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PRELIMINARY EVALUATION OF APPLICABLE  
PRIORITY TREATMENT TECHNIQUES ON  
EXISTING URBAN FREEWAYS IN TEXAS

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## ABSTRACT

Congestion is increasing significantly on Texas urban freeways. One means of increasing roadway capacity is to provide preferential treatment for high-occupancy vehicles (HOV).

This report documents the preliminary screening of five alternative priority treatment techniques that could be applied to 26 urban freeways in Texas. The improvements that could be undertaken are identified. No attempt is made to identify what HOV improvement should be undertaken. At least one priority treatment technique that appears to be technically feasible for each of the 26 freeways studied is identified.

Key words: Priority Treatment, High-Occupancy Vehicles, Exclusive Busway, Contraflow Lane, Reserved Lane-Concurrent Flow, Freeway Control with Priority Entry, Use of Frontage Roads.

## SUMMARY

Since the 1970's, congestion has increased significantly on urban free-ways in Texas. Approaches to increasing roadway capacity in a number of free-way corridors are being considered. One means to increase this capacity is to provide preferential treatment for high-occupancy vehicles. Availability of federal funding may require that HOV improvements at least be evaluated.

Five alternative priority treatment techniques are considered in this report. Each of those techniques requires certain freeway design features to exist in order to enhance feasibility. The applicability of the priority treatment techniques to 26 urban freeways in Texas is considered in this report.

This report provides a preliminary screening only; it documents those improvements that could be undertaken and does not identify the HOV improvement, if any, that should be undertaken. Cost/benefit studies may need to be performed to identify the most effective improvement. Also, HOV improvements that could be implemented within 5 years are emphasized; that eliminates improvements that would require a major freeway reconstruction in order to be implemented.

This report identifies at least one priority treatment technique that appears to be technically feasible for each freeway studied. However, no technique was identified that was both feasible and desirable in both peak periods for 8 of the freeways evaluated.

The material included in this report represents a summation of a lengthy working document submitted to the Department.

## IMPLEMENTATION STATEMENT

This project is oriented to assist the Department in planning and implementing priority treatment techniques for high-occupancy vehicles. Inclusion of HOV lanes has become a major consideration in obtaining federal approval for roadway improvements.

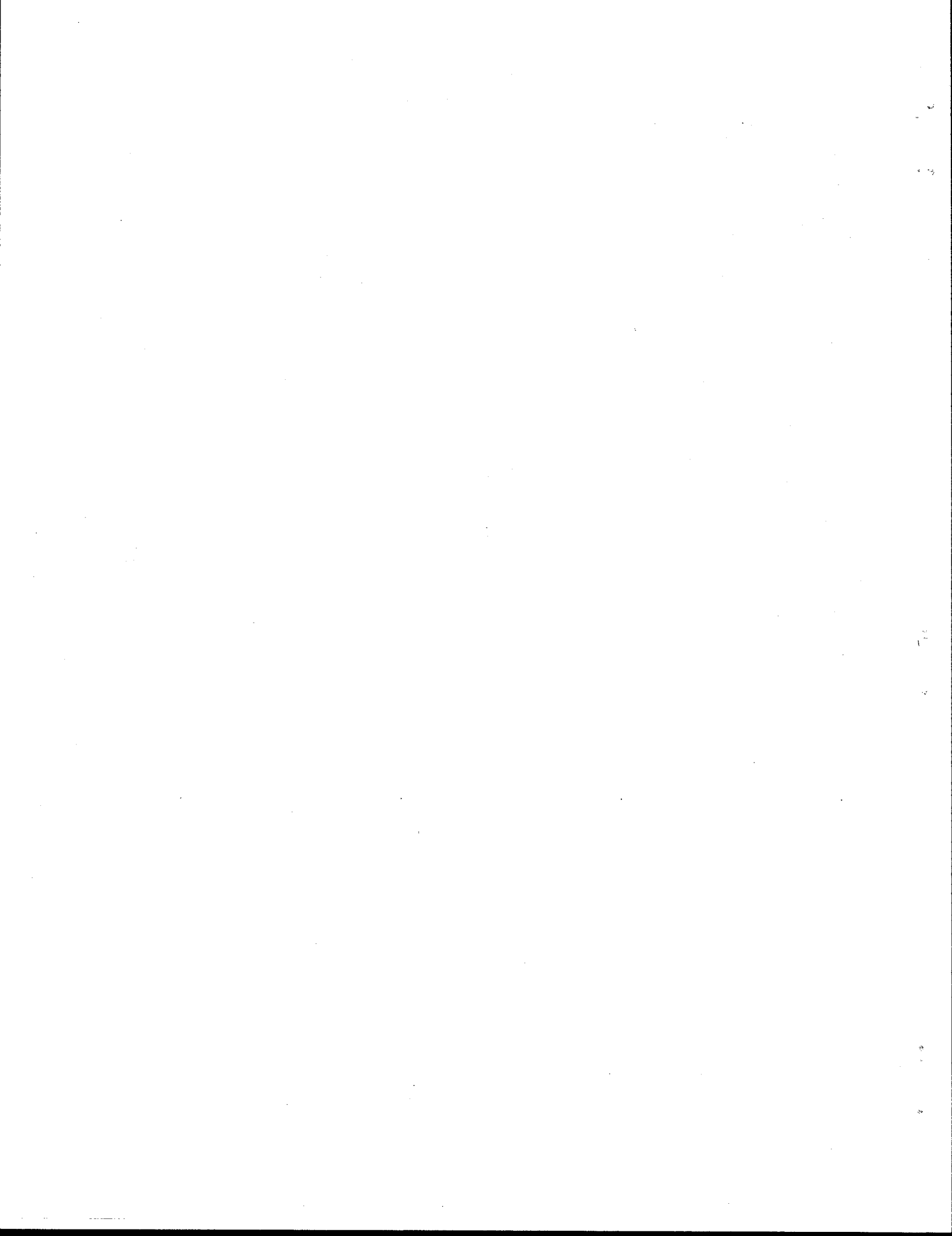
This report provides a preliminary screening of the applicability of various priority treatment techniques to radial freeways in Texas. The findings indicate those improvements that, based on existing design and operation, *could* be implemented on the various freeways in a relatively short time period (~5 years). The findings should not be interpreted to imply that those improvements *should* be implemented. Rather more intensive future evaluations, including benefit/cost analyses, can primarily focus on those improvements identified in this report as being applicable techniques for the freeway being studied.

## 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 or policies of the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.

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## INTRODUCTION

The development of guidelines for evaluating the suitability of various priority treatment techniques for urban freeways in Texas has been a primary objective of this research effort since its inception in 1974. A previous report developed under this study, Research Report 205-1 entitled "Evaluation of Alternative Concepts for Priority Use of Urban Freeways in Texas," provided some general guidelines, but they were not sufficiently specific to enable a determination as to which techniques were or were not applicable to any specific facility.

Due to the rapid growth experienced by several cities in Texas during the last few years, the need to implement some form of priority treatment for buses, carpools, and vanpools appears imminent. Also, the need to consider possible improvements is becoming more important in obtaining federal approval for roadway improvements. Hence, a preliminary evaluation of applicable priority treatment techniques was conducted for each of 26 radial freeways in the five largest cities in Texas. This report documents the results of that effort.

This report is, in effect, a summary of a much larger report. The larger report included both a schematic of each of the 26 freeways studied as well as an independent evaluation of each of those freeways. This report documents the methodology used in the analyses as well as the results of the applications of that methodology. The individual freeway evaluations are not included in this document.

The information included in this report is intended to facilitate the implementation process for HOV improvements in Texas.



## EVALUATION METHODOLOGY

In evaluating the potential for priority treatment on roadways in Texas, a number of alternative improvements justify consideration.

The intent of this section of the report is to screen the available priority treatment techniques. This section of the report identifies those priority treatments that appear to be technically feasible for application to roadways in Texas. The evaluation methodology yields those improvements that could be undertaken, not necessarily those that should be undertaken; more detailed studies are needed to identify the most desirable HOV improvement.

A previous research report (205-1) has identified and described alternative priority techniques. The applicability of the following 5 priority treatments to specific Texas Freeways is considered in this report.

1. Exclusive Busway - lanes that are physically separated from other traffic;
2. Contraflow lane - a lane reserved for buses on the left-hand side of the median barrier;
3. Reserved Lane-Concurrent Flow - a lane reserved for high-occupancy vehicles in the normal direction of flow that is not physically separated from other lanes;
4. Freeway Control with Priority Entry - a situation where total freeway traffic volumes are controlled by traffic signals at entry ramps, with high-occupancy vehicles provided special entry ramps; and
5. Use of Frontage Roads - the use of signal preemption, reserved lanes, or other devices to expedite the movement of buses along freeway frontage roads or other surface streets.

### Underlying Assumptions

Each of these techniques requires a different set of design and operational characteristics in order to be applicable to a specific freeway. A set of design and operational characteristics considered critical to the implementation

of each of the 5 techniques is developed as part of this research effort. In developing those characteristics, the underlying assumptions set forth below were utilized. If different underlying assumptions are considered, different guidelines will result.

1. Negative effects on existing traffic capacity available to the general public should be minimized.
  - a. To be effective and enforceable, all of the techniques implemented must have the support of the general public. An episode similar to the Los Angeles "Diamond Lane" controversy would be highly undesirable.
  - b. Removal of emergency parking shoulders would probably be acceptable as would narrowing of lane widths along short sections of roadway. Removal of an existing lane of travel in a congested portion of the freeway probably would not be acceptable.
2. The application of priority treatment to any segment of freeway should result either in improved HOV travel speeds or in improved bus schedule reliability.
  - a. Priority treatment along portions of freeways that are operating at 45 mph or better in mixed flow would yield little if any benefit. Such projects could not be justified unless there is strong evidence that the "free-flow" conditions will be short-lived and that early implementation of priority treatment would be beneficial.
  - b. No consideration is given to trying to force a reduction in Vehicle-Miles-of-Travel (VMT) through the implementation of priority treatment. The primary objective of priority treatment techniques is to increase the effective capacity of the existing facilities.

#### Design and Operational Characteristics

For each type of priority improvement, the design and operational characteristics of a freeway which are critical to implementation of that technique are presented in this section. It should be noted that these characteristics are divided into two sets: those considered to be "Required Attributes," and those considered to be "Desired Attributes." If a specific freeway does not

meet all of the "Required Attributes" for a certain priority treatment technique, then that particular technique is considered technically infeasible for application to the freeway being evaluated. The "Desired Attributes" are to be considered only if all "Required Attributes" are satisfied. If all desired characteristics are not met, the improvement may be undesirable but not necessarily infeasible.

The results of this evaluation present an indication of those techniques that initially appear to at least be feasible. More detailed evaluations would then be required to identify which HOV improvement, if any, really is the optimum improvement.

#### Exclusive Busway

The following exclusive busway guidelines pertain to the construction of busways that are primarily at-grade and only one-lane wide (In other words-- busways that can be built in existing freeway medians). A totally new grade-separated busway could probably be designed to follow any existing freeway. However, this study pertains to priority treatment techniques that can be implemented in approximately five years; therefore, totally grade-separated busways are not considered relevant.

Another point concerning busways should be made. Based on the criteria set forth in this section, a freeway should have a continuous wide median in order to consider application of this technique. However, cost/benefit studies performed in Houston have indicated that this can be an extremely effective HOV improvement. Thus, a cost/benefit study would probably be justified before this technique is totally rejected for any freeway; that is, the benefits that accrue may be sufficiently substantial to justify a large investment of funds

to make a freeway cross section accommodate a median busway. Such a construction effort, however, will probably take more than 5 years to complete.

Required Attributes. The following attributes are considered essential for application of an exclusive busway to an existing freeway.

- Continuous wide median section (≈20 feet wide) available along most of the critical segment.

*Note: Some occasional discontinuities can be accommodated at reasonable costs. For example, a short stretch of narrow median might be spanned by an elevated section or an extremely narrow cross-section. Also, discontinuities at overpass structures can sometimes be handled by decking between the two roadway structures or by the elimination of shoulders on the main travel lanes.*

- Buses are able to reach the exclusive lane expeditiously.

*Note: This can probably be accomplished at-grade if the desired entry point for buses is upstream of the congested section. If the improvement is several miles in length, opportunities for midpoint entry should exist.*

- No left-hand entrances or exits that cannot be grade-separated within available right-of-way.
- No existing underpasses with center columns that cannot be negotiated by restriping lanes or some device other than eliminating the columns.

Desired Attributes. The following attributes are considered desirable for application of an exclusive busway to an existing freeway.

- Minimum median clutter requiring relocation (Luminaire posts, sign structures, drainage inlets, etc.).
- Minimum grade differentials between roadways on each side of the median.
- Continuous median shoulders across existing overpass structures.

### Contraflow Lane

Required Attributes. The following attributes are considered absolute requirements for applicability of a contraflow lane.

- Minimum of three through lanes in the off-peak direction.

*Note: At least two remaining travel lanes must be available to the general public in the off-peak direction for the roadway to continue to function as a freeway.*

- A directional split high enough that the resulting flow rates in the off-peak direction will not exceed 1700\* vehicles per hour per lane after the lane is removed.

*Note: Flow rates as high as 1700 vehicles per hour per lane result in level-of-service E (speeds of 30-40 mph) and can easily deteriorate into level-of-service F (Stop-and-Go).*

- No left-hand entrance and exit ramps without bypass opportunities.

*Note: Obviously, these ramps would cause traffic conflict problems.*

- An opportunity to design a safe entrance to, and exit from, the contraflow lane on each end of the congested portion.

*Note: Safety considerations include sufficient sight distance, adequate weaving opportunity, and opportunity for police to enforce the restrictions.*

Desired Attributes. The following attributes are considered desirable for a contraflow lane.

- A directional split such that the resulting flow rates in the off-peak direction would be less than 1500\* vehicles per hour per lane after the lane is removed.
- An available median shoulder over most of the route for stalled vehicles.
- Acceptable sight distances along the freeway for safe operation during periods of infrequent bus traffic.
- Continuous freeway lighting over the entire contraflow segment.

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\*Special note: The absolute values of 1700 and 1500 vehicles per hour per lane are used as convenient, immediately available proxies for a level-of-service condition. The intent of this Attribute is to insure that conditions no worse than the beginning range of level-of-service E are imposed on those drivers that had been enjoying free-flow conditions (level-of-service A or B). It would be desirable if they were not forced further up the scale than level-of-service C (for which 1500 is used). It should be recognized that geometric conditions at any specific location can significantly change the actual flow rate that corresponds to a certain level-of-service. More detailed analyses would be required to determine the best flow rate value to be used on each freeway segment.

- Opportunities for designing intermediate entries to, and exits from, the contraflow lane, thereby increasing the flexibility of operations.

*Note: This attribute probably requires a wide median (at least 20 feet wide) in those locations where entry and exit points are desired.*

### Reserved Lane-Concurrent Flow

Evaluation of problems encountered concerning safety, public acceptance, operation, and enforcement of concurrent flow lanes have led to a recommendation against further implementation of this technique when that implementation involves taking a lane away from the general traffic. If a new lane is added to the facility to function as the concurrent flow lane, this treatment becomes less unattractive although probably not as desirable as other priority treatments that might be implemented if the space were available to add an extra lane. However, short segments of concurrent flow lanes, designed to connect with and provide transitions to other forms of priority treatment, may represent a means of greatly enhancing the flexibility associated with new freeway construction as well as the effectiveness of the other priority treatments; for example, a short section of concurrent flow lane is being evaluated as a possible approach to the I-45N contraflow lane in Houston.

As a result, this is not considered as a separate technique for evaluation in this report; its use would only be over short sections and, most likely, in conjunction with some other form of priority treatment.

### Freeway Control and Priority Entry

Required Attributes. The following attributes are considered to be absolute requirements for implementing this priority technique.

- Capability to control the total volume of traffic on the freeway sufficiently to assure no worse than level-of-service D in the critical segment.



*Note: It is considered highly undesirable if freeway-to-freeway traffic must be reduced sufficiently to back the queue onto the other freeway in order to meet this requirement.*

- Adequate queueing space available at each control location.

*Note: If isolated ramps fail to meet this criteria, they should either be closed completely or dedicated totally to high-occupancy vehicles (HOV's).*

- Available HOV entry ramp locations to permit HOV's to bypass queued vehicles to enter the freeway.

Desired Attributes. The following attributes are considered desirable for implementation of freeway control with priority entry.

- Continuous frontage roads--at least to an intersection with a suitable arterial street that could be used as a diversionary route.

*Note: This feature would permit cars to enter the ramp queue and remain long enough for the drivers to estimate how long it would require to enter the freeway and then divert to the frontage road if they so desire.*

- The ability to control the traffic along a section of freeway by installing ramp control at all entrance ramps along that portion of freeway and without placing unacceptably severe restrictions on traffic entering at certain ramps.

*Note: Cases of "discriminatory" metering may result in protests from those neighborhoods affected.*

### Use of Frontage Roads

Required Attributes. The following attributes are considered to be absolute requirements for implementing this priority technique.

- Continuous frontage roads over the length of the critical segment (or a combination of frontage roads and suitable parallel surface arterial streets).
- The ability to clear the queue ahead of the bus whenever signal preemption is used.

Desired Attributes. The following attribute is considered desirable for implementation of priority treatment on frontage roads.

- At least three approach lanes to each high volume intersection so that the buses will not be impeded by turning movements.

Using these criteria, the following section of this report documents the results of applying the evaluation methodology to 26 urban freeways in the five largest Texas cities.

## EVALUATION OF SPECIFIC FREEWAYS

The following list of radial freeways is evaluated to determine which priority techniques might be applicable in accordance with the guidelines presented in the previous section of this report. Only radial freeways approaching the central business district of each respective city were included in this list.

Houston	- North Freeway	(I-45)
	Eastex Freeway	(US 59)
	East Freeway	(I-10)
	Southwest Freeway	(US 59)
	Katy Freeway	(I-10)
Dallas	- Stemmons Freeway	(I-35E)
	North Central Expressway	(US 75)
	R. L. Thornton Freeway-East	(I-30)
	South Freeway	(I-45)
	R. L. Thornton Freeway-South D/FW Turnpike	(I-35E) (I-30)
Ft. Worth	- North Freeway	(I-35W)
	Airport Freeway	(SH 121)
	D/FW Turnpike	(I-30)
	Poly Freeway	(US 287)
	South Freeway	(I-35W)
	West Freeway	(I-30)
San Antonio	- Northwest Expressway	(I-10)
	McAllister Expressway	(US 281)
	North PanAm Expressway	(I-35)
	I-10 East	
	I-37 Southeast	
	South PanAm Expressway US 90 West	(I-35)
El Paso	- I-10 West	
	I-10 East	

The Gulf Freeway (I-45S) in Houston was not included in this evaluation because it is presently being reconstructed--a process that will take several years to complete. An exclusive median busway is being incorporated into that reconstruction.

## Determinations Regarding Applicable Priority Treatments

One of three determinations was made concerning each of the five priority treatment techniques for every freeway\*.

- If any "Required Attributes" were not met, the finding was No -- meaning that this priority treatment technique is not applicable to this particular freeway.
- If all "Required Attributes" were satisfied, but few, if any, of the "Desired Attributes" were present, the finding was Undesirable -- meaning that the application of this technique to this particular freeway is technically feasible, but an undesirable operating situation will result.
- If all "Required Attributes" and most "Desired Attributes" were satisfied, the finding was Yes -- meaning that this particular priority treatment technique is applicable to this freeway.

Again, however, this evaluation, by itself, is not sufficient to identify the particular treatment that should be applied to any particular facility. Cost/benefit analyses are the appropriate means of determining the most effective HOV improvement.

The results of applying the criteria set forth in this report to the 26 urban freeways in Texas are presented in the following section of this report.

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\*Note: If directional split data were not available for a specific freeway, an entry of "unknown" is made concerning the feasibility of contraflow.

## MAJOR FINDINGS

A lengthy working document evaluating each individual freeway was submitted to the Department. That document contained, for each freeway studied, the following information.

- A summary of findings on applicability of various techniques,
- An evaluation sheet for each of four priority treatment techniques, and
- A set of schematic strip maps showing design characteristics of that freeway.

The major findings identified in that working document are summarized in this section.

Initially, this study was to determine the applicability of five different priority treatment techniques to specific radial freeways in Texas; however, one of the five techniques (concurrent flow reserved lane) was dropped from further consideration. The operational problems with, and severe, adverse public reaction to, Reserved Lane-Concurrent Flow projects in other cities were sufficient to justify a conclusion that this technique is not a desirable approach for any purpose other than transition to other types of priority treatment. A summary of the findings concerning the applicability of the four other techniques to each freeway, by city, is presented in Table 1.

At least one priority treatment technique that appears to be technically feasible is identified for each freeway. However, no technique was identified that was both feasible and desirable in both peak periods for the following freeways.

Eastex Freeway (US 59) - Houston

Stemmons Freeway (I-35) - Dallas

North Central Expressway (US 75) - Dallas

D/FW Turnpike (I-30), Dallas and Ft. Worth ends

Table 1: Applicability of Priority Treatment Techniques on Radial Freeways in Texas by City

City	Freeway	Priority Treatment Technique <sup>1</sup>			
		Exclusive Busway	Contraflow	Freeway Control <sup>2</sup>	Frontage Roads
Houston	North (I-45)	Yes	Yes	Und.	No
	Eastex (US 59)	No	Und.	A.M. - Yes P.M. - Und.	No
	East (I-10)	Yes	A.M. - Und. P.M. - No	Und.	No
	Southwest (US 59)	Yes	No	A.M. - Yes P.M. - Und.	Yes
Dallas	Katy (I-10)	Und. <sup>3</sup>	No	A.M. - Yes P.M. - Und.	Yes
	Stemmons (I-35)	No	No	Und.	No
	North Central (US 75)	No	No	Und.	No
	Thornton East (I-35)	No	Yes	A.M. - Yes P.M. - No	No
	South (I-45)	Yes	Unknown	A.M. - Yes P.M. - Und.	No
	Thornton South (I-35) D/FW Turnpike (I-30)	No No	Yes Unknown	Und. A.M. - Yes P.M. - No	No No
Ft. Worth	North (I-35)	Yes	No	A.M. - Yes P.M. - No	No
	Airport (SH 121)	Yes	Unknown	A.M. - Yes P.M. - Und.	No
	D/FW Turnpike (I-30)	No	No	A.M. - Yes P.M. - No	No
	Poly (US 287)	Yes	Unknown	A.M. - Und. P.M. - No	No
	South (I-35)	No	No	A.M. - Yes P.M. - Und.	Yes
San Antonio	West (I-20)	No	No	Yes	No
	Northwest (I-10)	No	No	A.M. - Yes P.M. - No	No
	McAllister (US 281)	No	Unknown	A.M. - Yes P.M. - Und.	No
	North PanAm (I-35)	Yes	Unknown	Und.	Yes
	I-10 East	Yes	Unknown	Und.	No
	I-37 South	Und.	Und.	Und.	No
	South PanAm (I-35) - Into CBD - Between SH422 and I-10/US 90	No Yes	No Unknown	Und. Yes	No Yes
	US 90 West	Yes	Unknown	No	No
El Paso	I-10 East	Yes	A.M. - Yes P.M. - No	Und.	No
	I-10 West	Und.	No	A.M. - Yes P.M. - No	No

Und. = Undesirable, technically feasible but not a desirable application.

Unknown = Favorable design criteria, but unknown operational characteristics.

<sup>1</sup>This is, essentially, a summary of what HOV improvements could be undertaken on the various freeways with an implementation time of about 5 years. A cost/benefit study would be needed to determine what improvements should be pursued. This is particularly true for exclusive busways where the large benefits associated with that improvement may justify a higher implementation cost.

<sup>2</sup>Freeway control does provide opportunities to improve traffic flow for all vehicles which also will benefit HOV's.

<sup>3</sup>This conclusion assumes that a major reconstruction of Katy Freeway will not occur. If such a reconstruction occurs, the busway becomes feasible (refer to Research Report 205-10).

Northwest Expressway (I-10) - San Antonio

I-37 South - San Antonio

South PanAm Expressway (I-35), into CBD - San Antonio

I-10 West - El Paso

In summary, the applications of a suitable priority treatment technique to each of these freeways will require major construction projects that will be expensive and require several years to implement.

In Table 2, a summary of each evaluated preferential technique is shown along with a listing of the applicable freeways which appear to be suitable for that technique. While freeway control applications seem to outnumber other possibilities, the installation of HOV bypass lanes at most entrance ramps was typically found to be applicable only in the morning peak period. Freeway control applied to the afternoon peak flow direction would, however, benefit all traffic including high-occupancy vehicles.

This evaluation is intended to serve as a basis for identifying preferential techniques which might be expeditiously implemented along specific freeways that are presently experiencing capacity problems during peak periods. Certainly, the applicable approaches suggested herein are only a starting point. Intensive design studies of particular applications may be warranted before a specific technique is selected for implementation; such studies may require cost/benefit analyses.

Table 2: Applicable Freeways for Various Priority Treatment Techniques

Exclusive Busway	Contraflow	Freeway Control	Frontage Roads
North (I-45N) - Houston East (I-10) - Houston Southwest (US 59) - Houston South (I-45) - Dallas North (I-35) - Ft. Worth Airport (SH 121) - Ft. Worth Poly (US 287) - Ft. Worth N. PanAm (I-35) - San Antonio I-10 East - San Antonio S. PanAm (I-35) - San Antonio US 90 West - San Antonio I-10 East - El Paso	North (I-45N) - Houston Thornton E. (I-30) - Dallas Thornton S. (I-35) - Dallas I-10 East - El Paso (a.m.)	Turnpike (I-30) - Dallas (a.m.) Southwest (US 59) - Houston (a.m.) Katy (I-10) - Houston (a.m.) Thornton E. (I-30) - Dallas (a.m.) D/FW Turnpike (I-30) - Dallas (a.m.) North (I-35) - Ft. Worth (a.m.) Airport (SH 121) - Ft. Worth (a.m.) D/FW Turnpike (I-30) - Ft. Worth (a.m.) South (I-35) - Ft. Worth (a.m.) West (I-30) - Ft. Worth Northwest (I-10) - San Antonio (a.m.) McAllister (US 281) - San Antonio (a.m.) S. PanAm (I-35) - San Antonio (a.m.) I-10 West - El Paso (a.m.)	Southwest (US 59) - Houston Katy (I-10) - Houston South (I-35) - Ft. Worth N. PanAm (I-35) - San Antonio S. PanAm (I-35) - San Antonio

Note: The above list included only those freeways which appeared to be feasible and desirable candidates under each technique. Cost/benefit analyses will provide an indication of what HOV improvement is actually most effective.