.00	$0.00	$5.56
Emissions Cost	$5.50	$5.34	$5.60	$2.66	$7.71	$0.00	$0.00	$0.00	$26.81
Fuel Consumption Cost	$2.68	$2.64	$2.77	$1.34	$3.86	$0.00	$0.00	$0.00	$13.28
Toll Cost	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Toll Revenue (-$M)	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Total Costs ($M)	$22.18	$21.51	$22.41	$9.82	$25.86	$0.00	$0.00	$0.00	$101.78

Toll Costs	($/veh-mile)
Peak Hour	$0.05
Peak Period Shoulder Hours	$0.04
Off Peak Period Hours	$0.02

System Plan Corridor Critical Lane Volume and Public Cost Analysis Output

System of Units: US

26-Aug-97

Corridor: Interstate 635 LBJ **Design Year:** 2020

Alternative: 7 GP & HOT

Freeway Section:	1	2	3	4	5	6	7	8
Section Limits:	US75 - Skl.	Skl. - Gar.	Gar. - IH30	IH30-US80	US80-IH20	0	0	0
Length (Miles)								
Length At-Grade	3.2	3.2	3.5	2	6	0	0	0
Length Elevated	0	0.5	0.4	0	0.5	0	0	0

Traffic Inputs:

	1	2	3	4	5	6	7	8
Freeway ADT	258,522	228,849	226,243	201,982	178,000	0	0	0
HOV ADT	6,767	8,127	7,666	4,266	4,103	0	0	0
AD Transit Riders	95	95	1,987	0	0	0	0	0
Freeway K	0.08	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Freeway D	0.55	0.65	0.65	0.60	0.60	0.60	0.60	0.60
Carpool Occupancy	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20
GP Occupancy	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05

Lane Inputs:

	1	2	3	4	5	6	7	8
Existing Lanes	8	8	8	8	8	0	0	0
Proposed Lanes:								
General Purpose Free	8	8	8	8	8	0	0	0
General Purpose Toll	0	0	0	0	0	0	0	0
Express Rev At-Grade	0	0	0	0	0	0	0	0
Express Rev Elevated	0	0	0	0	0	0	0	0
Express Bi-drct At-Grade	0	0	0	0	0	0	0	0
Express Bi-drct Elevated	0	0	0	0	0	0	0	0
Toll Rev At-Grade	0	0	0	0	0	0	0	0
Toll Rev Elevated	0	0	0	0	0	0	0	0
Toll Bi-drct At-Grade	0	0	0	0	0	0	0	0
Toll Bi-drct Elevated	0	0	0	0	0	0	0	0
HOV Rev At-Grade	0	0	0	0	0	0	0	0
HOV Rev Elevated	0	0	0	0	0	0	0	0
HOV Bi-drct At-Grade	0	0	0	0	0	0	0	0
HOV Bi-drct Elevated	0	0	0	0	0	0	0	0
HOT Rev At-Grade	0	2	2	0	0	0	0	0
HOT Rev Elevated	0	0	0	0	0	0	0	0
HOT Bi-drct At-Grade	4	0	0	0	0	0	0	0
HOT Bi-drct Elevated	0	0	0	0	0	0	0	0

Peak Hour Peak Direction Volume per Lane:

	1	2	3	4	5	6	7	8
General Purpose	1,795	1,919	1,909	2,286	2,023	0	0	0
Express/Toll	0	0	0	0	0	0	0	0
HOV/HOT	1,593	2,057	2,027	0	0	0	0	0
Transit Riders (Persons)	43	43	0	0	0	0	0	0
Occupancy Rate	1.35	1.39	1.37	1.31	1.32	0.00	0.00	0.00

Peak Hour Off Peak Direction Volume per Lane:

	1	2	3	4	5	6	7	8
General Purpose	1,880	1,683	1,685	1,747	1,545	0	0	0
Express/Toll	0	0	0	0	0	0	0	0
HOV/HOT	993	0	0	0	0	0	0	0
Transit Riders (Persons)	0	0	497	0	0	0	0	0
Occupancy Rate	1.15	1.14	1.21	1.14	1.15	0.00	0.00	0.00

Costs ($Million):

	1	2	3	4	5	6	7	8	Subtotals
Construction Cost	$10.66	$10.95	$11.45	$2.76	$9.24	$0.00	$0.00	$0.00	$45.06
Right of Way Cost	$0.96	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.96
Operations Cost	$0.35	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.35
Pk Hr Recrnt Congstn Cost	$0.03	$0.31	$0.27	$1.34	$0.43	$0.00	$0.00	$0.00	$2.38
Recrnt Congstn Cost	$0.03	$0.31	$0.27	$1.34	$0.43	$0.00	$0.00	$0.00	$2.38
Subtotal Costs									$48.75
Nonrecrnt Congstn Cost	$0.32	$1.39	$1.26	$2.75	$1.13	$0.00	$0.00	$0.00	$6.86
Emissions Cost	$5.18	$5.02	$5.27	$2.62	$7.37	$0.00	$0.00	$0.00	$25.46
Fuel Consumption Cost	$2.51	$2.47	$2.59	$1.30	$3.70	$0.00	$0.00	$0.00	$12.57
Toll Cost	$0.01	$0.01	$0.01	$0.00	$0.00	$0.00	$0.00	$0.00	$0.03
Toll Revenue (-$M)	$0.01	$0.01	$0.01	$0.00	$0.00	$0.00	$0.00	$0.00	$0.03
Total Costs ($M)	$20.01	$20.15	$20.84	$10.77	$21.87	$0.00	$0.00	$0.00	$93.63

Toll Costs	($/veh-mile)
Peak Hour	$0.05
Peak Period Shoulder Hours	$0.04
Off Peak Period Hours	$0.02

System Plan Corridor Critical Lane Volume and Public Cost Analysis Output

System of Units: US

9-Sep-97

Corridor: State Highway 161 **Design Year:** 2020

Alternative: 4 Mobility Plan HOV

Freeway Section:	1	2	3	4	5	6	7	8
Section Limits:	IH20-IH30	IH30-S183	S183-A.C.	A.C.- Belt	Belt-IH635	0	0	0
Length (Miles)								
Length At-Grade	5.5	5.83	1.6	1.4	2.14	0	0	0
Length Elevated	0.45	0.17	0.2	0.1	0.17	0	0	0

Traffic Inputs:

Freeway ADT	92,719	153,900	153,025	185,036	201,151	0	0	0
HOV ADT	2,895	4,826	11,155	11,155	15,274	0	0	0
AD Transit Riders	0	0	0	0	0	0	0	0
Freeway K	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
Freeway D	0.65	0.60	0.55	0.55	0.55	0.60	0.60	0.60
Carpool Occupancy	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20
GP Occupancy	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05

Lane Inputs:

Existing Lanes	0	0	0	0	0	0	0	0
Proposed Lanes:								
General Purpose Free	4	6	0	0	0	0	0	0
General Purpose Toll	0	0	6	8	8	0	0	0
Express Rev At-Grade	0	0	0	0	0	0	0	0
Express Rev Elevated	0	0	0	0	0	0	0	0
Express Bi-drct At-Grade	0	0	0	0	0	0	0	0
Express Bi-drct Elevated	0	0	0	0	0	0	0	0
Toll Rev At-Grade	0	0	0	0	0	0	0	0
Toll Rev Elevated	0	0	0	0	0	0	0	0
Toll Bi-drct At-Grade	0	0	0	0	0	0	0	0
Toll Bi-drct Elevated	0	0	0	0	0	0	0	0
HOV Rev At-Grade	0	0	0	0	0	0	0	0
HOV Rev Elevated	0	0	0	0	0	0	0	0
HOV Bi-drct At-Grade	0	0	2	2	2	0	0	0
HOV Bi-drct Elevated	0	0	0	0	0	0	0	0
HOT Rev At-Grade	0	0	0	0	0	0	0	0
HOT Rev Elevated	0	0	0	0	0	0	0	0
HOT Bi-drct At-Grade	0	0	0	0	0	0	0	0
HOT Bi-drct Elevated	0	0	0	0	0	0	0	0

Peak Hour Peak Direction Volume per Lane:

General Purpose	2,400	2,400	1,927	1,850	2,027	0	0	0
Express/Toll	0	0	0	0	0	0	0	0
HOV/HOT	0	0	1,800	1,800	1,800	0	0	0
Transit Riders (Persons)	0	0	0	0	0	0	0	0
Occupancy Rate	1.21	1.20	1.31	1.26	1.30	0.00	0.00	0.00

Peak Hour Off Peak Direction Volume per Lane:

General Purpose	1,487	1,910	1,793	1,648	1,761	0	0	0
Express/Toll	0	0	0	0	0	0	0	0
HOV/HOT	0	0	1,339	1,339	1,757	0	0	0
Transit Riders (Persons)	0	0	0	0	0	0	0	0
Occupancy Rate	1.11	1.12	1.27	1.23	1.27	0.00	0.00	0.00

Costs ($Million):

									Subtotals
Construction Cost	$8.33	$10.37	$3.22	$3.16	$4.88	$0.00	$0.00	$0.00	$29.96
Right of Way Cost	$0.00	$0.00	$0.31	$0.51	$0.79	$0.00	$0.00	$0.00	$1.61
Operations Cost	$0.30	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.30
Pk Hr Recrnt Congstn Cost	$3.95	$6.03	$0.26	$0.20	$0.62	$0.00	$0.00	$0.00	$11.06
Recrnt Congstn Cost	$11.84	$18.21	$0.94	$0.88	$1.82	$0.00	$0.00	$0.00	$33.69
Subtotal Costs									$65.56
Nonrecrnt Congstn Cost	$24.23	$34.93	$0.22	$0.13	$0.61	$0.00	$0.00	$0.00	$60.12
Emissions Cost	$4.39	$6.65	$1.77	$1.81	$3.06	$0.00	$0.00	$0.00	$17.68
Fuel Consumption Cost	$2.03	$3.26	$0.86	$0.87	$1.50	$0.00	$0.00	$0.00	$8.53
Toll Cost	$0.00	$0.00	$0.28	$0.22	$0.37	$0.00	$0.00	$0.00	$0.88
Toll Revenue (-$M)	$0.00	$0.00	$0.28	$0.22	$0.37	$0.00	$0.00	$0.00	$0.88
Total Costs ($M)	$51.13	$73.42	$7.33	$7.36	$12.65	$0.00	$0.00	$0.00	$151.89

Toll Costs	($/veh-mile)
Peak Hour	$0.05
Peak Period Shoulder Hours	$0.04
Off Peak Period Hours	$0.02

System Plan Corridor Critical Lane Volume and Public Cost Analysis Output

System of Units: US

26-Aug-97

Corridor: State Highway 161 **Design Year:** 2020

Alternative: 9 GP & HOT

Freeway Section:	1	2	3	4	5	6	7	8	
Section Limits:	IH20-IH30	IH30-S183	S183-A.C.	A.C.-Belt	Belt-IH635	0	0	0	
Length (Miles)									
Length At-Grade	5.5	5.83	1.6	1.4	2.14	0	0	0	
Length Elevated	0.45	0.17	0.2	0.1	0.17	0	0	0	
Traffic Inputs:									
Freeway ADT	92,719	153,900	153,025	185,036	201,151	0	0	0	
HOV ADT	2,895	4,826	11,155	11,155	15,274	0	0	0	
AD Transit Riders	0	0	0	0	0	0	0	0	
Freeway K	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	
Freeway D	0.65	0.60	0.55	0.55	0.55	0.60	0.60	0.60	
Carpool Occupancy	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	
GP Occupancy	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	
Lane Inputs:									
Existing Lanes	0	0	0	0	0	0	0	0	
Proposed Lanes:									
General Purpose Free	4	6	6	6	6	0	0	0	
General Purpose Toll	0	0	0	0	0	0	0	0	
Express Rev At-Grade	0	0	0	0	0	0	0	0	
Express Rev Elevated	0	0	0	0	0	0	0	0	
Express Bi-drct At-Grade	0	0	0	0	0	0	0	0	
Express Bi-drct Elevated	0	0	0	0	0	0	0	0	
Toll Rev At-Grade	0	0	0	0	0	0	0	0	
Toll Rev Elevated	0	0	0	0	0	0	0	0	
Toll Bi-drct At-Grade	0	0	0	0	0	0	0	0	
Toll Bi-drct Elevated	0	0	0	0	0	0	0	0	
HOV Rev At-Grade	0	0	0	0	0	0	0	0	
HOV Rev Elevated	0	0	0	0	0	0	0	0	
HOV Bi-drct At-Grade	0	0	0	0	0	0	0	0	
HOV Bi-drct Elevated	0	0	0	0	0	0	0	0	
HOT Rev At-Grade	1	2	1	0	1	0	0	0	
HOT Rev Elevated	0	0	0	0	0	0	0	0	
HOT Bi-drct At-Grade	0	0	2	4	4	0	0	0	
HOT Bi-drct Elevated	0	0	0	0	0	0	0	0	
Peak Hour Peak Direction Volume per Lane:									
General Purpose	1,779	1,802	1,472	1,873	1,831	0	0	0	
Express/Toll	0	0	0	0	0	0	0	0	
HOV/HOT	1,512	1,158	1,347	1,537	1,277	0	0	0	
Transit Riders (Persons)	0	0	0	0	0	0	0	0	
Occupancy Rate	1.34	1.34	1.49	1.41	1.52	0.00	0.00	0.00	
Peak Hour Off Peak Direction Volume per Lane:									
General Purpose	1,387	1,784	1,559	1,867	1,873	0	0	0	
Express/Toll	0	0	0	0	0	0	0	0	
HOV/HOT	0	0	1,800	1,085	1,433	0	0	0	
Transit Riders (Persons)	0	0	0	0	0	0	0	0	
Occupancy Rate	1.19	1.20	1.39	1.33	1.39	0.00	0.00	0.00	
Costs ($Million):									Subtotals
Construction Cost	$10.39	$15.25	$3.48	$3.06	$5.28	$0.00	$0.00	$0.00	$37.46
Right of Way Cost	$1.01	$0.60	$0.49	$0.55	$1.05	$0.00	$0.00	$0.00	$3.70
Operations Cost	$0.35	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.35
Pk Hr Recrnt Congstn Cost	$0.00	$0.00	$0.00	$0.01	$0.01	$0.00	$0.00	$0.00	$0.03
Recrnt Congstn Cost	$0.00	$0.00	$0.00	$0.01	$0.01	$0.00	$0.00	$0.00	$0.03
Subtotal Costs									$41.54
Nonrecrnt Congstn Cost	$0.16	$0.29	$0.07	$0.15	$0.18	$0.00	$0.00	$0.00	$0.85
Emissions Cost	$3.12	$5.27	$1.53	$1.57	$2.53	$0.00	$0.00	$0.00	$14.04
Fuel Consumption Cost	$1.51	$2.55	$0.72	$0.75	$1.20	$0.00	$0.00	$0.00	$6.73
Toll Cost	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.01
Toll Revenue (-$M)	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.01
Total Costs ($M)	$16.55	$23.96	$6.29	$6.10	$10.26	$0.00	$0.00	$0.00	$63.15

Toll Costs	($/veh-mile)
Peak Hour	$0.05
Peak Period Shoulder Hours	$0.04
Off Peak Period Hours	$0.02

APPENDIX C
SYSTEM PLANNING METHODOLOGY USER'S MANUAL

As part of the "Dallas Freeway/HOV System Planning Study" report, a spreadsheet-based iterative process was developed to aid system-wide planning, based upon the total cost of congestion and construction of several corridor alternatives. This process allowed the user to test alternative freeway configurations in sections of a corridor. The updated version uses a combined spreadsheet that combines the functions of the Critical Lane Volume (CLV) spreadsheet and the Cost Estimation spreadsheet. In order to use the updated software, the user must have access to a PC computer with Microsoft Windows 3.1 or higher and Microsoft Excel version 5.0 or higher. In addition, it is recommended that the user have access to a 486 computer with at least 8 megabytes memory.

The spreadsheet is divided into several worksheets. The first worksheet is the Input Sheet, and all necessary inputs are made on this worksheet. The user defines continuous sections of the corridor according to major changes in traffic volume, length, or changes in number of lanes, and inputs data for each corridor section. All unit conversions, hourly volume estimates, and cost estimations are computed on additional worksheets. The Unit Sheet handles the unit conversion from SI units to US units if the inputs are in SI units. The Output Sheet contains all the various results needed to compare corridor alternatives. The CLV Sheet estimates the critical lane volumes for both the peak and off peak direction. The Cost Sheet computes the construction, right-of-way, and recurrent congestion cost, and summarizes the toll impacts, the nonrecurrent congestion cost, the air quality cost, and the fuel consumption cost. Sheets A, B, and C compute the toll impacts for the different combinations of toll and free lanes. Sheet D estimates the nonrecurrent congestion cost. Sheet E estimates the cost of emissions, and Sheet F estimates the cost of fuel consumption. Sheet G contains the lookup table for emissions and fuel consumption factors.

Input Sheet

All inputs for the spreadsheet are contained in this worksheet. The other worksheets read the inputs from this worksheet. The inputs are described below.

The first input shows the system of units to be used either SI (International System of Units) or US (US Customary Units). Input either "si" or "us" in cell D4. The default values on the Input sheet are in US units the equivalent SI units are shown in parentheses in this user's manual.

Row 6 and row 7 contain the basic corridor information. Input the name of the corridor being analyzed in cell B6. Input the design year in cell G6. Input the alternative number and description in cells B7 and C7. Additional descriptive information can be entered into cell E7.

Define the number of continuous sections along the corridor according to major changes in traffic volume, length, changes in the number of lanes, or other vehicle movement influencing factors and give the section names according to section limits (Row 10). The number of sections in a corridor is unlimited; however, the number of columns can be increased by copying the last column multiple times in each worksheet. The process of expanding the spreadsheet is discussed in further detail below. The default number of sections is eight. The sectional information will remain the same for each alternative of a corridor and need not be changed for alternative comparisons. The sectional information is described below.

Sectional information (Row 10 to Row 31):

Row 12	Length At-Grade—Section length at grade level (kilometers or miles).
Row 13	Length Elevated—Section length elevated above grade level (kilometers or miles).
Row 15	Freeway ADT—Predicted 24-hour volumes for design year.
Row 16	HOV ADT—Predicted 24-hour volumes for multiple rider vehicles.
Row 17	AD Transit Riders—Predicted 24-hour volumes for bus passengers.
Row 18	Freeway K—Percentage (in decimal) of daily traffic in peak hour.
Row 19	Freeway D—Percentage (in decimal) of traffic traveling in the peak direction during the peak hour (also known as the peak-hour directional distribution).
Row 20	HOV K—Percentage (in decimal) of HOV daily traffic in peak hour. Default value of 0.25.
Row 21	D—Percentage (in decimal) of HOV traffic traveling in the peak direction.
Row 22	K—Percentage (in decimal) of daily bus riders in peak hour. Default value of 0.25.
Row 23	D—Percentage (in decimal) of daily bus riders traveling in the peak direction.
Row 24	Percent Carpools—Percentage (in decimal) of carpools in the defined corridor section that can be expected if no preference is given to bus and carpool traffic.
Row 25	Percent Express—Percentage (in decimal) of through traffic for a corridor.
Row 26	Capacity—Hourly freeway capacity per lane (often determined using the Highway Capacity Manual HCM procedures).
Row 27	Max % New Carpools—The maximum percentage (in percent) of new carpools that are allowed to be formed in the freeway section due to HOV treatment.
Row 28	Bus Occupancy—The average number of persons utilizing a single bus. The default value is 30.
Row 29	Carpool Occupancy—The average number of persons per eligible carpool vehicle in an HOV lane. The default value is 2.2.
Row 30	GP Occupancy—The average number of persons per vehicle in the general purpose lanes if an HOV lane is present in the alternative. The default value is 1.05.
Row 31	GP Truck Percent—The percentage (in decimal) of trucks in general purpose traffic lanes.

Additional sectional information (Row 61 to Row 66):

Row 61	Base ROW (unit of width) - the average width (meters or feet) of the existing ROW for each section of the freeway corridor.

Row 62 Existing F.R. Lanes - the existing number of frontage road lanes for each section of the freeway corridor. This spreadsheet only calculates the cost of new frontage roads where the frontage road currently exists and where additional ROW is needed. If no additional ROW is needed, it is assumed that the frontage roads are not relocated or reconstructed.

Row 63 ROW Cost $/Area - The average cost in dollars per area (square meters or square feet) for additional ROW for each section of the freeway corridor.

Row 66 Percent of section requiring noise walls - the percent of the length of each section which requires noise walls. This value is assumed to be the same for each alternative, but it can be changed if necessary.

The next section of the worksheet is the Lane Inputs section. The existing lanes are the present number of lanes in each section. Each alternative will have a different combination of proposed lanes. The proposed lanes consist of the total general purpose lanes, either free or toll. The spreadsheet assumes an equal number of lanes in each direction unless the lanes are noted as reversible. Additional lanes are in addition to the general purpose free lanes and consist of express lanes, toll lanes, HOV lanes, and HOT (High Occupancy and Toll) lanes. Bi-directional lanes are assumed to be an equal number of lanes in both directions, and reversible are assumed to be in the peak direction only. Additional lanes at-grade are assumed to be at the same grade as the general purpose lanes. The elevated lanes are assumed to be above the grade of the general purpose lanes and cantilevered over the general purpose lanes or other at grade lanes.

Row 34 Existing Lanes - Total number of existing lanes in both directions.

Proposed Lanes (Row 36 to Row 56):

Row 36 General Purpose Free - Number of general purpose free lanes.
Row 37 General Purpose Toll - Number of general purpose toll lanes.
Row 41 Express Rev At-Grade - Number of reversible express lanes at grade.
Row 42 Express Rev Elevated - Number of reversible elevated express lanes.
Row 43 Express Bi-drct At-Grade - Number of bi-directional express lanes at grade.
Row 44 Express Bi-drct Elevated - Number of bi-directional elevated express lanes.
Row 45 Toll Rev At-Grade - Number of reversible toll lanes at grade.
Row 46 Toll Rev Elevated - Number of reversible elevated toll lanes.
Row 47 Toll Bi-drct At-Grade - Number of bi-directional toll lanes at grade.
Row 48 Toll Bi-drct Elevated - Number of bi-directional elevated toll lanes.
Row 49 HOV Rev At-Grade - Number of reversible HOV lanes at grade.
Row 50 HOV Rev Elevated - Number of reversible elevated HOV lanes.
Row 51 HOV Bi-drct At-Grade - Number of bi-directional HOV lanes at grade.
Row 52 HOV Bi-drct Elevated - Number of bi-directional elevated HOV lanes.
Row 53 HOT Rev At-Grade - Number of reversible HOT lanes at grade.
Row 54 HOT Rev Elevated - Number of reversible elevated HOT lanes.
Row 55 HOT Bi-drct At-Grade - Number of bi-directional HOT lanes at grade.

Row 56 HOT Bi-drct Elevated - Number of bi-directional elevated HOT lanes.

The additional corridor inputs will remain unchanged for each alternative of a corridor; most will remain the same for each corridor analyzed as a system. The default values are given but may be changed if necessary. Each input is described below:

Cell C69	Ultimate capacity per lane - the theoretical maximum capacity per lane used for determining the level of congestion - the default value for the ultimate capacity is 2400 vehicles per hour and should not be changed.
Cell C70	Present value of person time - the default value is $11.31 per hour of person time.
Cell C71	Present value of truck time - the default value is $60.00 per hour of truck time.
Cell C72	Annualizing factor for capital costs - the annualizing factor for the present, 1997, capital cost to the 2020 design year at a 4 percent interest factor for annual compounding is 0.0673.
Cell C73	Annualizing factor for congestion - the annualizing factor to arrive at an average annual cost of congestion. The cost of congestion is calculated for the design year volume in 2020. The default value of 0.35 assumes that if the specified alternative were built today that the congestion cost is initially negligible and increases at a nonlinear rate.
Cell C74	Annualizing factor for tolls - the annualizing factor to arrive at an average annual cost of tolls. This is similar to the factor for congestion; however, an initial toll collection is assumed which will increase to the design year of 2020. The default value is given as 0.75.
Cell C75	Working days per year - the default value is 250 working days per year.
Cell C76	Present cost of volume (liter or gallon) of fuel - The default value is $1.15 per gallon ($0.28 per liter) for fuel.

Present value of emissions for DFW - The control-cost based emission factors represent the cost ($) to control a kilogram (kg) of each emission for the DFW region.

Cell C79	kilogram of VOC - The default values for VOC is $12.97 per kg.
Cell C80	kilogram of CO - The default values for CO is $2.51 per kg.
Cell C81	kilogram of NO_X - The default values for NO_X is $13.68 per kg.

The average time of incidents assumes an effective surveillance, communications, and control (SC&C), and mobility assistance programs are in place, the cost of which are included in the construction and the operating and maintenance cost.

Cell C83	Average time of incident (minutes) - the weighted average time for detection, response, and clearance for all incidents is assumed to be 30 minutes.

Toll costs (present dollars per unit of distance per vehicle) - tolls are calculated as a cost to compare to the other costs, but the toll revenue, which is the sum of the tolls collected minus some operating loses, is calculated as a benefit, which lowers the overall lowest public cost.

Cell H70	Peak hour - during the two peak hours, the default toll is $0.05 per mile ($0.03 per km) per vehicle.
Cell H71	Shoulder hours - during the 12 shoulder hours, the default toll is $0.04 per mile ($0.025 per km) per vehicle.
Cell H72	Off hours - during the remaining 10 off peak hours, the default toll is $0.02 per mile ($0.012 per km) per vehicle.
Cell I74	Percentage of toll revenue lost - toll revenue is lost to toll collection costs and financing costs. Many factors affect these costs. The default was set at zero and should be adjusted for local conditions.

Construction costs per lane unit of length - The at-grade and elevated construction costs per unit of distance (Row 86 to Row 97):

Cell B86	At-grade general purpose - At-grade construction cost (million $) of a general purpose lane per unit of distance per lane. The default value is $2.5 million per mile ($4.0 million per km) per lane.
Cell B87	At-grade express 2 lanes - Construction cost (million $) per unit of distance per lane of at-grade express lane. The default value is $3 million per mile ($4.8 million per km) per lane for one or two at-grade express lanes.
Cell B88	At-grade express 3 lanes - Construction cost (million $) per unit of distance per lane of at-grade express lane. The default value is $3.33 million per mile ($5.36 million per km) per lane for three or more at-grade express lanes.
Cell B89	At-grade HOV 1 lane - Construction cost (million $) per lane per unit of distance of at-grade HOV lane. The default value is $5 million per mile ($8.0 million per km) per lane for one at-grade express lane.
Cell B90	At-grade HOV 2 lanes - Construction cost (million $) per lane per unit of distance of at-grade HOV lane. The default value is $3.5 million per mile ($5.6 million per km) per lane for two or more at-grade HOV lanes.
Cell B91	Elevated general purpose - Construction cost (million $) per unit of distance per lane of elevated general purpose lane. The default value is $3.5 million per mile ($5.6 million per km) per lane.
Cell B92	Elevated express 2 lanes - Construction cost (million $) per unit of distance per lane of elevated express lane. The default value is $4.5 million per mile ($7.2 million per km) per lane for one or two elevated express lanes.
Cell B93	Elevated express 3 lanes - Construction cost (million $) per unit of distance per lane of elevated express lane. The default value is $5 million per mile ($8.0 million per km) per lane for three or more elevated express lanes.

Cell B94	Elevated HOV 1 lane - Construction cost (million $) per unit of distance per lane of elevated HOV lane. The default value is $7 million per mile ($11.3 million per km) per lane for one elevated HOV lane.
Cell B95	Elevated HOV 2 lanes - Construction cost (million $) per unit of distance per lane of elevated HOV lane. The default value is $5 million per mile ($8.0 million per km) per lane for two or more elevated HOV lanes.
Cell B96	SC&C - Construction cost (million $) per unit of distance of surveillance, communications, and control system. The default value is $0.5 million per mile ($0.3 million per km) for each facility, regardless of the number of lanes.
Cell B97	Noise wall cost - construction cost (million $) per unit of distance to construct noise walls where required. The default value is $1.09 million per mile ($0.68 million per km) per lane.

After any inputs are changed, the F9 key must be pressed by the user to calculate the new outputs. It is important to realize that the output for the previous alternative will remain until the F9 key is pressed and the calculations are completed. Toll alternatives require an additional step to complete the calculations. The toll cost to travel delay cost relationship equation for toll options requires several iterations to balance. To achieve this balance, both sides of the equation must be initiated, and cell H58 must be set to zero "0" prior to pressing the F9 key. After the initial calculation is completed, cell H58 must be changed to one "1" which allows the iterations to begin after the F9 key is pressed again. The spreadsheet must not be interrupted while the iterations are being processed since any keystroke will stop the procedure before a balance is achieved. For nontoll alternatives, cell H58 should be left as zero.

Unit Sheet

The Unit sheet appears the same as the input sheet with the exception that the lane inputs are removed. All the spreadsheet calculations are made with US units, and the unit sheet converts the SI inputs from the input worksheet into US units. It is important that no inputs are placed on the unit sheet to avoid writing over the conversion formulas.

Output Sheet

The Output sheet is the only worksheet that needs to be printed to compare alternatives. All the necessary information for alternative comparisons is contained on the single sheet. The top half of the worksheet, row 2 to row 42, contains the alternative description, sectional data, and lane input data which is referenced from the input or unit sheets. The peak hour, peak direction, and off peak direction vehicle volumes per lane, transit riders, and the overall occupancy rate are output in row 44 to row 56. The public costs are summarized from row 58 to row 70. The total cost for the alternative is shown in cell J70. The subtotal cost, shown in cell J64, is the sum of the capital costs and the recurrent congestion cost, which were the costs estimated in the original system plan. The toll costs are reproduced in cells B73, B74, and B75 so that alternatives with different toll levels can be compared.

CLV Sheet

The CLV sheet is designed to estimate the critical lane volume demands for the peak hour for sections of a corridor given a particular combination of lanes and the average daily traffic volumes, K and D factors, and other traffic data input into the input sheet. The only part of the CLV sheet that the user may need to change is the Ridership equation, which is used to predict the number of HOV and transit riders. The equation assumes that the directional hourly volume per lane will be used to predict HOV ridership. If another variable is used, the spreadsheet cells that reference this equation (i.e., Rows 137, 144, 151, 158, and 165) must be modified to reflect the new ridership prediction equation inputs. The default intercept value in row 37 is -0.13952, and the coefficient in row 38 is 0.00011.

The worksheet will perform all necessary calculations to estimate output values for the following worksheets with the input factors and equations. It is important for the user to determine the reasonableness and sensitivity of the model to changes in input values. This can be accomplished by changing input values (e.g., increasing and decreasing volume by 10 percent) or testing several alternative cross sections. If HOV lane projects are tested, the user should examine the percentage of new carpools and transit riders for reasonableness; values that are too high should be adjusted.

The estimates provided by the CLV sheet are located in the "Outputs" section. The critical lane volume outputs (Row 42 to Row 46) referenced by the other sheets include:

Row 42	General Purpose - The number of vehicles in a general purpose lane in the peak hour of traffic flow.
Row 43	Express - The number of vehicles in an express lane during the peak hour.
Row 44	HOV - The number of vehicles in an HOV lane during the peak hour.
Row 45	New Transit Riders - The number of new transit riders during the peak hour.
Row 46	Total Trucks - The number of trucks in the general purpose lanes during the peak hour.

Additional descriptive outputs are located in the general outputs section (Row 49 to Row 53). This information includes:

Row 49	Vehicles - Total number of vehicles in a freeway section.
Row 50	Persons - Total number of persons in a freeway section.
Row 51	Occupancy - The value obtained by dividing the total number of persons by the total number of vehicles in a freeway section.
Row 52	Vehicle Distance of Travel (VDT) - Distance traveled by vehicles in the section.
Row 53	Person Distance of Travel (PDT) - Distance traveled by persons in the section.

The final three sections of the CLV sheet are represented by the headings of "Calculations," "Adjustments," and "Iterations." The following discussion will briefly describe the process employed through these sections to manipulate the provided inputs into the listed outputs.

Preliminary values are computed from the input factors in the "Calculations" section. The capacity for the general purpose (Row 59), express (Row 60), and HOV (Row 61) lanes are calculated. The initial CLV information (Rows 63 and 64) is determined from the freeway ADT, HOV ADT, and transit riders inputs. The values of expected carpools (Row 66) are determined from the freeway ADT and the percent carpools. Last, the values of CLV needed for the "Adjustments" section are computed for total general purpose (Row 68), express only general purpose (Row 69), non-express general purpose vehicles (Row 70), and carpools (Row 71).

The "Adjustments" section has the purpose of balancing the freeway, express, and HOV volumes based on various factors. The five adjustments on the values of CLV accomplished in this section are as follows:

- Adjusted CLV from the volume per lane versus Ridership Iteration (Row 76 to Row 80)—This correction takes the input value for freeway CLV and applies the predictive HOV ridership equation to find the number of new HOV riders that can be created. This correction utilizes the "Iterations" section which begins in row 131 and continues until row 169. Additional information is also referenced in this adjustment and is provided in row 171 to row 180. The result is a freeway congestion level that is consistent with the HOV ridership value.

- Adjusted CLV for HOV Capacity (Row 83 to Row 89)—This modification examines the HOV CLV per lane and compares it to the listed capacity. If the capacity has been exceeded, carpool and bus passengers are "sent back" to the general purpose lanes in the occupancy rate specified in row 28.

- Adjusted CLV for General Purpose Congestion (Row 82 to Row 98)—In some circumstances, new HOV riders are estimated even though freeway capacity is not exceeded. This adjustment "sends back" enough HOV riders to fill the general purpose freeway lanes to capacity.

- Adjusted CLV for Max Percent New Carpools (Row 101 to Row 105)—This adaptation is performed if the calculated percentage of new carpools exceeds the specified limit from the inputs in row 25. If this occurs, carpools are "sent back" to the general purpose lanes until the percentage is lowered to the maximum permitted.

- Adjusted CLV for Corridor (Row 108 to Row 127)—Knowing that carpools and bus ridership cannot be assembled and dispersed from section to section, this adjustment identifies the critical section of the corridor, and adjusts the HOV riders and bus passengers for the other sections based on the critical section.

Other modifications can be made to the CLV sheet to meet particular needs. Caution must be employed, however, when altering the worksheet from its current form so that existing cell references are preserved.

Cost Sheet

The Cost sheet uses the inputs from the input and unit sheets and outputs from the other sheets to obtain the capital cost of construction and right-of-way, the operation cost, and the recurrent cost of congestion for each section of an alternative of a freeway corridor. The costs of tolls, nonrecurrent congestion, emissions, and fuel consumption are determined in the following worksheets and summarized in the Cost sheet.

The alternative title, sectional information, and the number of lanes are shown at the top of the worksheet in row 6 to row 26, and additional corridor inputs in row 144 to row 151 at the bottom of the worksheet are also reproduced from the unit sheet.

The critical lane volumes from the CLV sheet are shown in row 22 to row 33, and occupancy rates also from the CLV sheet are shown in row 34 to row 37.

The summation of all costs per direction in millions are annualized and shown in row 39 to row 50. These costs per direction are summed and reproduced on the Output sheet.

Row 40	Construction Cost - the annualized summation of construction cost.
Row 41	ROW Cost - the annualized summation of right-of-way cost.
Row 42	Operation Cost - the annual operating and maintenance cost for the alternative. This parameter is determined only one time per alternative and appears only in column B.
Row 43	Pk Hr Recrnt Congstn Cost - the average annual cost of recurrent congestion only during the two peak hours.
Row 44	Recrnt Congstn Cost - the total average annual cost of recurrent congestion for all hours.
Row 45	Nonrecrnt Congstn Cost - the total average annual cost of nonrecurrent congestion for all hours.
Row 46	Emissions Cost - the average annual control cost for emissions of VOC, CO, and NO_X.
Row 47	Fuel Consumption Cost - the average annual cost for fuel.
Row 48	Toll Cost - the average annual amount paid in tolls.
Row 49	Toll Revenue (-$M) - the amount of tolls collected minus some operating costs.

The peak hour critical lane volumes, the shoulder hour lane volumes, and the off hour lane volumes are summarized in row 52 to row 67. The number of transit riders per hour are shown in row 69 to row 73. The truck volumes per hour per lane are shown in row 75 to row 85.

The lost time calculations in row 87 to row 103, based on the lane volumes in row 52 to row 67, are used to determine the recurrent congestion.

The recurrent congestion costs per hour are calculated in row 105 to row 110.

The minimum required right-of-way (ROW), the ROW cost, and the number of frontage road lanes are calculated in row 112 to row 120.

Row 113	Base ROW feet - the average width of the existing ROW for each section of the freeway corridor.
Row 114	ROW Cost $/Sq ft - The average cost in dollars per square feet for additional ROW for each section of the freeway corridor.
Row 115	Existing F.R. Lanes - the existing number of frontage road lanes for each section of the freeway corridor. This worksheet only calculates the cost of new frontage roads where the frontage road currently exists and where additional ROW is needed. If no additional ROW is needed, it is assumed that the frontage roads are not relocated or reconstructed.
Row 116	Required ROW feet - the minimum ROW for the alternative in feet.
Row 117	Total required ROW feet - the sum of the required ROW in each direction.
Row 118	Added ROW feet - the additional ROW needed over the base ROW.
Row 119	Total lanes - the total number of lanes.
Row 120	Total F.R. lanes - if the total number of lanes are greater than eight then there are three frontage road lanes in each direction; otherwise, there are two in each direction.

The capital cost of construction is calculated in row 122 to row 126, and the construction costs from the unit sheet are shown in row 128 to row 136.

Sheet A

This worksheet determines the toll effects for a traditional tollway, that is, tolls on each general purpose lane. The toll cost to travel time delay cost equation is set up with the assumption that vehicles that do not pay toll are forced to the arterial street network with a constant travel delay of three minutes per mile (1.9 minutes per km), which is equivalent to 15 mph (24 kph). Because of this assumption, the all tollway option should not be run with any combination of additonal lanes. It is conceivable to have an HOV lane within a tollway section, though it is uncertain how the toll will effect HOV formation. Such an alternative would be inappropriate for this spreadsheet. On the input sheet, each section should either be all toll general purpose lanes or all free general purpose lanes. A mixture of free sections with toll sections is suitable for analysis.

Alternative data is shown in row 6 to row 24, and additional corridor inputs are shown at the bottom of the worksheet in row 148 to row 156.

The initial general purpose demand per lane per hour is calculated in row 26 to row 31, and the initial toll demands are calculated in row 33 to row 38. The initial left and right sides of the toll cost to delay cost equilibrium equation are calculated in row 40 to row 45 and row 47 to row 52. Iterations on the equation are made in row 56 to row 83, and the adjusted demands are shown in row 87 to row 92.

The spillover calculations for capacity in the general purpose lanes are made in row 94 to row 106. The volume shifted to parallel routes is shown in row 108 to row 113, and the recurrent congestion cost for the shifted vehicles is estimated in row 139 to row 144. The per hour and daily totals for the toll cost and toll revenues is estimated in row 117 to row 133.

Sheet B & Sheet C

Sheet B determines the toll effects for a mixture of toll lanes and free lanes within a section, and sheet C uses the same procedure to determine the toll effects for a mixture of HOT lanes and free lanes within a section. Similar to the problem noted in sheet A, toll lanes and HOT lanes should not be mixed within a section, since the effect on HOV formation is uncertain. It is alright to mix express lanes and HOV lanes within a section. Toll lanes and HOT lanes should also not be mixed within a corridor alternative.

Alternative data is shown in row 6 to row 29 of both worksheets, and additional corridor inputs are shown at the bottom of both worksheets in row 160 to row 167.

The initial general purpose demand per lane per hour is calculated in row 31 to row 38, and the initial toll or express volumes on sheet B or the HOV volumes on sheet C per lane per hour are calculated in row 38 to row 42. The initial toll HOT demands that result in no delay in the free general purpose lanes are calculated in row 50 to row 54. The initial left and right sides of the toll cost to delay cost equilibrium equation are calculated in row 62 to row 66 and row 68 to row 72 on both sheets. Iterations on the equation are made in row 76 to row 99, and the adjusted general purpose demands are shown in row 103 to row 108.

The spillover calculations for capacity in the general purpose lanes are made in row 110 to row 122, and the toll or express lane volumes or the HOT or HOV lane volumes are estimated in row 136 to row 140. The per hour and daily totals for the toll cost and toll revenues are estimated in row 144 to row 156.

Sheet D

The nonrecurrent congestion calculations are located in sheet D. Alternative information and additional corridor information needed to estimate nonrecurrent congestion levels is located in row 6 to 31 and row 264 to row 276. The lane volumes adjusted in sheets A, B, and C are shown in row 33 to row 48.

The vehicle distance of travel is calculated in row 50 to row 65. The section average vehicle speed estimated from the lane volumes is shown in row 67 to row 82. The speed allows the vehicle miles per incident to be estimated in row 84 to row 99, and the number of incidents per section are estimated in row 101 to row 116.

The capacity reduction for each incident is shown in row 118 to row 121, and the reduced capacity is calculated in row 123 to row 138. The volume to capacity ratio is shown in row 140 to row 155. The adjusted speed based on the volume to capacity ratio is estimated in row 157 to 172. The vehicle miles per incident and the number of incidents are recalculated based on the adjusted speed in row 174 to row 208.

The service rate volume, which is the expected level of flow through the reduced capacity section, is estimated in row 210 to row 225. The duration of queue per incident in hours is calculated in row 227 to row 242, and the additional delay per hour in vehicle hours is calculated in row 244 to row 259.

Sheet E

The emissions calculations are located in sheet E. Alternative information and additional corridor information is located in row 6 to row 19 and row 342 to row 356. The lane volumes adjusted in sheets A, B, and C are shown in row 28 to row 43. The vehicle distance of travel per section per hour is shown in row 45 to row 60. The section average vehicle speed estimated from the lane volumes is shown in row 62 to row 67.

The emissions in grams per vehicle mile are estimated in row 79 to row 131. The total hourly emissions are summed in row 135 to row 187. The emissions due to vehicles shifted to parallel routes from tollways are estimated in row 193 to row 225, and the additional emissions from nonrecurrent congestion are estimated in row 230 to row 336.

Sheet F

The fuel consumption calculations are located in sheet F. The same procedure used to calculate emissions is used to calculate the fuel consumption per alternative. The alternative information and additional corridor information is located in row 9 to row 19 and row 177 to row 186. The lane volumes adjusted in sheets A, B, and C are shown in row 25 to row 40. The vehicle distance of travel per section per hour is shown in row 42 to row 57. The section average vehicle speed estimated from the lane volumes is shown in row 59 to row 74.

The fuel consumption in gallons per vehicle mile is estimated in row 76 to row 92. The total hourly fuel consumption is summed in row 96 to row 112. The fuel consumption due to vehicles shifted to parallel routes from tollways is estimated in row 115 to row 133, and the additional fuel consumption from nonrecurrent congestion is estimated in row 138 to row 172.

Sheet G

Sheet G contains the look up table of emission rates and fuel consumption rates that are needed to estimate the amount of emissions and fuel consumption in sheets E and F. The emission rates were obtained from MOBILE5a runs for the Dallas/Ft. Worth region. The fuel consumption rates were estimated using the ARFCOM program, and the same vehicle mix was used for the emission rates. If different rates are used, it is important that the rates are placed in the correct cells corresponding with the column headings and the speeds in column A. The default rates should be suitable for other locations since only the relative difference in emissions or fuel consumption is needed for comparing different alternatives.

Expanding the worksheets

The spreadsheet is setup with eight sections, and several steps are required to expand or add sections to the spreadsheet. On the Input sheet, copy column I above the additional corridor Inputs in row 68 to column J or to as many additional columns as needed, and repeat this step for the Unit sheet. On the Output sheet, a column or the required number of columns needs to be inserted into column J, and the new sections can be copied from column I. The subtotal equations must be changed to include the new columns in the summation - change the reference in each equation from column I to column J or the last column. The remaining sheets have sections for both the peak and off peak directions of travel, and it is important that column M not be copied over. For the CLV sheet, insert the necessary number of columns between column I and column M. Copy column I to column J or to as many additional columns as needed, and copy column U to column V or to as many additional columns as needed. The equation shown in row 77 of the CLV sheet must be modified. For the "SUM($B34:$I34)" part of the equation, the letter of the column corresponding to the last (right most) column used must be inserted for the current value "I." The equations in rows 108, 109, 114, and 115 most also be changed in the same manner. All other equations refer to only one section or column at a time. The remaining sheets: the Cost sheet, and sheets A, B, C, D, E, and F, require only that the necessary number of columns be inserted between column I and M, and that columns I and U be copied to columns J and V or to as many additional columns as needed. No changes are needed for sheet G.

Summary

The worksheets, described in the preceding sections, allow the user to compare alternatives for a freeway corridor, based upon total cost of capital, recurrent and nonrecurrent congestion, emission controls, fuel consumption, and tolls. This spreadsheet can be modified from the original format to allow the user to base the alternative comparisons on additional parameters; however, caution must be employed when altering the spreadsheet from its current form so that the existing cell references are preserved. It is important for the user to determine the reasonableness of the output from the spreadsheet.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	This one combines the clv and cost sheets includes Non-recurrent congestion cost below 15 mph, improved incident delay calculation, and improved toll lane, road options, and/or HOT lane options.													
2														
3	**System Plan Corridor Critical Lane Volume and Public Cost Analysis**													
4	Input the system of units SI or US:			us										
5														
6	Corridor:	Interstate xx			Design Year:		2020							
7	Alternative:	1	Example											
8														
9	Freeway Section:	1	2	3	4	5	6	7	8					
10	Section Limits:	A - B	B - C	C - D	D - E	E - F	F - G	G - H	H - I					
11	Length (Miles)													
12	Length At-Grade	2	6	2	3	1	1	1	1					
13	Length Elevated	0.2	0.6	0.5	0.1	0.1	0.2	0.2	0.2					
14	Traffic Inputs:													
15	Freeway ADT	311,172	232,989	211,950	237,453	139,375	150,000	150,000	150,000					
16	HOV ADT	13,186	10,847	9,621	8,582	2,253	3,000	3,000	3,000					
17	AD Transit Riders (Persons)	0	1,421	2,898	4,098	4,098	200	200	200					
18	Freeway K	0.085	0.085	0.085	0.085	0.085	0.085	0.085	0.085					
19	Freeway D	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60					
20	HOV K	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25					
21	HOV D	0.75	0.80	0.80	0.90	0.90	0.75	0.75	0.75					
22	Transit K	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25					
23	Transit D	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00					
24	Percent Carpools	15%	15%	15%	15%	15%	15%	15%	15%					
25	Percent Express	60%	60%	60%	60%	60%	60%	60%	60%					
26	Capacity	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000					
27	Max % New Carpools	100	100	100	100	100	100	100	100					
28	Bus Occupancy	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00					
29	Carpool Occupancy	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20					
30	GP Occupancy	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05					
31	GP Truck Percent	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03					
32														
33	**Lane Inputs:**													
34	Existing Lanes	6	6	6	6	6	6	6	6					
35	Proposed Lanes:													
36	General Purpose Free	12	10	10	10	6	8	8	8					
37	General Purpose Toll	0	0	0	0	0	0	0	0					
38														
39	Input the type of additional lanes Reversible(one direction per peak) and/or Bi-directional(both directions per peak):													
40														
41	Express Rev At-Grade	0	0	0	0	0	0	0	0					
42	Express Rev Elevated	0	0	0	0	0	0	0	0					
43	Express Bi-drct At-Grade	0	0	0	0	0	0	0	0					
44	Express Bi-drct Elevated	0	0	0	0	0	0	0	0					
45	Toll Rev At-Grade	0	0	0	0	0	0	0	0					
46	Toll Rev Elevated	0	0	0	0	0	0	0	0					
47	Toll Bi-drct At-Grade	0	0	0	0	0	0	0	0					
48	Toll Bi-drct Elevated	0	0	0	0	0	0	0	0					
49	HOV Rev At-Grade	0	0	0	0	0	0	0	0					
50	HOV Rev Elevated	0	0	0	0	0	0	0	0					
51	HOV Bi-drct At-Grade	0	0	0	0	0	0	0	0					
52	HOV Bi-drct Elevated	0	0	0	0	0	0	0	0					
53	HOT Rev At-Grade	0	0	0	0	0	0	0	0					
54	HOT Rev Elevated	0	0	0	0	0	0	0	0					
55	HOT Bi-drct At-Grade	0	0	0	0	0	0	0	0					
56	HOT Bi-drct Elevated	0	0	0	0	0	0	0	0					
57														
58	For Toll Demand iterations set to zero 0 to initiate calculation, to start iterations change to one 1							0						
59														
60	Right-of-Way													
61	Base ROW Feet	300	300	300	300	300	300	300	300					
62	ROW Cost $/Sq Ft	30	30	30	30	30	30	30	30					
63	Existing F.R. Lanes	4	4	4	4	4	4	4	4					
64														
65	Percent of Section													
66	Requiring Noise Walls	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%					
67														
68	Additional Corridor Inputs:													
69	Ultimate Capacity per lane		2400	Vehicles per Hour			Toll Costs	($/mile)						
70	Present Value of Person Time		$11.94				Peak Hour	$0.05						
71	Present Value of Truck Time		$60.00				Shldr Hrs	$0.04						
72	Annualizing Factor for Capital Costs		0.0673				Off Hrs	$0.02						
73	Annualizing Factor for Congestion		0.35											
74	Annualizing Factor for Tolls		0.75				Toll Revenue Lost %		0.00%					
75	Working Days per Year		250											
76	Present Cost of Gallon of Fuel		$1.15											
77														
78	Present Value of Emissions for DFW													
79	kg of VOC		$12.97											
80	kg of CO		$2.51											
81	kg of NOx		$13.68											
82														
83	Average Time of Incident (min)		30											
84														
85	Construction Costs ($M)	Per Lane Mile												
86	At-Grade GP	$2.50												
87	At-Grade Express (2 lanes)	$3.00												
88	At-Grade Express (3 lanes)	$3.33												
89	At-Grade HOV (one lane)	$5.00												
90	At-Grade HOV (2 lanes)	$3.50												
91	Elevated GP	$3.50												
92	Elevated Express (2 lanes)	$4.50												
93	Elevated Express (3 lanes)	$5.00												
94	Elevated HOV (one lane)	$7.00												
95	Elevated HOV (2 lanes)	$5.00												
96	SC&C.	$0.50												
97	Noise Wall Cost	$1.09												

SPM Input Sheet

	A	B	C	D	E	F	G	H	I	J
1	**System Plan Corridor Critical Lane Volume and Public Cost Analysis Output**									
2	System of Units: US									
3									22-Sep-97	
4	Corridor:	Interstate xx			Design Year:		2020			
5	Alternative:	1	Example							
6										
7	Freeway Section:	1	2	3	4	5	6	7	8	
8	Section Limits:	A - B	B - C	C - D	D - E	E - F	F - G	G - H	H - I	
9	Length (Miles)									
10	Length At-Grade	2	6	2	3	1	1	1	1	
11	Length Elevated	0.2	0.6	0.5	0.1	0.1	0.2	0.2	0.2	
12										
13	Traffic Inputs:									
14	Freeway ADT	311,172	232,989	211,950	237,453	139,375	150,000	150,000	150,000	
15	HOV ADT	13,186	10,847	9,621	8,582	2,253	3,000	3,000	3,000	
16	AD Transit Riders	0	1,421	2,898	4,098	4,096	200	200	200	
17	Freeway K	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	
18	Freeway D	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	
19	Carpool Occupancy	2.20	2.20	2.20	2.20	2.20	2.20	2.20	2.20	
20	GP Occupancy	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	
21										
22	Lane Inputs:									
23	Existing Lanes	6	6	6	6	6	6	6	6	
24	Proposed Lanes:									
25	General Purpose Free	12	10	10	10	6	8	8	8	
26	General Purpose Toll	0	0	0	0	0	0	0	0	
27	Express Rev At-Grade	0	0	0	0	0	0	0	0	
28	Express Rev Elevated	0	0	0	0	0	0	0	0	
29	Express Bi-drct At-Grade	0	0	0	0	0	0	0	0	
30	Express Bi-drct Elevated	0	0	0	0	0	0	0	0	
31	Toll Rev At-Grade	0	0	0	0	0	0	0	0	
32	Toll Rev Elevated	0	0	0	0	0	0	0	0	
33	Toll Bi-drct At-Grade	0	0	0	0	0	0	0	0	
34	Toll Bi-drct Elevated	0	0	0	0	0	0	0	0	
35	HOV Rev At-Grade	0	0	0	0	0	0	0	0	
36	HOV Rev Elevated	0	0	0	0	0	0	0	0	
37	HOV Bi-drct At-Grade	0	0	0	0	0	0	0	0	
38	HOV Bi-drct Elevated	0	0	0	0	0	0	0	0	
39	HOT Rev At-Grade	0	0	0	0	0	0	0	0	
40	HOT Rev Elevated	0	0	0	0	0	0	0	0	
41	HOT Bi-drct At-Grade	0	0	0	0	0	0	0	0	
42	HOT Bi-drct Elevated	0	0	0	0	0	0	0	0	
43										
44	Peak Hour Peak Direction Volume per Lane:									
45	General Purpose	2,400	2,400	2,400	2,400	2,400	2,015	2,015	2,015	
46	Express/Toll	0	0	0	0	0	0	0	0	
47	HOV/HOT	0	0	0	0	0	0	0	0	
48	Transit Riders (Persons)	0	355	725	1,025	1,025	50	50	50	
49	Occupancy Rate	1.21	1.26	1.29	1.29	1.26	1.14	1.14	1.14	
50										
51	Peak Hour Off Peak Direction Volume per Lane:									
52	General Purpose	1,826	1,619	1,471	1,598	1,571	1,296	1,296	1,296	
53	Express/Toll	0	0	0	0	0	0	0	0	
54	HOV/HOT	0	0	0	0	0	0	0	0	
55	Transit Riders (Persons)	0	0	0	0	0	0	0	0	
56	Occupancy Rate	1.14	1.13	1.13	1.08	1.06	1.09	1.09	1.09	
57										
58	Costs ($Million):									Subtotals
59	Construction Cost	$6.90	$18.39	$7.15	$8.52	$1.19	$1.76	$1.76	$1.76	$47.44
60	Right of Way Cost	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
61	Operations Cost	$0.10	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.10
62	Pk Hr Recrnt Congstn Cost	$4.39	$11.61	$4.58	$5.76	$1.25	$0.07	$0.07	$0.07	$27.79
63	Recrnt Congstn Cost	$13.81	$25.09	$4.90	$13.98	$1.39	$0.07	$0.07	$0.07	$59.37
64	Subtotal Costs									$106.91
65	Nonrecrnt Congstn Cost	$28.54	$52.04	$11.91	$31.73	$3.32	$0.17	$0.17	$0.17	$128.07
66	Emissions Cost	$4.61	$10.32	$3.35	$5.08	$1.02	$1.16	$1.16	$1.16	$27.85
67	Fuel Consumption Cost	$2.26	$5.02	$1.69	$2.45	$0.51	$0.58	$0.58	$0.58	$13.67
68	Toll Cost	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
69	Toll Revenue (-$M)	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
70	Total Costs ($M)	$56.21	$110.86	$29.00	$61.75	$7.44	$3.74	$3.74	$3.74	$276.50
71										
72	Toll Costs	($/veh-mile)								
73	Peak Hour	$0.05								
74	Peak Period Shoulder Hours	$0.04								
75	Off Peak Period Hours	$0.02								

SPM Output Sheet