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16. Abstract

The major urban areas in Texas have experienced a period of unprecedented growth. Along with that growth came significant increases in traffic congestion with corresponding declines in urban mobility. This study uses available traffic data to assess the relative mobility levels in Austin, Corpus Christi, Dallas, El Paso, Fort Worth, Houston and San Antonio between 1975 and 1984. An estimate of the number of years before congestion reaches an undesirable level was generated for each major urban area.

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METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
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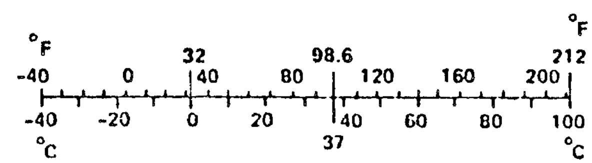
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



RELATIVE MOBILITY IN TEXAS CITIES, 1975 TO 1984

by

Timothy J. Lomax
Assistant Research Engineer

Research Report 339-8

Improving Urban Mobility Through Application of
High-Occupancy Vehicle Priority Treatments

Research Study Number 2-10-84-339

Sponsored By

State Department of Highways and Public Transportation
in cooperation with the
U.S. Department of Transportation
Federal Highway Administration

TEXAS TRANSPORTATION INSTITUTE
The Texas A&M University System
College Station, Texas 77843

December 1986

ABSTRACT

The major urban areas in Texas have experienced a period of unprecedented growth. Along with that growth came significant increases in traffic congestion with corresponding declines in urban mobility. This study uses available traffic data to assess the relative mobility levels in Austin, Corpus Christi, Dallas, El Paso, Fort Worth, Houston and San Antonio between 1975 and 1984. An estimate of the number of years before congestion reaches an undesirable level was generated for each major urban area.

Key Words: Mobility, Congestion, Transportation Planning

IMPLEMENTATION STATEMENT

As a means of assisting the State Department of Highways and Public Transportation in planning future highway needs and identifying funding requirements, it is desirable to have a measure of the seriousness of the congestion and mobility problem in major Texas cities. The report provides a quantification of those mobility levels. This information should be of value in identifying and prioritizing transportation needs.

DISCLAIMER

SUMMARY

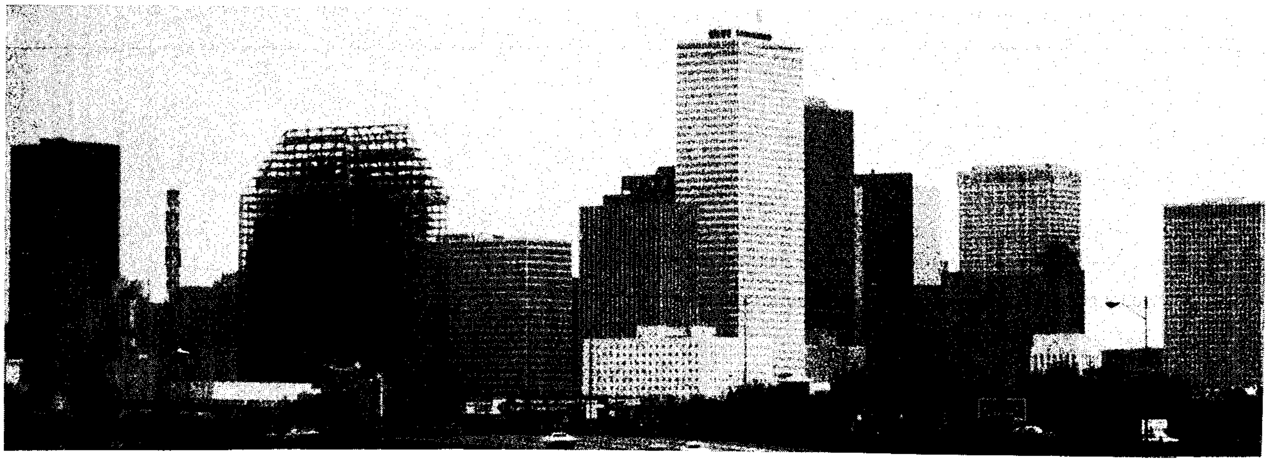
In the last 15 to 20 years, maintaining mobility in major Texas cities has become increasingly difficult as the economy of the Sunbelt has expanded. The rapid rise of urban Texas population during the 1970s and 1980s was, in part, due to the perceived "quality of life" enjoyed in the 1960s and 1970s by residents of Texas cities. The decrease in the rate of urban freeway and arterial roadway construction during the 1970s coincided with an increase in traffic volumes to bring about a relatively rapid rise in congestion. During that decade, Houston was transformed from a large city with excellent mobility to one of the most congested major metropolitan areas in the U.S.

Funding commitments and new roadway construction in several large Texas cities have been expanded in the last few years in an effort to reverse the declining trend in mobility and accommodate economic growth. Individual projects may succeed in reducing delay for particular roadways, but a comprehensive transportation improvement program is necessary for major areawide congestion reductions to be achieved. A favorable areawide urban mobility rating, however, does not indicate good traffic conditions throughout a city; significant congestion problems do exist within all major Texas urban areas.

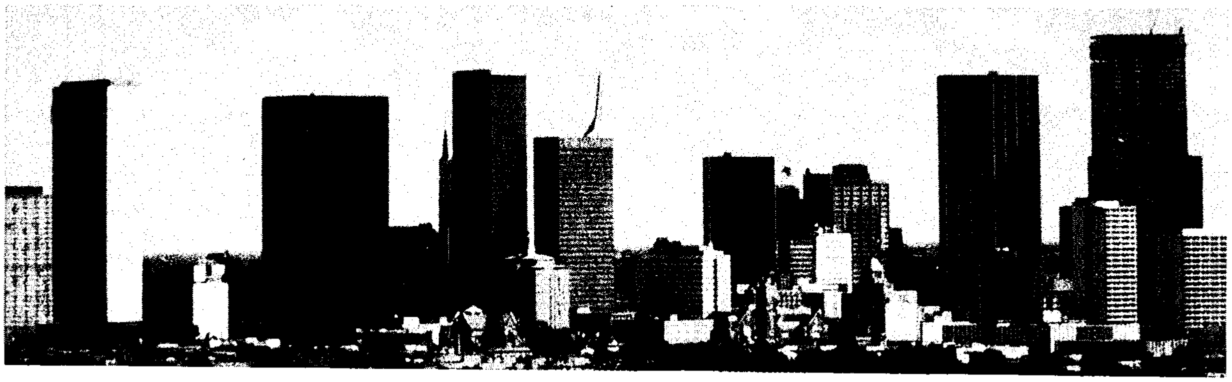
A previous report, "Estimates of Relative Mobility in Major Texas Cities," detailed the use of Houston traffic data to determine congestion measures indicative of undesirable mobility levels. While the data base for estimating relative urban area congestion problems has limitations, the following guidelines appear to represent congestion levels that should not be allowed to occur in an urban area. These values may appear low when applied to individual sections of roadway, but when an areawide transportation system is evaluated the factors correspond to undesirable mobility levels.

- Urban Area Average Traffic Volume
  - Freeway: 13,000 vehicles per lane per day
  - Principal Arterial: 4,500 vehicles per lane per day

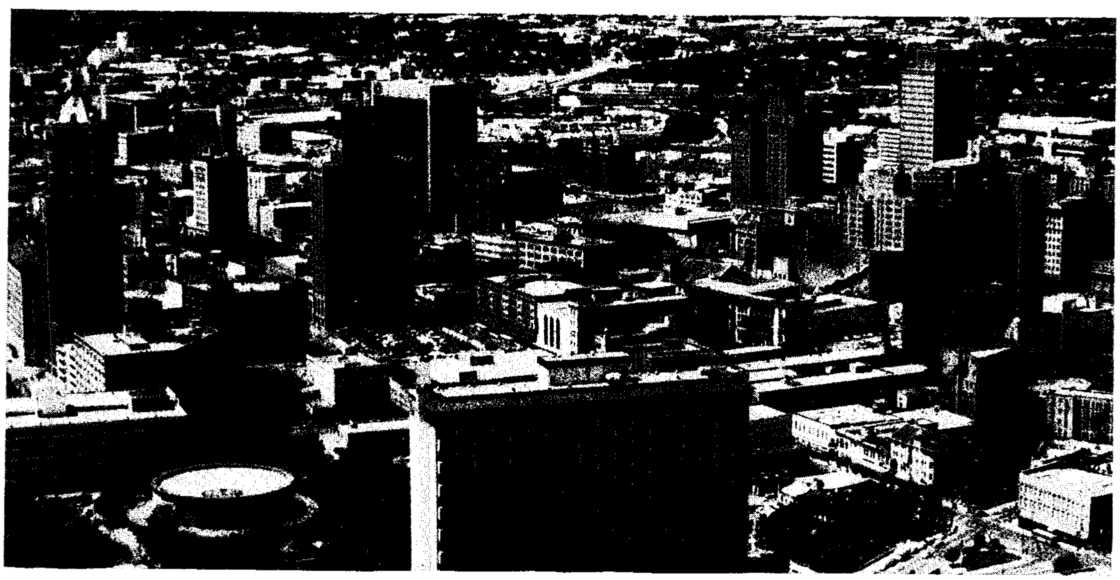
- Percentage of County Freeway System with ADT Greater than 15,000 Per Lane: 30 percent



Houston Mid-1970s

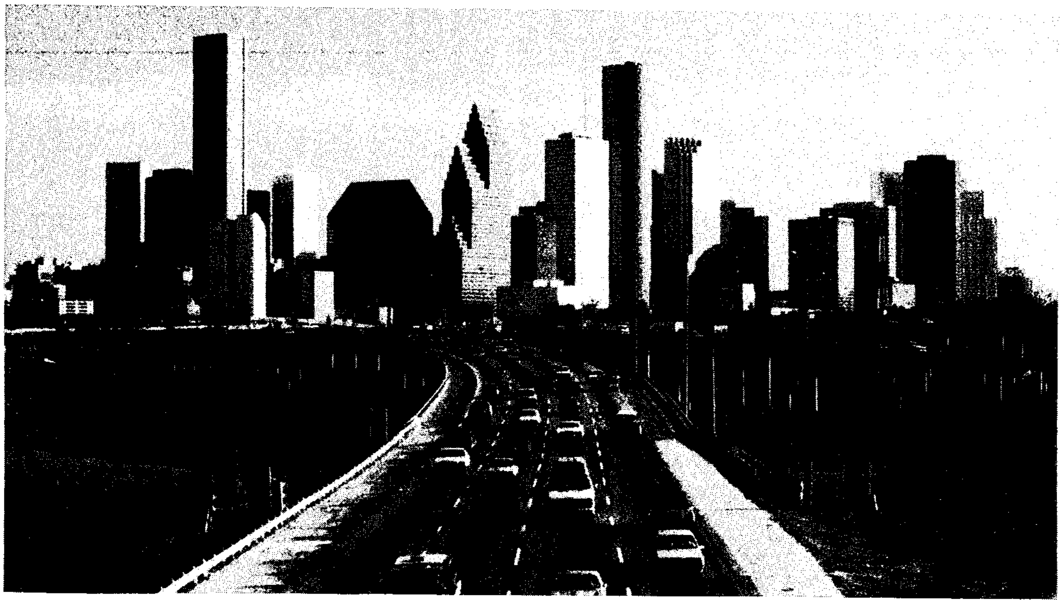


Dallas Mid-1970s

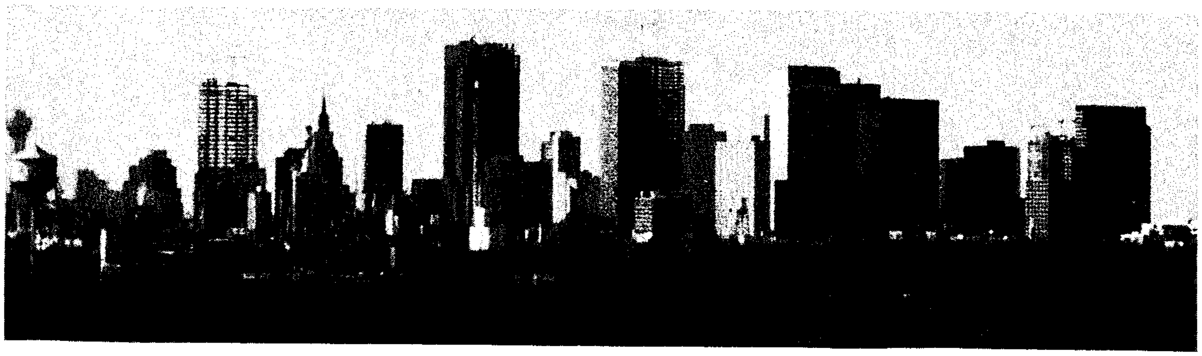


San Antonio Mid-1970s

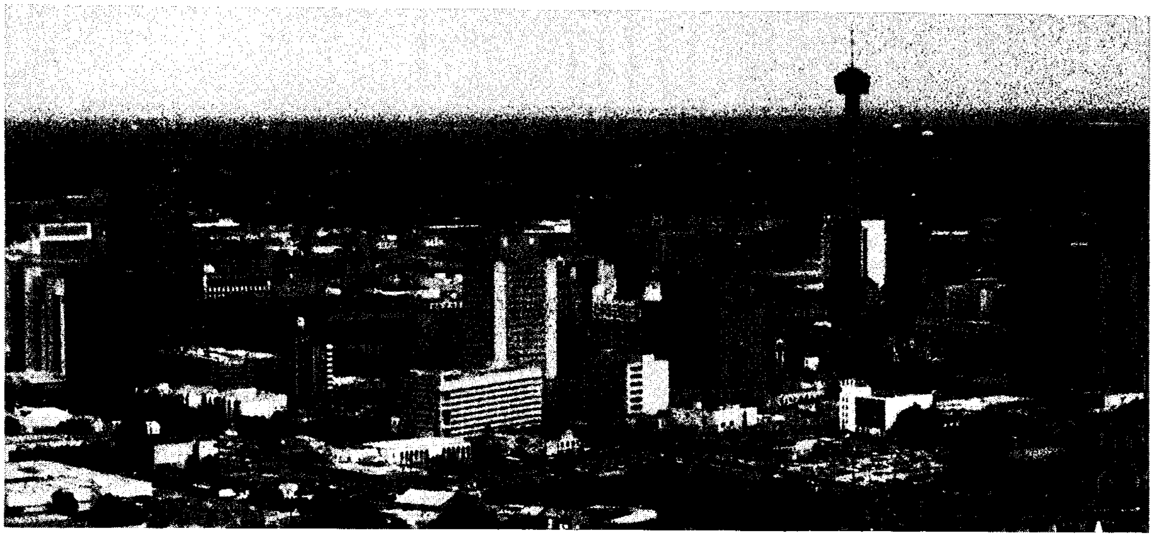
Increases in economic activity are reflected in the



Houston Mid-1980s



Dallas Mid-1980s



San Antonio Mid-1980s

changing downtown skylines of Houston, Dallas and San Antonio.

- Systemwide Freeway k-Factor (percent of ADT in the peak-hour): 9.2 percent

These measures were used to compare relative mobility levels in Austin, Corpus Christi, Dallas, El Paso, Fort Worth, Houston and San Antonio. Figure S-1 summarizes the decline in relative mobility levels for the study cities since 1975. If the 1975 to 1984 rate of increase in congestion is used, Figure S-2 represents the number of years until each city attains the congestion indicator and the 1984 Houston congestion level. It must be noted that the 1984 data are almost two years old and, therefore, congestion levels are almost certainly higher than those shown in Figure S-1 for several cities.

Houston exceeded the critical areawide congestion level in 1976 or 1977 and was 25 percent above the critical level in 1984. Dallas and San Antonio were five to six years behind the Houston level of congestion in 1984 and may already have surpassed the congestion indicator. The significantly higher growth rate experienced in Austin since 1980 suggests that it is near the critical level and may presently be closer to Dallas and San Antonio than Figure S-2 indicates. Data for Fort Worth indicate areawide congestion levels may reach the critical level in the early-1990s, while El Paso roadway conditions may decline to that level in the mid- to late-1990s.

As noted before, Figures S-1 and S-2 represent areawide mobility levels and should not be interpreted as an indication of any individual roadway condition. Each of the study cities have locations of severe congestion. Each of these cities may also be subjected to periods of economic growth which make it difficult to maintain, much less increase, mobility levels. Between 1975 and 1984, only one city had a congestion increase less than 30 percent. The rate of new facility construction and increase in person movement capacity in large Texas cities will have to be greater during the next ten years than in the past ten years if significant reductions in urban congestion are to be realized.

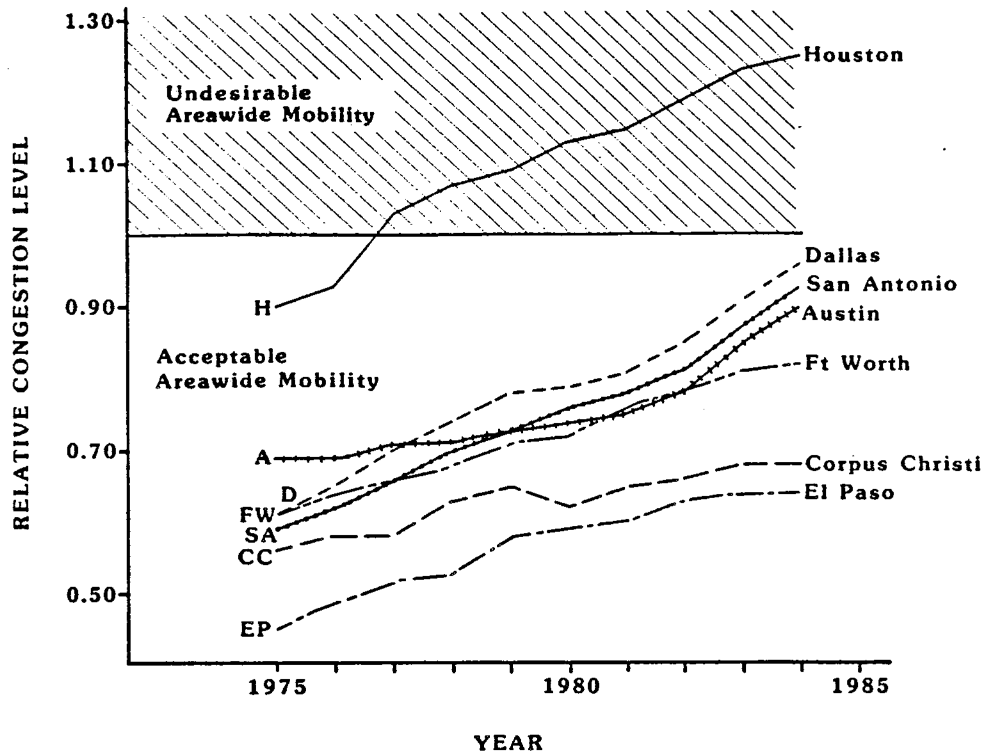


Figure S-1. Relative Congestion Levels in Major Texas Urban Areas, 1975 to 1984

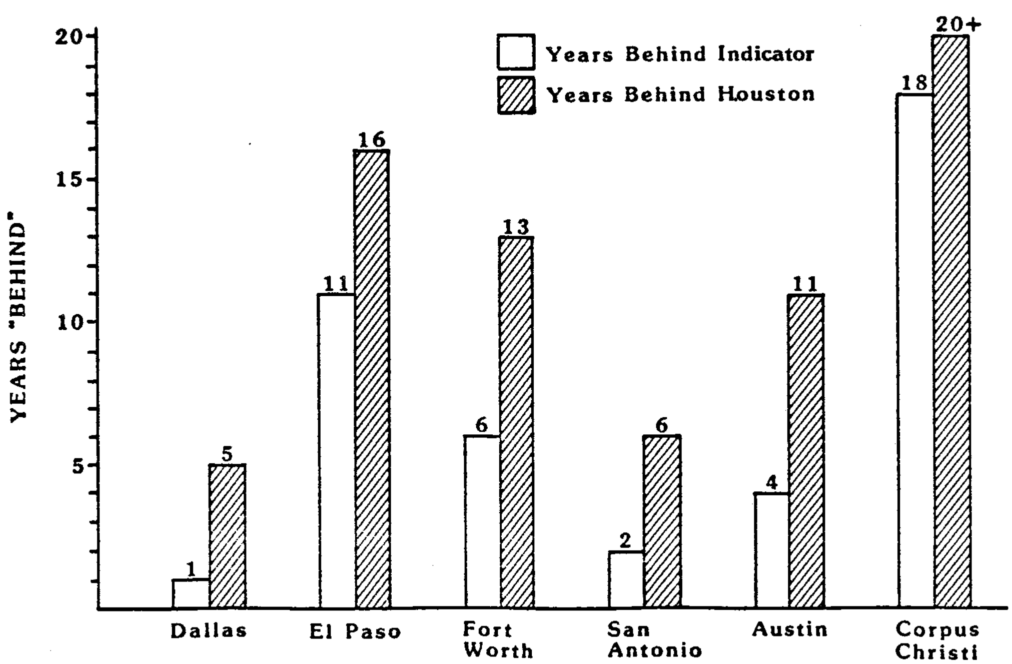


Figure S-2. Time Until Congestion Indicator and 1984 Houston Congestion Levels Are Attained, 1975 to 1984

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Michael Morris
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El Paso Area

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Houston Area

Chris Olavson
Houston-Galveston Regional Transportation Study
State Department of Highways and Public Transportation

San Antonio Area

Emil Seewald and David Otwell
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State Department of Highways and Public Transportation

Statewide Data

Ben Barton, Harrison Scott, Otto Wehring
Planning and Research Division, Austin
State Department of Highways and Public Transportation

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INTRODUCTION

Economic growth in major Texas urban areas since the decade of the 1960s has been widely reported, along with the factors that facilitated that growth. Among other factors, the perceived "quality of life" enjoyed by residents of large Texas cities in the 1960s led to an increase in major business relocation and new business formation in Texas and throughout the Sunbelt. Good transportation and single-family dwellings in suburban areas within relatively short commuting distances to employment centers were important factors, along with the increase in economic activity, in the expansion of major Texas cities. Freeway, expressway and arterial street systems were expanded or constructed during the initial years of this growth. Inexpensive land and increasing levels of mobility provided by freeways resulted in residential, commercial and office space construction at increasing distances from the traditional city centers. Urban Texans have shown that they will locate 20 miles or more from downtown in order to obtain a single-family house on an individual lot.

This choice of residential development has not been without its costs, however, as an analysis of traffic volume demand and roadway capacity indicates. The decade of the 1970s saw a decline in the rate of new freeway and major street construction and a rapid increase in traffic volume due to economic growth. While lack of funding and available right-of-way and environmental concerns slowed new freeway construction in many large cities, much greater than projected traffic volume growth rates produced congested roadways much sooner than expected. The promise of near ultimate mobility with the automobile was broken with the rapid rise of congestion.

The mobility decline detailed in this report helped to prompt increases in federal, state and local funding for transportation improvement projects. Expenditures and project justifications are determined on an individual basis, but the condition of the transportation system as a whole is indicative of overall urban mobility. The manner in which projects are chosen, the economic resources expended in their construction, and their impact on reducing commuter travel delay are important factors which determine the amount of support urban residents will have for new projects.

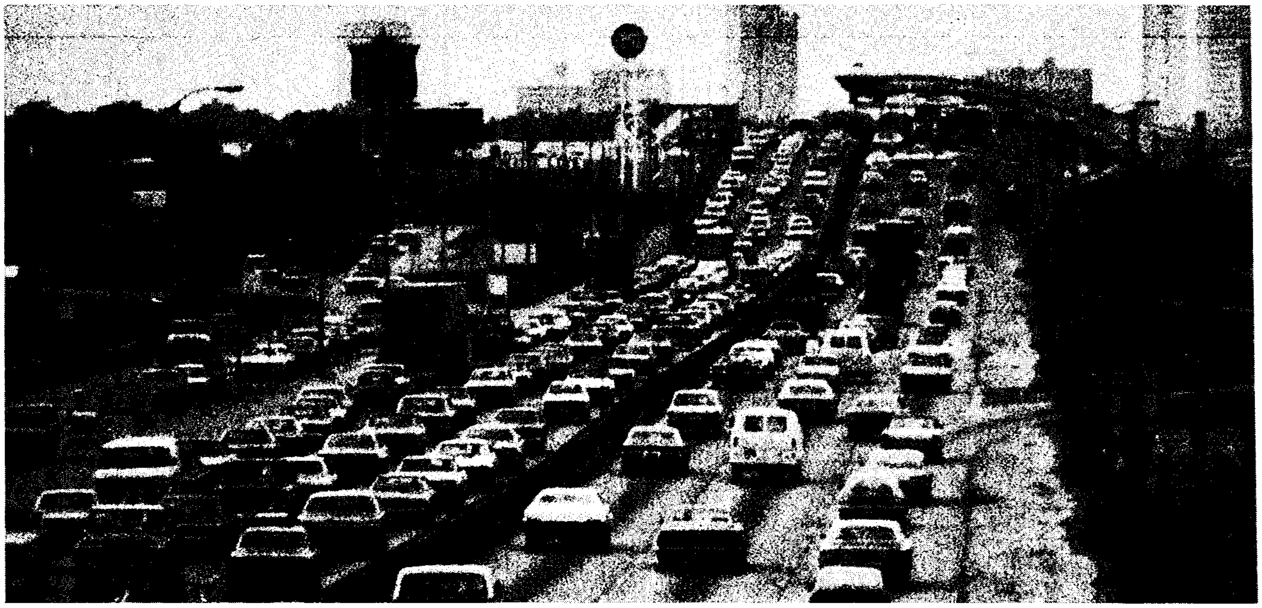
Decline in Mobility

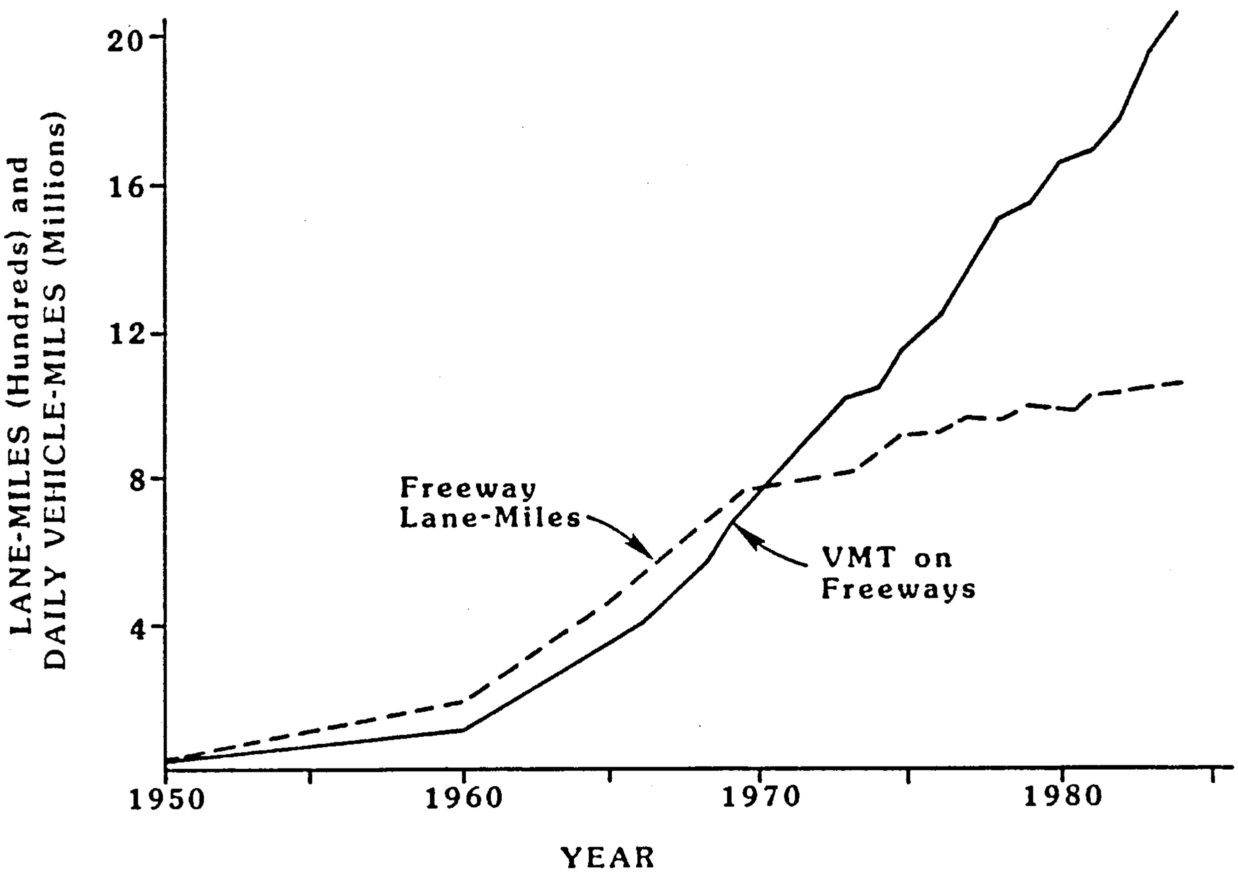
Significant losses in mobility began to occur in some Texas cities during the 1970s. These losses occurred for two primary reasons. The rate of growth in highway construction slowed, while the vehicle-miles of travel increased. In Houston, for example, freeway lane-miles were expanded at an annual rate of 15 percent from 1960 to 1970, but at a rate of less than 3 percent from 1970 to 1984 (Figure 1). Freeway vehicle-miles of travel (VMT) increased at 20 percent per year from 1960 to 1970 and more than 8 percent annually between 1970 and 1984 (1). Thus, absolute demand increased at a greater rate than supply, or roadway capacity, for a period of 20 years.

The result was a significant increase in urban congestion and loss in mobility. While major Texas cities enjoyed the near ultimate in urban mobility in the late 1960s, in a period of only ten years one of those cities -- Houston -- had become one of the more congested cities in the United States; other major Texas cities are not far behind the congestion levels that exist in Houston.

The decline in mobility carries with it a substantial cost. A study (2) performed in Houston estimated that, in 1981, congestion cost Houstonians $1.9 billion. By most standards, the level of congestion that has existed in Houston during the early 1980s is not acceptable. Significant transportation improvements are needed to "bring back" a higher level of mobility. Furthermore, the levels of congestion that exist in other major Texas cities should not be allowed to reach the levels that currently exist in the Houston area. That, too, will require significant transportation improvements in several cities.

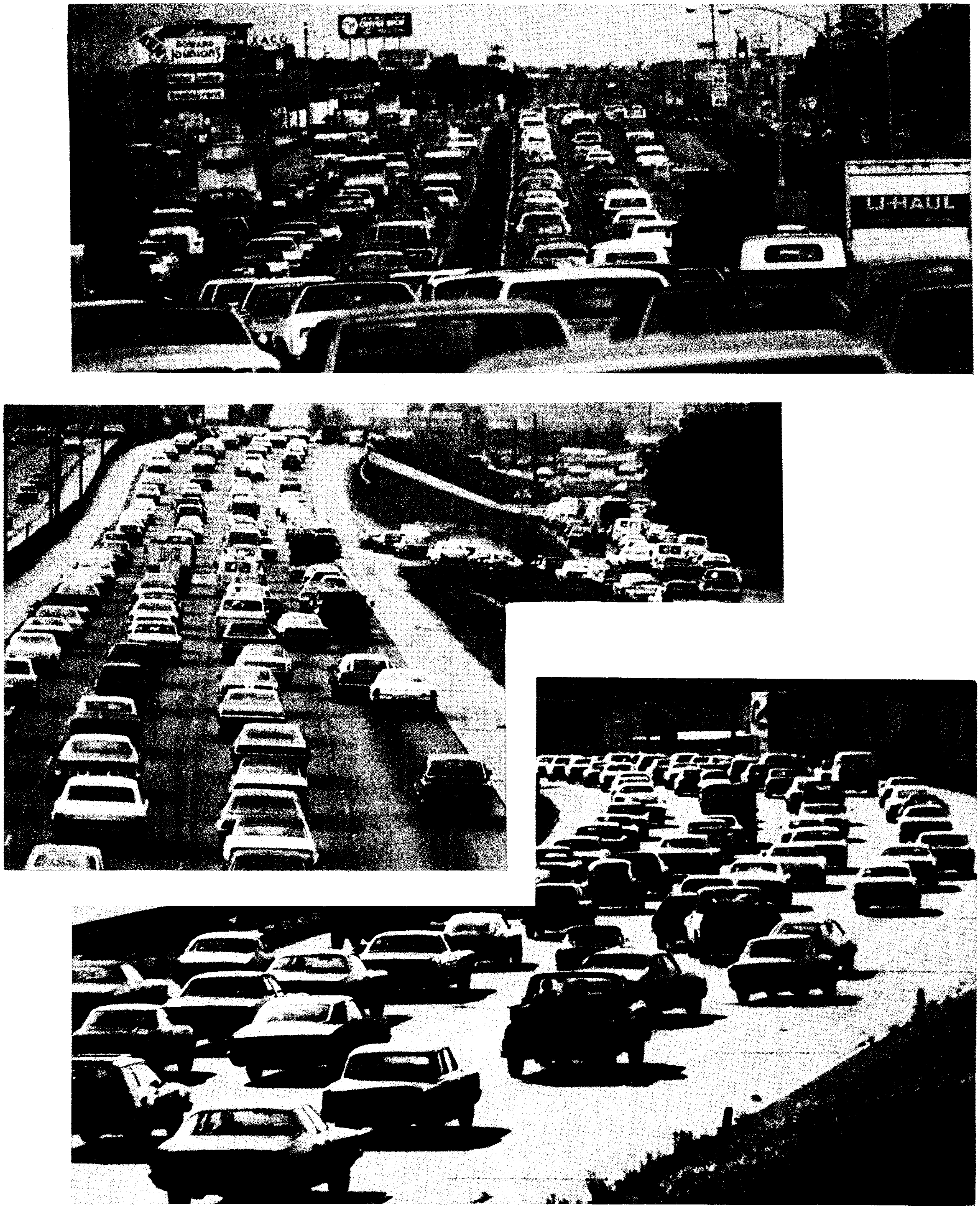
The recent decline in the general economy of Texas has reduced the rate of increase in traffic volumes and congestion in some major cities. This study, however, focuses on the time period from 1975 to 1984; a period of





Source: Reference 1.

Figure 1. Freeway Capacity and Travel in Houston, 1950 to 1984



Traffic volume increases and lack of new roadway construction in the 1970s resulted in the rapid growth of congestion in Houston.

time for which comparable and reliable traffic data were available. This study did not attempt to estimate future mobility levels, but, rather, attempted to illustrate and quantify historical changes in traffic volumes and congestion.

Transportation Infrastructure

The importance of automobiles and roadway systems to the person movement capabilities in most large Sunbelt cities helps to simplify a mobility analysis. Bus and rail transit account for a large percentage of person-trips to the central business districts of most large, older North American urban areas (Table 1). By comparison, the cities in Table 1 that have significantly expanded since the 1950s have done so principally around automobiles and highways. Mobility, then, for most urban Texans is still defined by the single-occupant auto operating on streets and freeways.

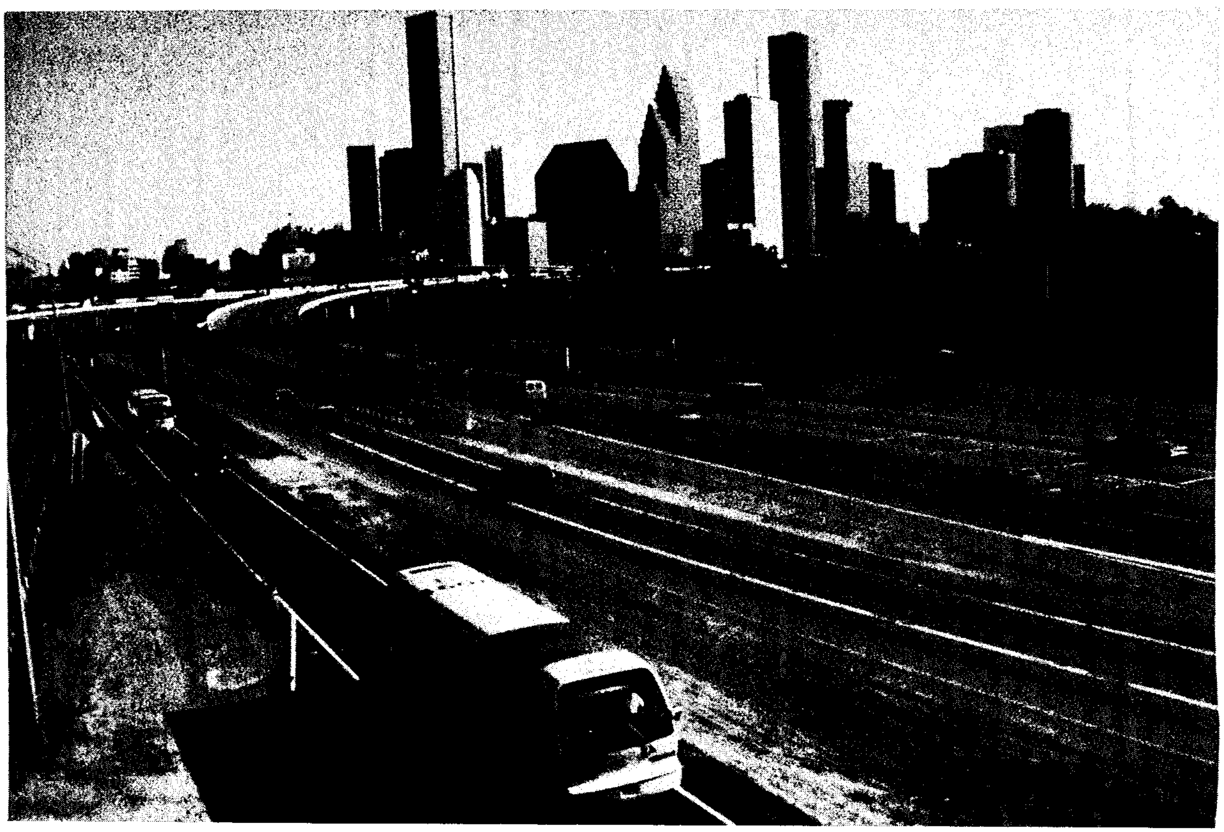
Table 1. Percent of Peak-Period Downtown Work Trips Served by Mass Transportation, Selected North American Cities

City	% of Trips	City	% of Trips	City	% of Trips
Atlanta	40%	HOUSTON, TX	18%	Pittsburgh	65%
Boston	49	Los Angeles	39	Portland, OR	45
Chicago	81	Miami	14	SAN ANTONIO, TX	27
Cleveland	50	Milwaukee	25	Seattle	50
DALLAS, TX	30	New York City	80	Toronto	80
Denver	30	Ottawa	70	Vancouver	40
Detroit	35	Philadelphia	64	Washington, DC	38
FT. WORTH, TX	7				

Average, 18 cities outside of Texas 51%

Average, 4 Texas cities 25%

Source: Reference 3.



Mass transportation improvements are now being used to increase the person movement capacity in a limited number of transportation corridors.

MOBILITY INDICATORS FOR TEXAS CITIES, 1975 TO 1984

Appendix A of this report details the methodology and major findings of a 1982 report, "Estimates of Relative Mobility in Major Texas Cities" (4). Key transportation measures which are indicative of "unacceptable" levels of traffic congestion were identified in that report. This section summarizes the estimates of each measure for the Austin, Corpus Christi, Dallas, El Paso, Fort Worth, Houston and San Antonio urban areas between 1975 and 1984.

Urban Area Definition

Data presented for the various urban areas were derived from several sources, only some of which utilize an urban/rural distinction. Many data summaries are for city or county boundaries. This study uses a population density of more than 1000 persons per square mile as the criterion for urban area delineation. While limited factual information is available in a usable form to allow an urban area boundary to be drawn, data sources with urban/rural classifications for facility mileage and travel volume were used to estimate the quantitative values presented subsequently. It appears that inconsistencies in the data are present in the same degree for all urban areas.

Important Mobility Measures

The value of the key congestion indicators associated with impending undesirable levels of mobility were identified in the 1982 report (4). Once conditions in an urban area approach these indicators, there is reason to believe that serious congestion problems will exist in the near future. The guidelines, presented in apparent order of ability to predict undesirable mobility, are utilized to estimate relative congestion levels in major Texas urban areas.

- Urban Area Average Traffic Volume
  - Freeway: 13,000 vehicles per lane per day
  - Principal Arterial: 4,500 vehicles per lane per day

- Percentage of County Freeway System with ADT Greater than 15,000 Per Lane: 30 percent.

- Systemwide Freeway k-Factor (percent of ADT in the peak-hour): 9.2 percent.

Freeway and Principal Arterial Travel Per Lane

Tables 2 and 3 present estimates of lane-miles and vehicle-miles of travel (VMT) for freeways and principal arterials in the seven urban areas. These were combined into VMT per lane-mile of freeway and principal arterial in Table 4 and Figures 2 and 3.

The freeway data in Tables 2 and 4 and Figure 2 are some of the more reliable data used in this study. Figure 2 indicates the critical freeway congestion measure derived from the 1975-6 Houston value (consult Appendix A for a more detailed discussion). The Houston urban area has remained significantly higher than other areas throughout the study period. Dallas and San Antonio freeway volumes steadily increased during the mid- to late-70s and increased at a faster rate during the early 1980s. Austin remained at a fairly constant level of freeway traffic volume per lane until about 1981, when freeway congestion began increasing at a rate parallel to that of Dallas and San Antonio. These three urban areas, based on historical growth trends, should cross the critical freeway congestion measure well before 1990. While the Fort Worth freeway travel per lane was not increasing as rapidly as that of Dallas, Austin or San Antonio, its 1984 value of 10,000 VMT per lane-mile was exceeded by each of those areas since 1980. El Paso and Corpus Christi are characterized by lower, but increasing, VMT per lane-mile values.

Table 2. Freeway Capacity and Travel in Major Urban Areas

Year	Houston		Dallas		El Paso		Ft. Worth		San Antonio		Austin		Corpus Christi	
	Lane Miles	Daily VMT (1000)	Lane Miles	Daily VMT (1000)	Lane Miles	Daily VMT (1000)	Lane Miles	Daily VMT (1000)	Lane Miles	Daily VMT (1000)	Lane Miles	Daily VMT (1000)	Lane Miles	Daily VMT (1000)
1984	1,460	23,615	1,620	19,925	345	2,800	965	9,685	840	9,710	290	3,300	165	1,360
1983	1,410	22,555	1,580	18,400	335	2,690	935	9,230	825	8,915	280	2,970	165	1,370
1982	1,375	21,080	1,550	16,870	325	2,560	905	8,625	800	8,025	265	2,530	160	1,300
1981	1,330	19,800	1,515	15,750	310	2,325	880	8,140	775	7,475	250	2,275	160	1,270
1980	1,255	18,405	1,485	15,015	295	2,155	855	7,535	750	7,115	240	2,130	160	1,190
1979	1,265	17,950	1,465	14,620	275	1,975	825	7,145	735	6,680	240	2,100	155	1,235
1978	1,180	16,405	1,450	13,695	275	1,790	795	6,660	685	5,880	240	2,050	155	1,200
1977	1,175	15,650	1,430	12,840	260	1,665	755	6,100	675	5,475	235	2,000	155	1,100
1976	1,210	14,405	1,395	11,555	260	1,545	730	5,670	670	5,080	230	1,900	150	1,070
1975	1,145	13,190	1,350	10,445	260	1,415	720	5,275	660	4,755	215	1,780	150	1,020

Source: Reference 1, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16.

Table 3. Principal Arterial and Capacity and Travel in Major Urban Areas

Year	Houston		Dallas		El Paso		Ft. Worth		San Antonio		Austin		Corpus Christi	
	Lane Miles	Daily VMT (1000)	Lane Miles	Daily VMT (1000)	Lane Miles	Daily VMT (1000)	Lane Miles	Daily VMT (1000)	Lane Miles	Daily VMT (1000)	Lane Miles	Daily VMT (1000)	Lane Miles	Daily VMT (1000)
1984	1,920	10,860	1,650	7,640	800	2,820	825	4,015	1,015	5,265	380	1,825	320	1,350
1983	1,845	10,350	1,595	7,035	780	2,705	800	3,845	985	4,795	360	1,710	315	1,300
1982	1,785	9,725	1,555	6,440	760	2,600	785	3,660	950	4,355	340	1,595	310	1,250
1981	1,715	9,165	1,510	6,010	740	2,525	760	3,450	915	4,065	325	1,535	305	1,220
1980	1,655	8,565	1,475	5,730	725	2,470	745	3,255	870	3,790	310	1,460	300	1,185
1979	1,585	7,690	1,435	5,400	715	2,410	740	3,150	840	3,520	300	1,410	295	1,150
1978	1,520	7,230	1,395	5,080	710	2,300	725	3,000	805	3,270	280	1,310	295	1,110
1977	1,450	6,925	1,375	4,840	695	2,170	710	2,870	765	3,005	280	1,300	290	1,040
1976	1,380	6,345	1,350	4,490	685	2,070	690	2,725	760	2,895	260	1,210	285	1,000
1975	1,310	5,875	1,320	4,150	675	1,945	665	2,560	740	2,750	245	1,120	285	960

Source: References 1, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16.

Table 4. Daily VMT Per Lane-Mile on Freeways and Principal Arterials in Major Urban Areas

Year	Houston		Dallas		El Paso		Ft. Worth		San Antonio		Austin		Corpus Christi	
	Freeway	Prin. Art.	Freeway	Prin. Art.	Freeway	Prin. Art.	Freeway	Prin. Art.	Freeway	Prin. Art.	Freeway	Prin. Art.	Freeway	Prin. Art.
1984	16,175	5,655	12,300	4,630	8,110	3,525	10,035	4,865	11,560	5,185	11,380	4,805	8,240	4,220
1983	15,995	5,610	11,645	4,410	8,030	3,470	9,870	4,805	10,805	4,870	10,605	4,750	8,305	4,125
1982	15,330	5,450	10,885	4,140	7,875	3,420	9,530	4,660	10,030	4,585	9,545	4,690	8,125	4,030
1981	14,885	5,345	10,395	3,980	7,500	3,410	9,250	4,540	9,645	4,445	9,100	4,725	7,940	4,000
1980	14,665	5,175	10,110	3,885	7,305	3,405	8,815	4,370	9,485	4,355	8,875	4,710	7,440	3,950
1979	14,190	4,850	9,980	3,765	7,180	3,370	8,660	4,255	9,090	4,190	8,750	4,700	7,970	3,900
1978	13,905	4,755	9,445	3,640	6,510	3,240	8,375	4,140	8,585	4,060	8,540	4,680	7,740	3,765
1977	13,320	4,775	8,980	3,520	6,405	3,120	8,080	4,040	8,110	3,930	8,510	4,645	7,095	3,585
1976	11,905	4,600	8,285	3,325	5,940	3,020	7,765	3,950	7,580	3,810	8,260	4,655	7,135	3,510
1975	11,520	4,485	7,735	3,145	5,440	2,880	7,325	3,850	7,205	3,715	8,280	4,570	6,800	3,370

Source: References 1, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16.

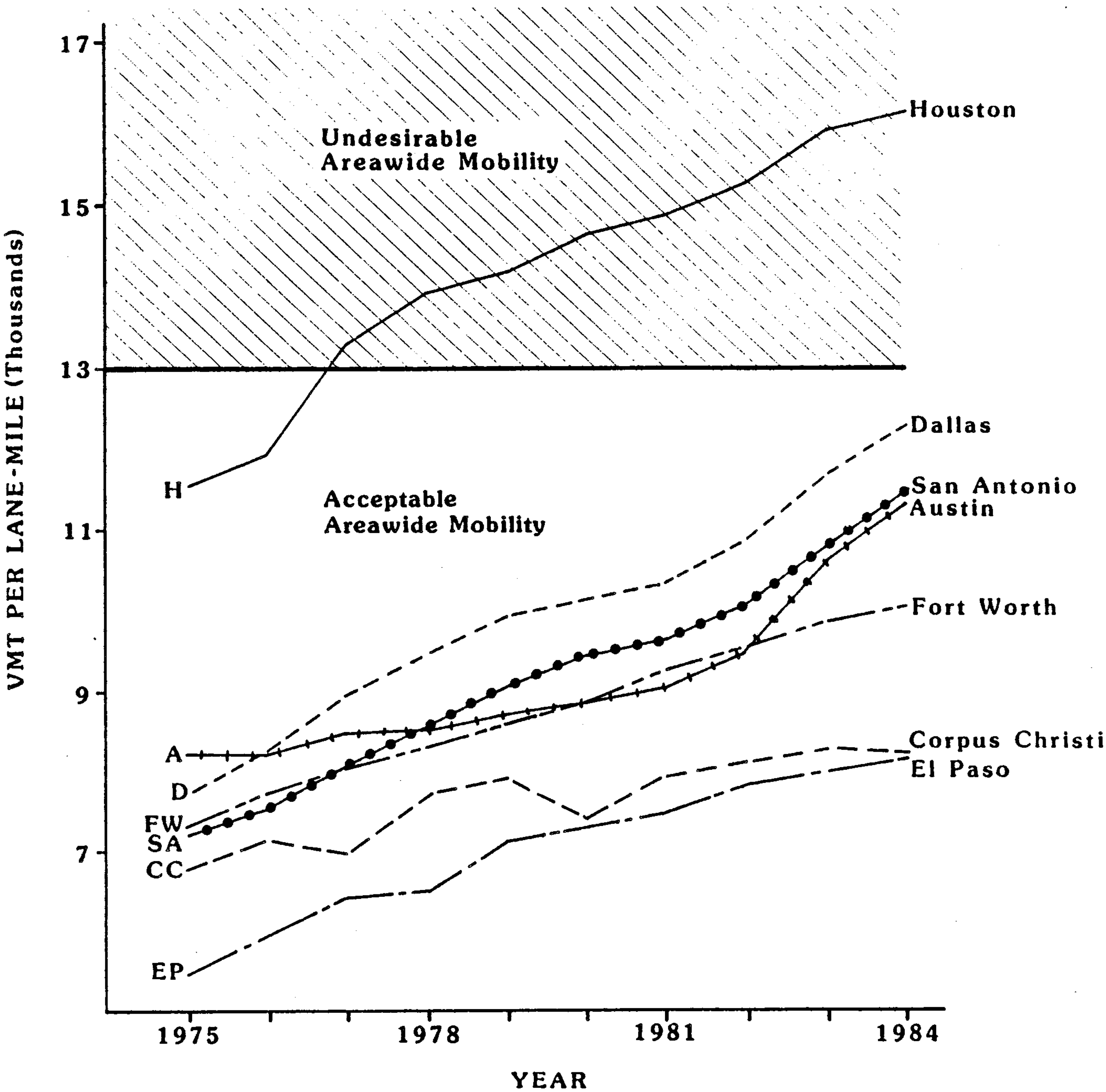


Figure 2. Travel Per Freeway Lane-Mile For Major Texas Urban Areas, 1975 to 1984

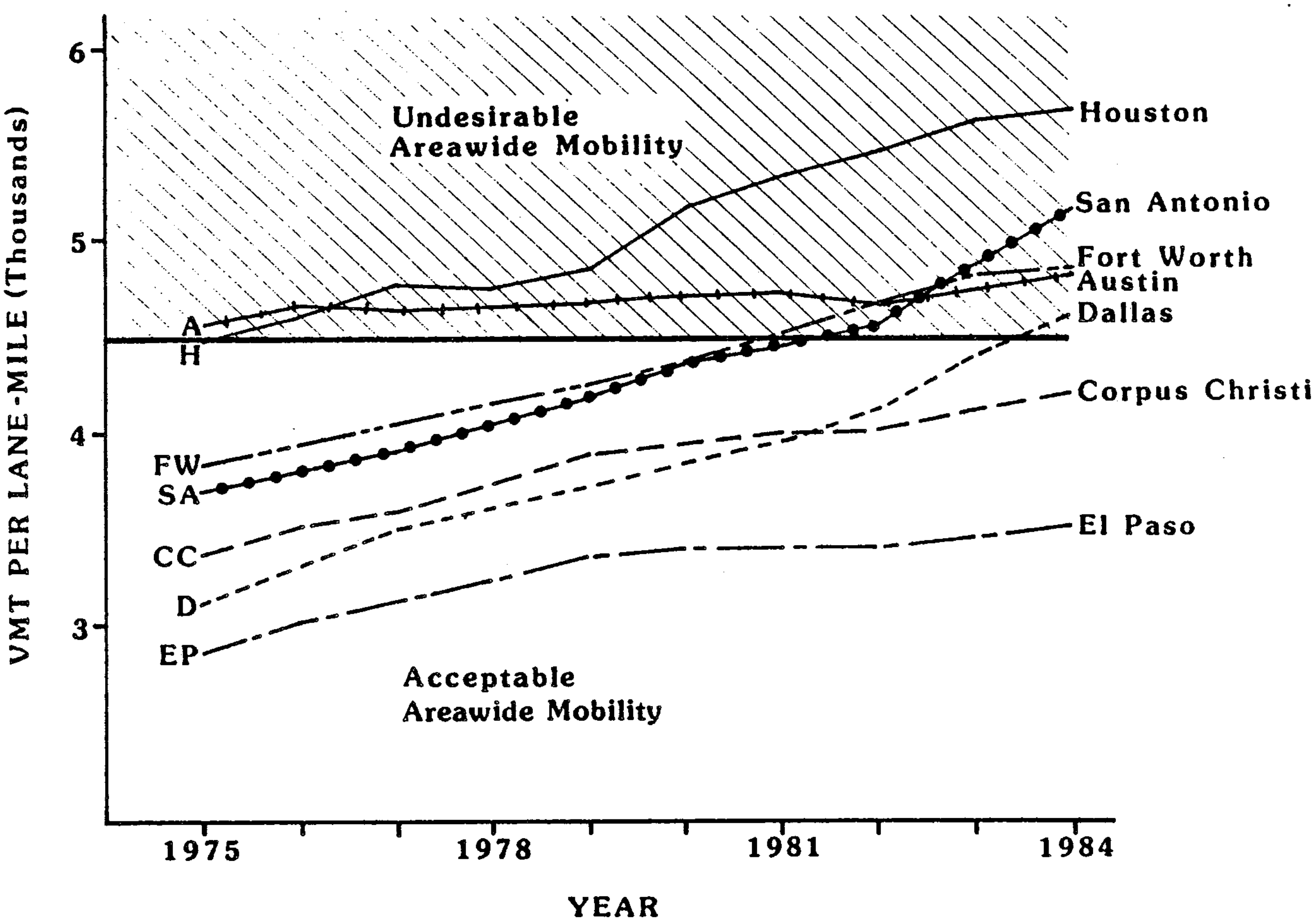


Figure 3. Daily Travel Per Principal Arterial Lane-Mile For Major Texas Urban Areas, 1975 to 1984

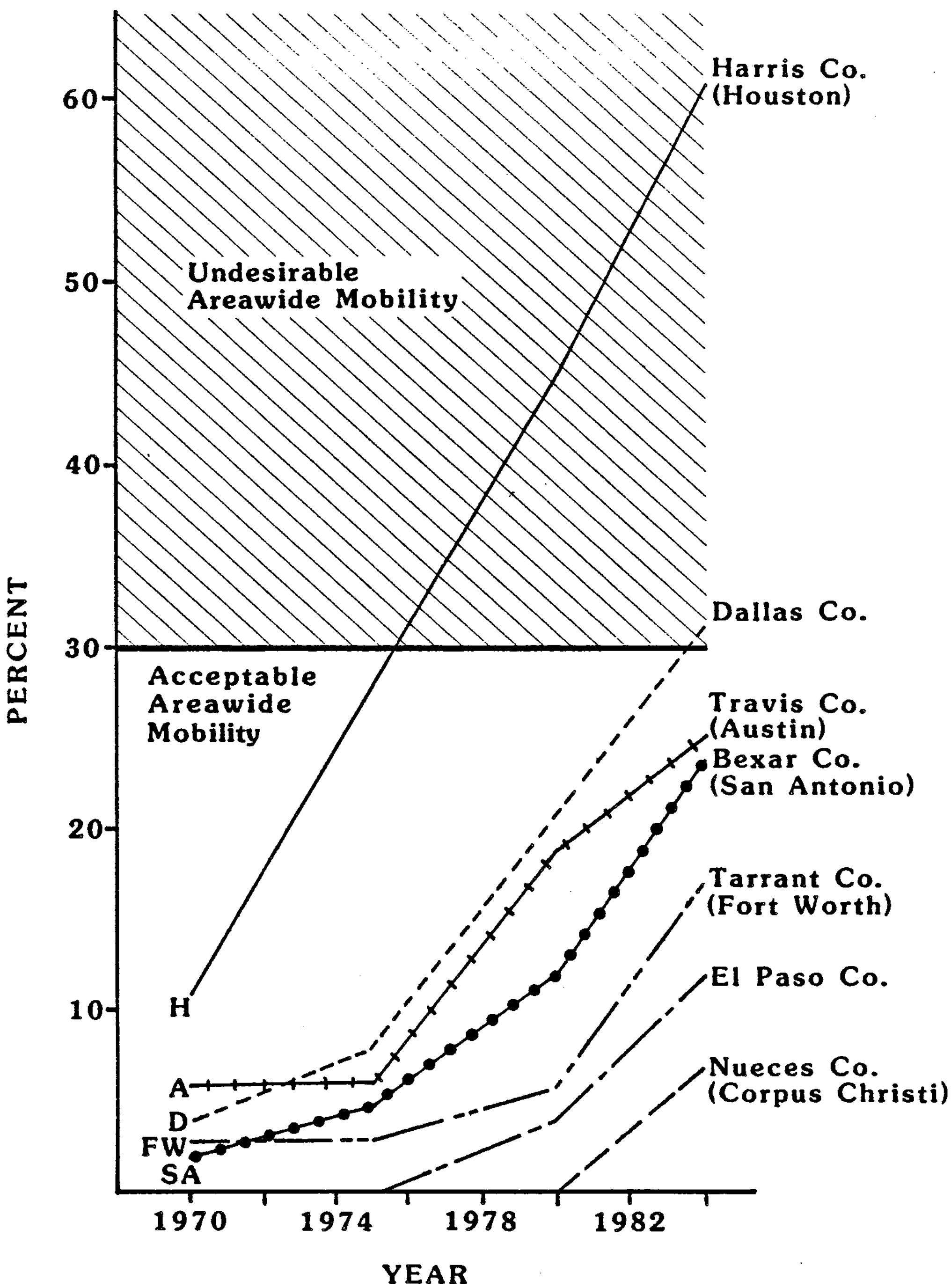
The data for VMT per principal arterial lane-mile are shown in Tables 3 and 4 and Figure 3. As was the case with the freeway measure, Houston's principal arterials handle more traffic volume per lane than is served in the other areas. The San Antonio, Fort Worth and Austin arterials, however, are estimated to operate with higher volumes than those in Dallas, which was second to Houston in the freeway rankings. The five highest major urban area arterial VMT per lane-mile levels exceeded the critical congestion measure in 1984; only Houston exceeded the freeway measure.

The freeway and principal arterial roadway systems were chosen for this analysis due to the availability of data and the importance to areawide mobility. A subsequent section presents the combination of these two classifications into a single indicator of relative mobility.

Percentage of Congested Freeway

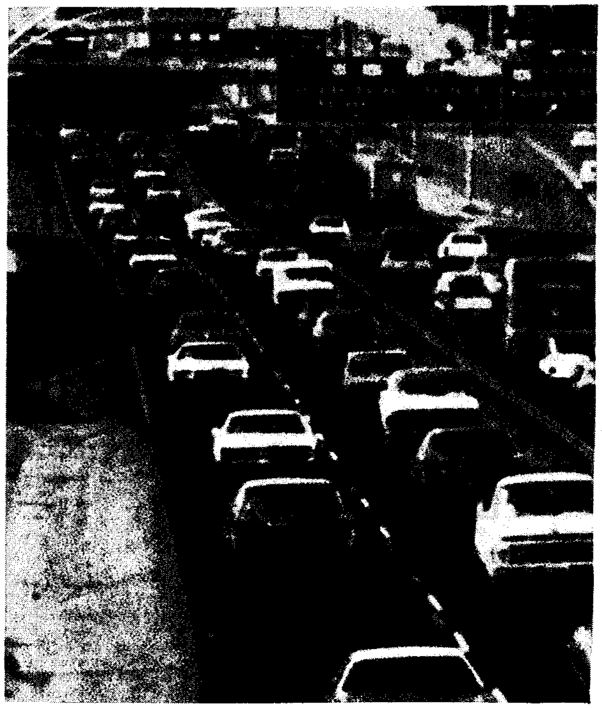
Figure 4 illustrates the percentage of freeway lane-miles in each major urbanized county with average daily traffic volumes in excess of 15,000. Harris (Houston) County reached (in 1984) a congested freeway mileage level more than double that of the critical measure. The Dallas freeway system was also beyond the congestion measure in 1984 after a decade of growth that parallelled Harris County's. Travis (Austin) and Bexar (San Antonio) Counties have exceeded 20 percent, and have congestion growth trends nearly parallel to those of Dallas and Harris. Based on historic growth trends, Travis, Bexar and Tarrant (Fort Worth) Counties should exceed the 30 percent level before 1990. Although below 15 percent, the El Paso and Nueces (Corpus Christi) County growth rates were fairly high between 1980 and 1984.

The difficulty with urban area boundary definition, and the readily available traffic and roadway link data for counties, resulted in the use of county boundaries for this indicator. Some allowance should be made for the difference in county land use patterns and their effect on traffic volumes. Dallas County has a smaller percentage of rural area than the other counties; the percentage of congested freeway lane-miles is, therefore, slightly higher for Dallas County in relation to that for the urban area. Similarly, the percentage of congested miles would be higher for the other six counties if

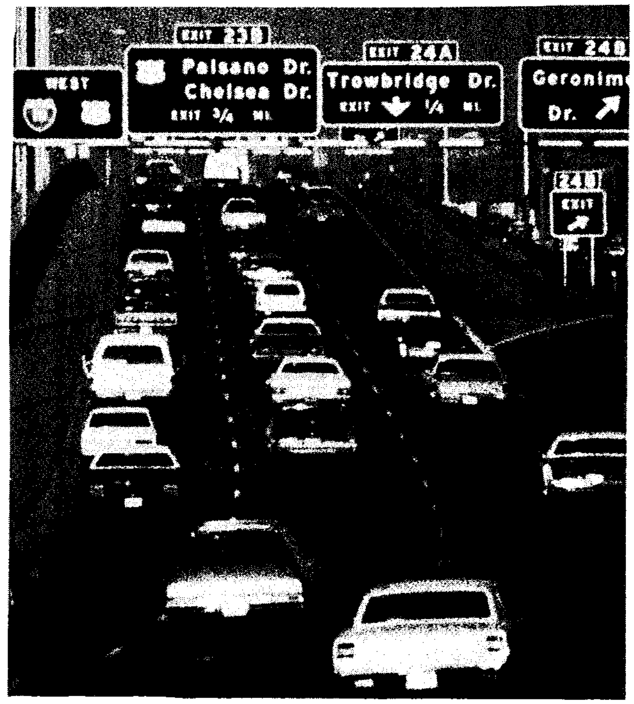


Source: References 1, 5, 7, 8, 10, 12, 15, 16.

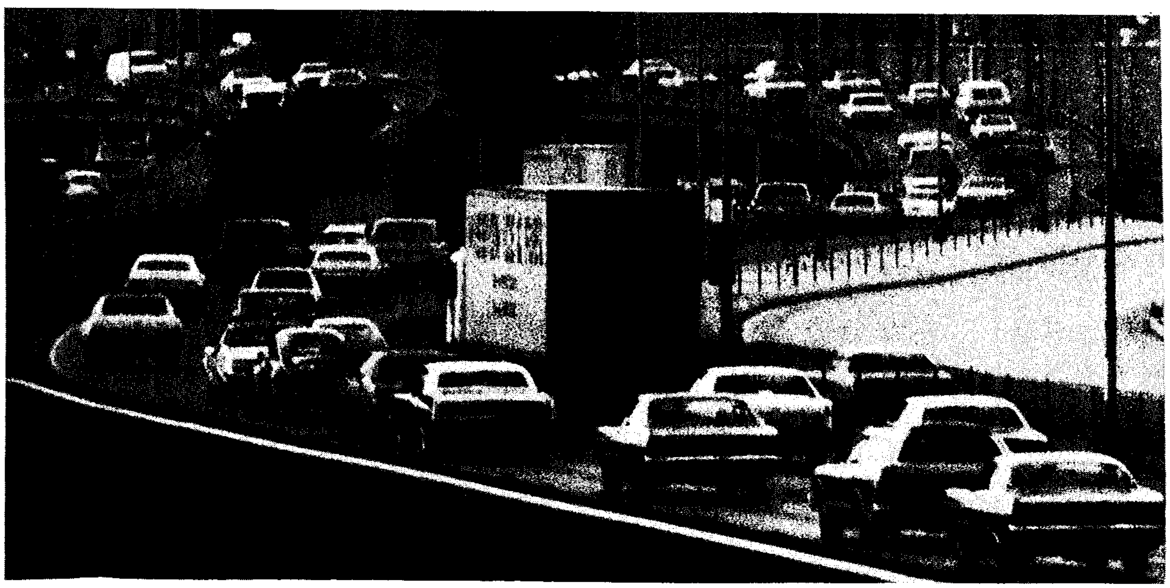
Figure 4. Percent of Freeway Lane-Miles With More Than 15,000 ADT For Urbanized Texas Counties, 1970 to 1984



Fort Worth



El Paso



San Antonio

Freeway congestion may be found at some locations in all large Texas urban areas.

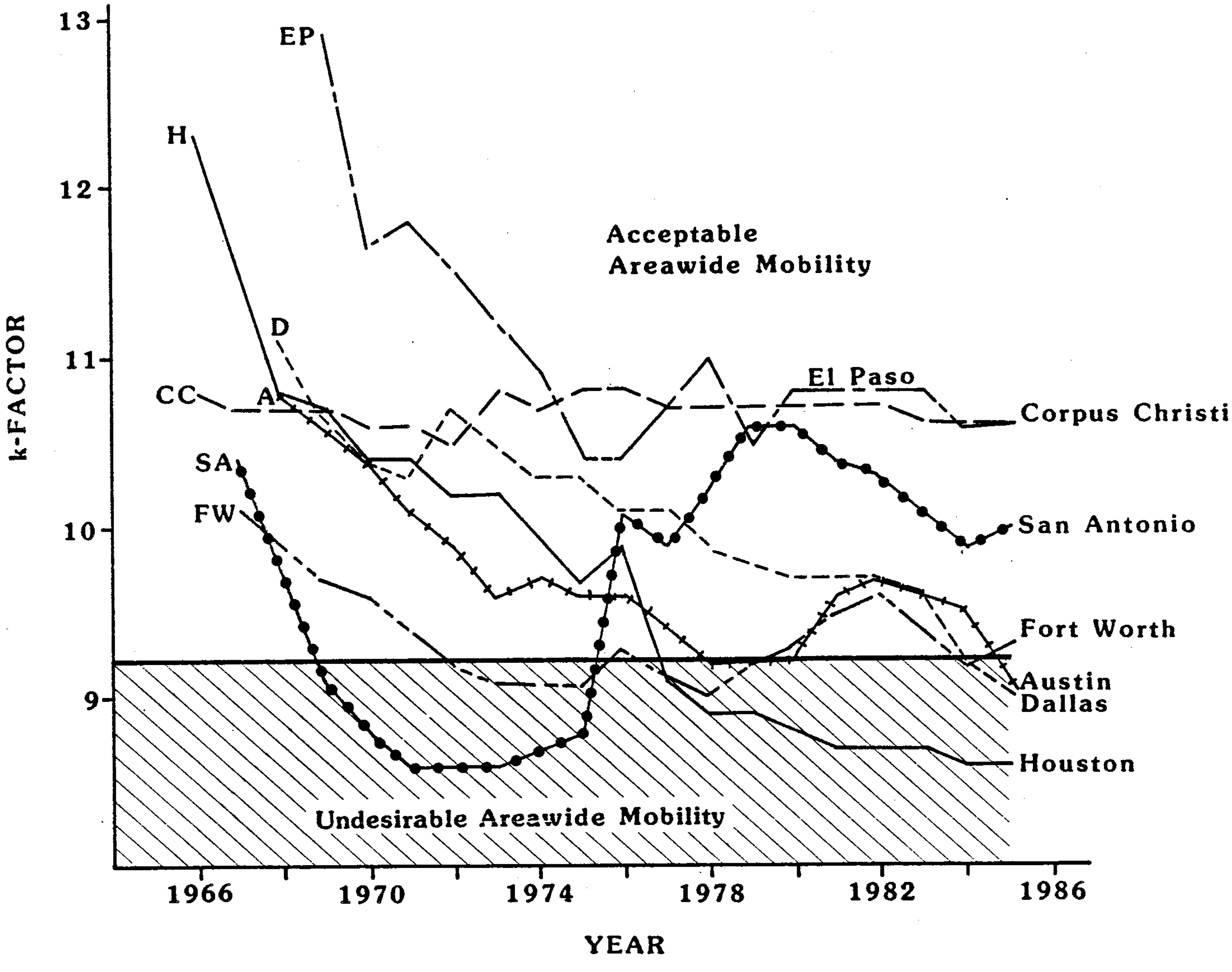
the indicator were calculated for those urban area (rather than county) boundaries.

k-Factor and Average Daily Traffic Per Lane

The location of automatic traffic recorder (ATR) stations in Texas cities does not provide a statistically accurate sample of urban area travel. The number of stations is too low, and the locations are not similar in relation to congested freeway segments in every urban area. New ATR stations opened in relatively new and lower volume freeway sections, and older stations taken out of service during freeway reconstruction projects, further disrupt the consistency of the data. (These stations were included on the premise that more data was better than "consistent" data when the "consistent" data are not statistically representative of actual conditions). The percentage of daily traffic that occurs in the peak hour (k-Factor) and the average daily traffic (ADT) per lane at these ATR stations are, however, at least somewhat indicative of the growth in freeway congestion.

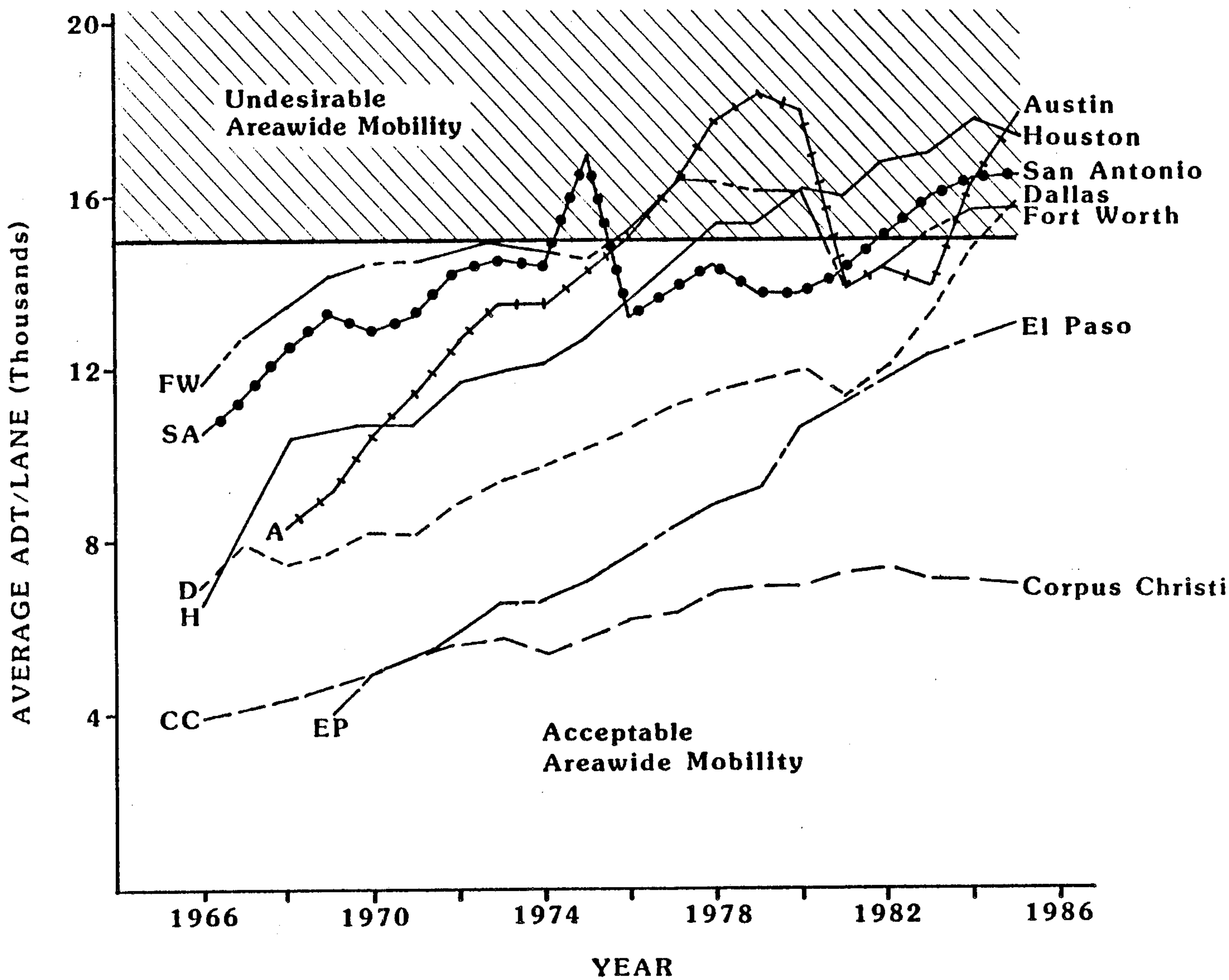
The peak-hour capacity of a freeway section is relatively constant and, therefore, during periods of increasing traffic demand, the traffic volume during the hours adjacent to the peak increases. The trend of increasing freeway volume accompanies a decline in the k-Factor (Figure 5). Houston, Austin, Dallas and Fort Worth are at or below the 9.2 percent level determined to indicate impending congestion. San Antonio is somewhat higher than the other areas due to several new traffic count stations installed on relatively uncongested roadways in 1976. The El Paso and Corpus Christi data do not presently indicate significant freeway problems.

Daily freeway volume per lane can be calculated from the ATR station data. Figure 6 presents the 15,000 vehicles per day per lane value (maximum volume for level-of-service C) (17) utilized in Figure 4 to illustrate the position of the cities relative to a critical measure. Again, the lack of comparability in ATR data reduces the usefulness of this measure, but the figure illustrates the same trends noted in other data. Austin, Dallas, Fort Worth, Houston and San Antonio are above the 15,000 ADT per lane level. Austin and Dallas had significant increases in traffic per lane since 1982.



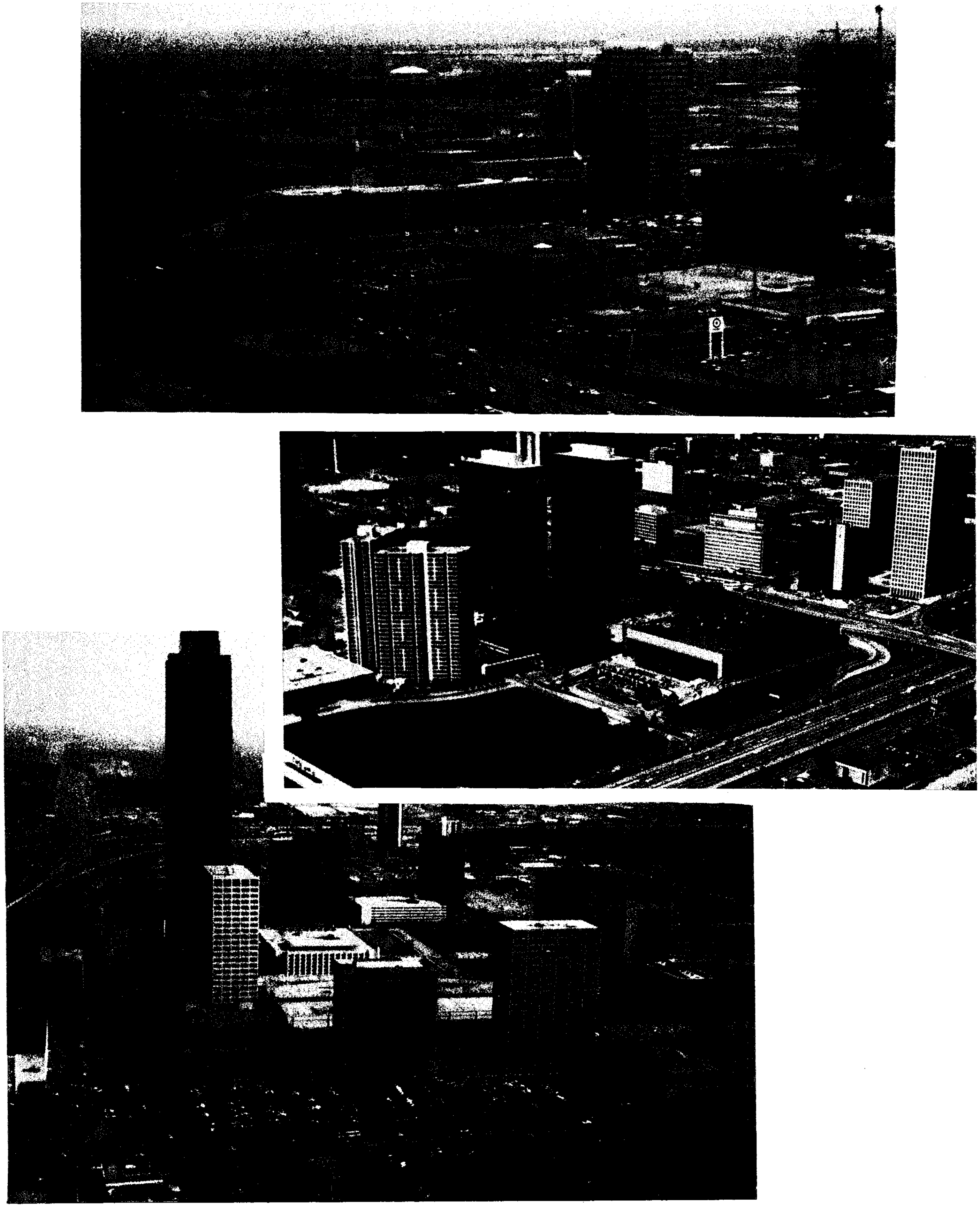
Source: Reference 15.

Figure 5. Percent of Daily Traffic Volume During Peak-Hour (k-Factor) At Automatic Traffic Recorder Stations in Major Texas Urban Areas, 1966 to 1985



Source: Reference 15.

Figure 6. Average Daily Traffic Per Freeway Lane at Automatic Traffic Recorder Stations in Major Texas Urban Areas, 1966 to 1985



Suburban office centers have contributed to urban area economic growth.

RELATIVE MOBILITY IN TEXAS CITIES, 1975 TO 1984

The data presented in this report indicate that varying levels of congestion exist in the large urban areas of Texas. Those areas which do not have severe areawide congestion nevertheless experience traffic problems at some locations within the urban area.

The 1982 report, "Estimates of Relative Mobility in Major Texas Cities", (4) details the analysis technique used in this report. A relative congestion index was generated by combining freeway and principal arterial VMT per lane (Table 4) for each major urban area. Freeways in most of the large Texas cities carry approximately twice the VMT of the principal arterials (Tables 2 and 3). The freeway VMT per lane value was doubled to account for this increased importance and added to the arterial VMT per lane. The congestion levels were then normalized, with the critical congestion indicator set equal to 1.0 (Equation 1).

$$\text{Relative Congestion Level} = \frac{2\ (\text{Fwy. VMT/Lane}) + \text{Princ. Art. VMT/Lane}}{2\ (\text{Fwy. Standard}) + \text{Princ. Art. Standard}} \qquad \text{(Eq. 1)}$$

$$\text{Example:} \quad \text{Houston (1984)} = \frac{2(16{,}175) + 5655}{2(13{,}000) + 4500} = 1.25$$

Source: Reference 4

The relative congestion levels in Table 5 are illustrated along with the urban area congestion indicator in Figure 7. Houston exceeded the critical level in 1977 and was 25 percent above that level in 1984. Dallas, San Antonio and Austin were within 10 percent of the critical indicator, and their congestion levels increased at almost twice the rate of Houston between 1980 and 1984. The Fort Worth congestion level was approximately equal to those cities in 1980, but has not increased at the same rate as Dallas, San Antonio and Austin. The Corpus Christi and El Paso mobility levels (the inverse of the congestion level) have remained relatively high, although they have been declining.

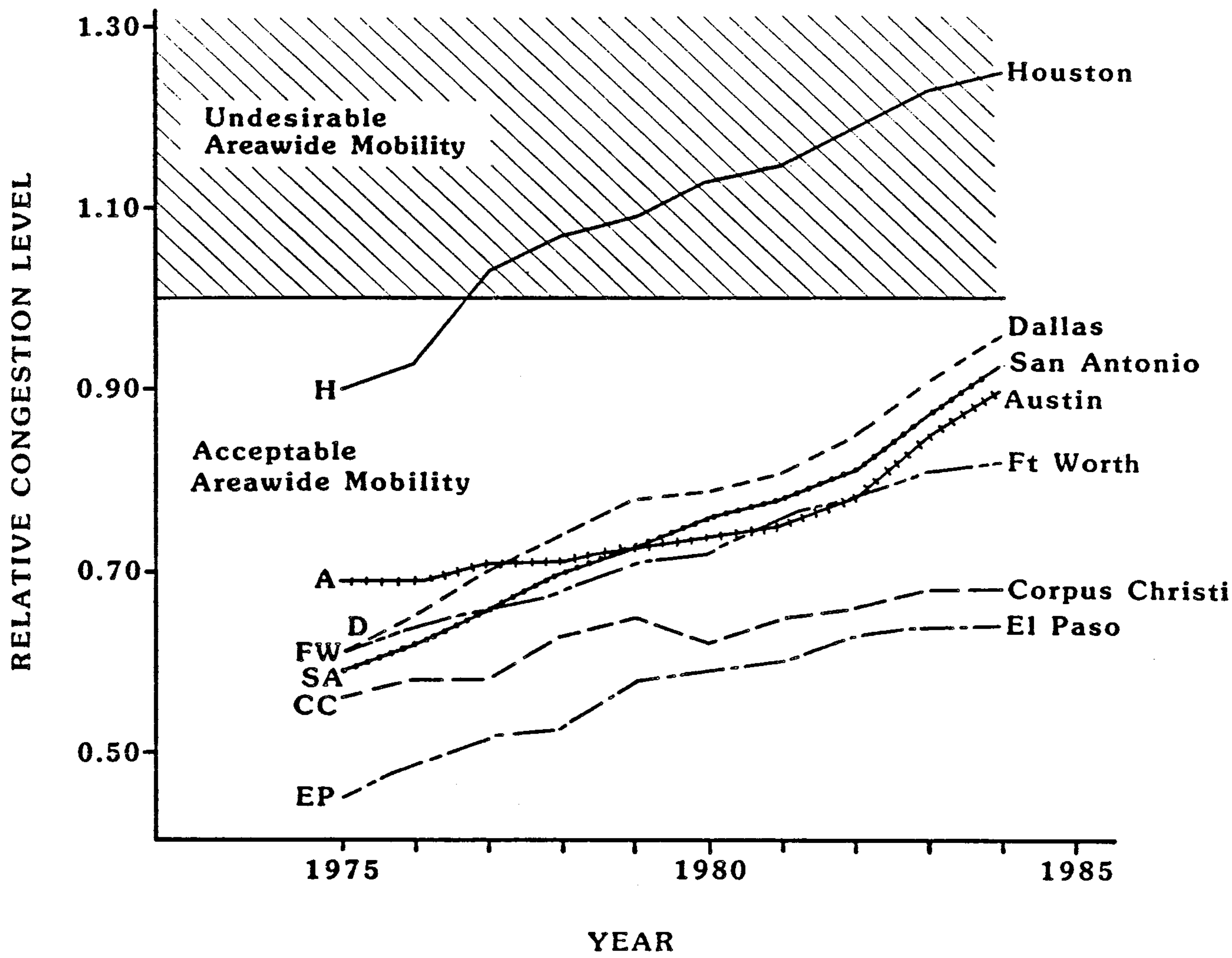
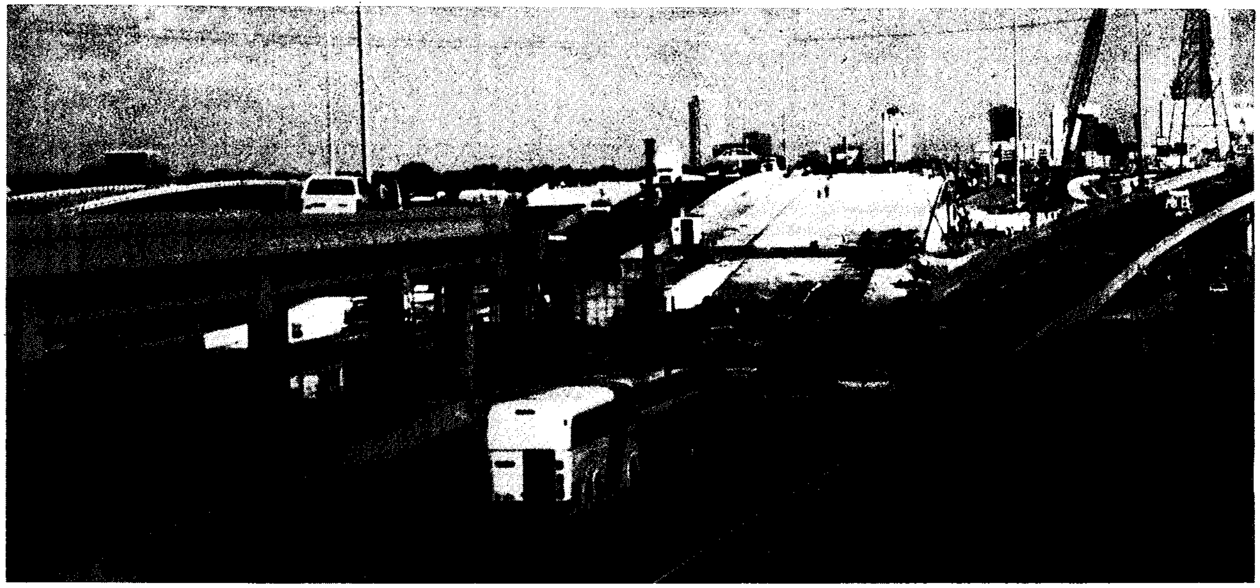
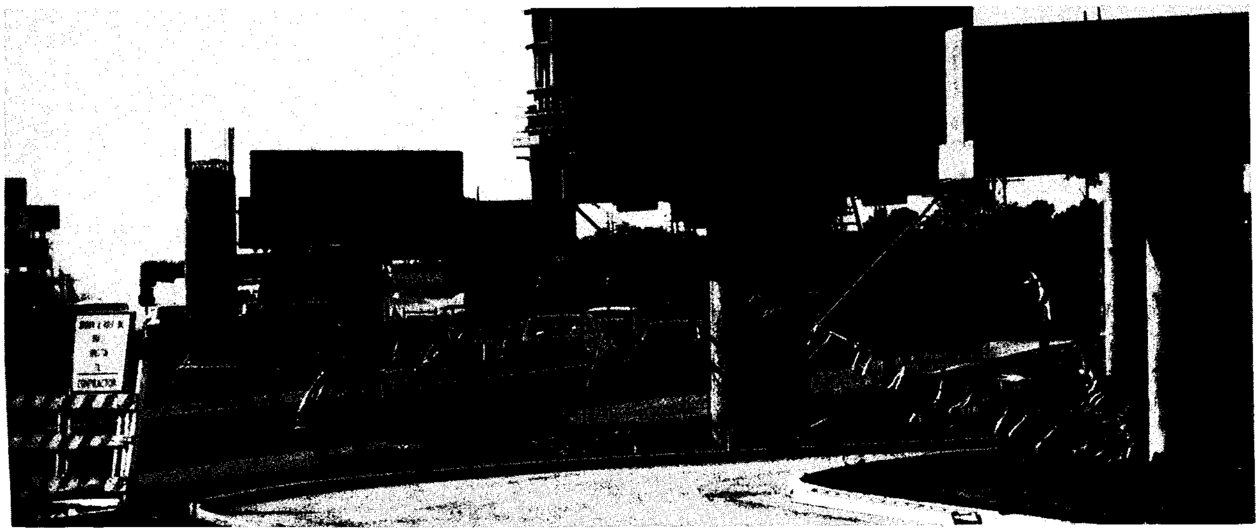


Figure 7. Relative Congestion Levels in Major Texas Urban Areas, 1975 to 1984





Freeway rehabilitation and HOV lane construction can utilize the expertise of multiple agencies and combine a variety of funding sources.

Table 5. Areawide Relative Congestion Levels

Year	Houston	Dallas	El Paso	Ft. Worth	San Antonio	Austin	Corpus Christi
1984	1.25	0.96	0.65	0.82	0.93	0.90	0.68
1983	1.23	0.91	0.64	0.81	0.87	0.85	0.68
1982	1.18	0.85	0.63	0.78	0.81	0.78	0.66
1981	1.15	0.81	0.60	0.76	0.78	0.75	0.65
1980	1.13	0.79	0.59	0.72	0.76	0.74	0.62
1979	1.09	0.78	0.58	0.71	0.73	0.73	0.65
1978	1.07	0.74	0.53	0.68	0.70	0.71	0.63
1977	1.03	0.70	0.52	0.66	0.66	0.71	0.58
1976	0.93	0.65	0.49	0.64	0.62	0.69	0.58
1975	0.90	0.61	0.45	0.61	0.59	0.69	0.56
Congestion Increase 1975 to 1984	39%	57%	44%	34%	58%	30%	21%

Note: A congestion level higher than 1.00 is considered undesirable.

Source: TTI Analysis

The relationship between freeway and arterial operating conditions should also be examined. Table 5 lists Houston as the only urban area with freeways worse than the congestion indicator, but five areas exceed the critical arterial value. Greater emphasis is placed on freeway operations, but the important role of principal arterials as alternate routes for freeway trips and as major collection/distribution roadways for freeway access should not be overlooked. A transportation improvement plan that coordinates the use of all roadway resources is more efficient and better able to meet the needs of an auto-oriented society.

Figure 8 presents a summary of the growth trends in the freeway and arterial congestion index between 1975 and 1984. Dallas and San Antonio are estimated to be one to two years from the indicator and five to six years

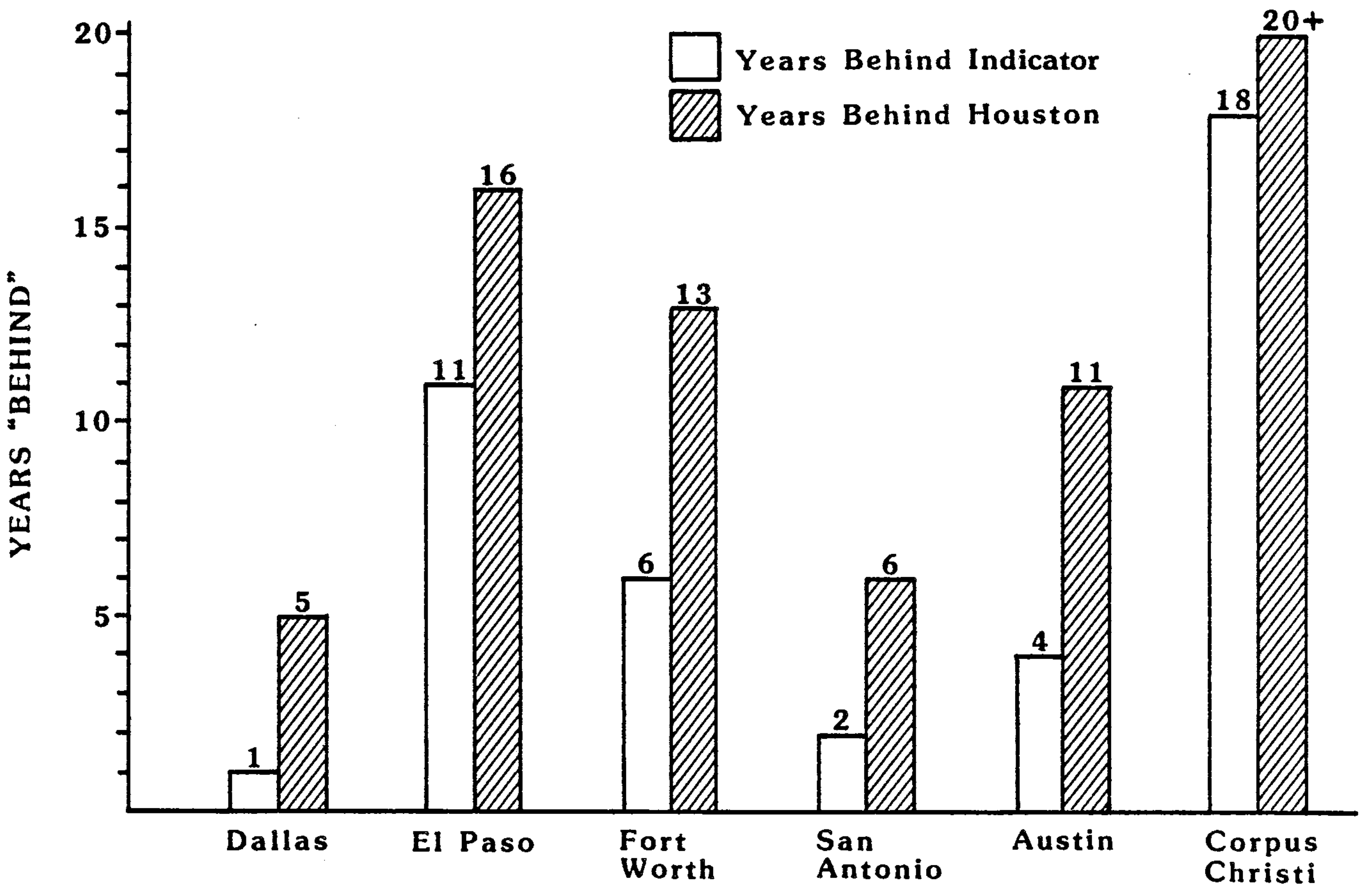
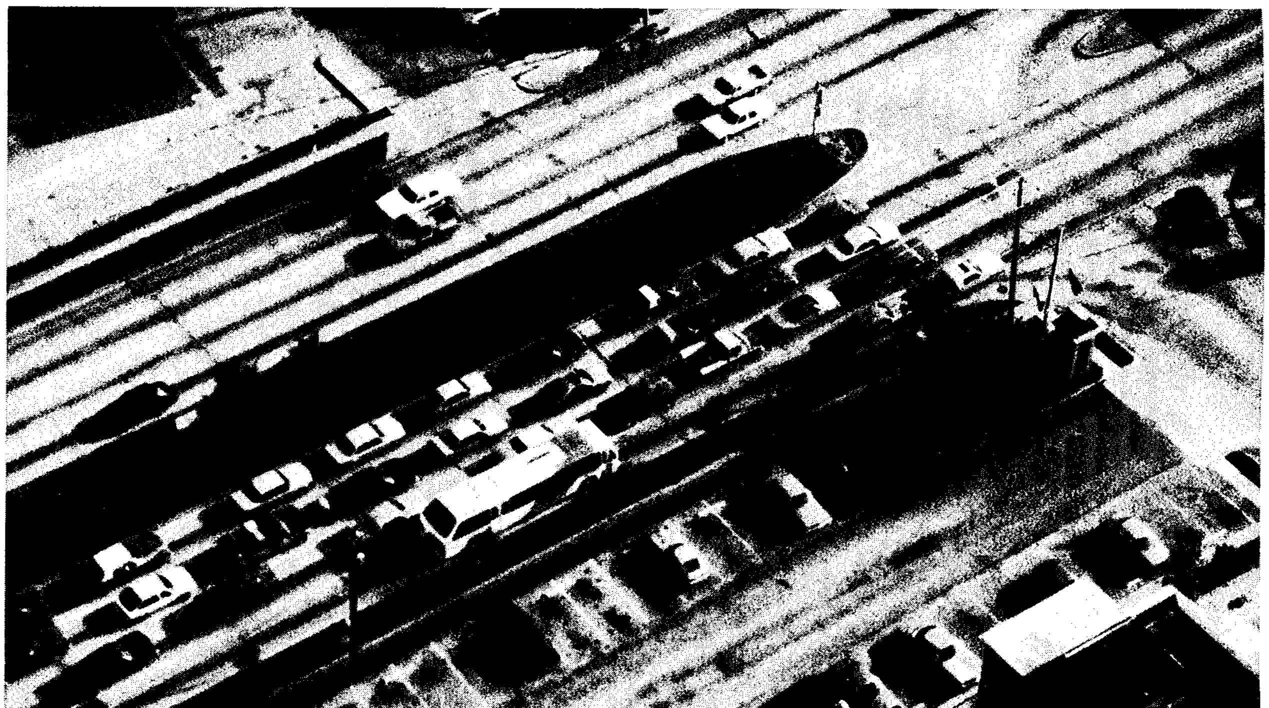


Figure 8. Time Until Congestion Indicator and 1984 Houston Congestion Levels Are Attained, Extrapolation of 1975 to 1984 Data



Relief of principal arterial congestion is an important part of urban area mobility improvement plans.

from the 1984 Houston areawide congestion level. Austin and Fort Worth appear to be approximately five years behind the congestion indicators and slightly more than ten years behind the 1984 Houston level. Austin, however, had a significantly higher growth rate after 1980 and, if that were considered, its "years behind" estimate would resemble those of Dallas and San Antonio. El Paso is estimated to reach the critical congestion level in the mid-1990s and reach the 1984 Houston level in 2000. Corpus Christi is not estimated to have a significant areawide congestion problem before 2000.

It should be noted that the data used in this report end in 1984. Any "years behind" assessment must be examined with an additional two years of mobility decline in mind. Dallas and San Antonio, therefore, may have already exceeded the critical indicator values, with Austin very near to that undesirable congestion level.

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7. State Department of Highways and Public Transportation, Regional Planning Office - Arlington, "Roadway and Population Estimates for the Dallas/Fort Worth Intensive Study Area."

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APPENDIX A

MOBILITY LEVEL ESTIMATION, 1975 TO 1980

Previous research (4) into mobility levels in Texas resulted in comparisons for Houston, Dallas, Fort Worth, San Antonio and El Paso between 1975 and 1980. This section summarizes the data base, analysis procedure and major findings of that research effort.

Data Base

In conducting the initial relative mobility study, available data proved to be the largest problem. Consistent data that allowed an accurate comparative assessment of urban congestion are not collected by any agency or group of agencies. Data collected in several ways by many sources were acquired. In the opinion of the research staff and reviewers of the research report, however, the quantitative measures used in the study did provide a reasonably accurate measure of overall urban mobility. The general nature of the mobility assessment and the variety of data sources as well as the experience of the reviewing agencies combined to provide analysis results consistent with the accuracy level desired.

Comparability of the measures was achieved using several estimates of both travel and area statistics. For example, in defining urban area, it was not always possible to use jurisdictional limits as the defining boundaries due to either lack of data on related travel measures or non-comparability of information. County boundaries may appear to provide consistency, but variations in county size, as well as percentage of urbanization, significantly impaired the utility of county-based data.

Statewide Data

Several recording forms are utilized on a yearly basis to report transportation statistics. The automated traffic recorder (ATR) information (15) and Texas Traffic Map (16) were useful due to the detailed nature of the data collected. The ATR data, however, were available for only a few selected locations in each city. As an areawide analysis tool, its usefulness is limited. The Traffic Map was useful in analyzing freeway condition, but of marginal value for any other roadway classifications.

Roadway mileage and volume data were available through the Roadway Inventory Tables (RI2-TLOG) (12), the Form TT Tables (13) and the Highway Performance Monitoring System (HPMS) (14). The latter two principally contained information relevant to State Department of Highways and Public Transportation (SDHPT)-maintained roadways and, thus, were not adequate to analyze major municipal roadway systems. HPMS reporting forms are required by the Federal Highway Administration (FHWA) and contain urban area information, but these data were not available before 1978. Its usefulness for the 1975 and 1980 time period was, therefore, limited.

Local Agency Developed Data

Regional planning offices of SDHPT, Metropolitan Planning Organizations (MPO) and other local planning agencies provided data from their files for the research effort. These data included planning model calibration information, annual travel mileage updates and population and land use statistics. While not all of the data provided by local sources was readily usable (the major problem being the urban area designation), when combined with SDHPT-generated data, it validated and clarified the trends noted in other data. Local data that were concerned with urbanized development boundaries were, in fact, the primary source of information about travel and roadway characteristics.

Use of the Data

Developing reasonably comparable numbers for the 1975 to 1980 time period required numerous assumptions and estimates to be made based on limited data. As mentioned, the multiple sources of data and planning agency review of the conclusions of the 1982 report increased the confidence of the researchers that the congestion and mobility measures were representative of the overall urban area. The range of error in the congestion indices was not significantly higher than that of the data from which they were derived.

Houston's Experience with Declining Mobility

The Houston data detailing the increase in congestion were analyzed to provide a basis for quantitative indicators of mobility decline. The rapid increase in congestion on Houston area freeways and arterial streets during the 1970s emphasized the need for actions to restore and maintain good mobility.

The disparity between increases in freeway lane-miles and freeway travel during the 1970s in Houston is quantified in Table A-1 and Figure 1. The rate of new freeway construction in the 1970s was one-sixth that of the 1960s, while daily freeway VMT increased at approximately the same rate throughout the 20-year period. Vehicle registration, population, and traffic volume counts were thoroughly analyzed and also indicated the shift from relatively good mobility to relatively poor mobility in only a few years.

Congestion increases were also apparent in the travel delay estimates. Peak-period volume and travel time information were utilized to generate the data in Table A-2 and Figure A-1. Six major radial freeways were evaluated in each of four travel studies conducted by the Houston-Galveston Regional Transportation Study (HGRTS) (19). The dramatic (380 percent) increase in delay between I-610 and Beltway 8 (Figure A-1) from 1969 to 1979 indicates the decline in mobility outside the central city area. The decrease in delay inside I-610 may be attributable to several factors, including the

Table A-1. City of Houston Growth Trends, 1950 to 1980

Year	Annual Average Population (1000)	Annual Average Vehicles (1000)	Freeway Travel in VMT Per Day[1] (1000)	Freeway Capacity (Lane-Miles)	Daily VMT Per Freeway Lane-Mile (1000)
1950	596[2]	240	201	24	8.4
1955	692[2]	375	620	100	6.2
1960	938[2]	480	1,044	187	5.6
1965	1,084	625	3,425	456	7.5
1970	1,240	777	7,320	761	9.6
1975	1,440	1,000	11,366	898	12.7
1980	1,604	1,272	16,308	959	17.0
Percent Increase Per Year					
1960-70	2.8	4.9	19.6	15.1	5.5
1970-80	2.6	5.1	8.4	2.4	5.9

[1]VMT--Vehicle-Miles of Travel

[2]As of April 1

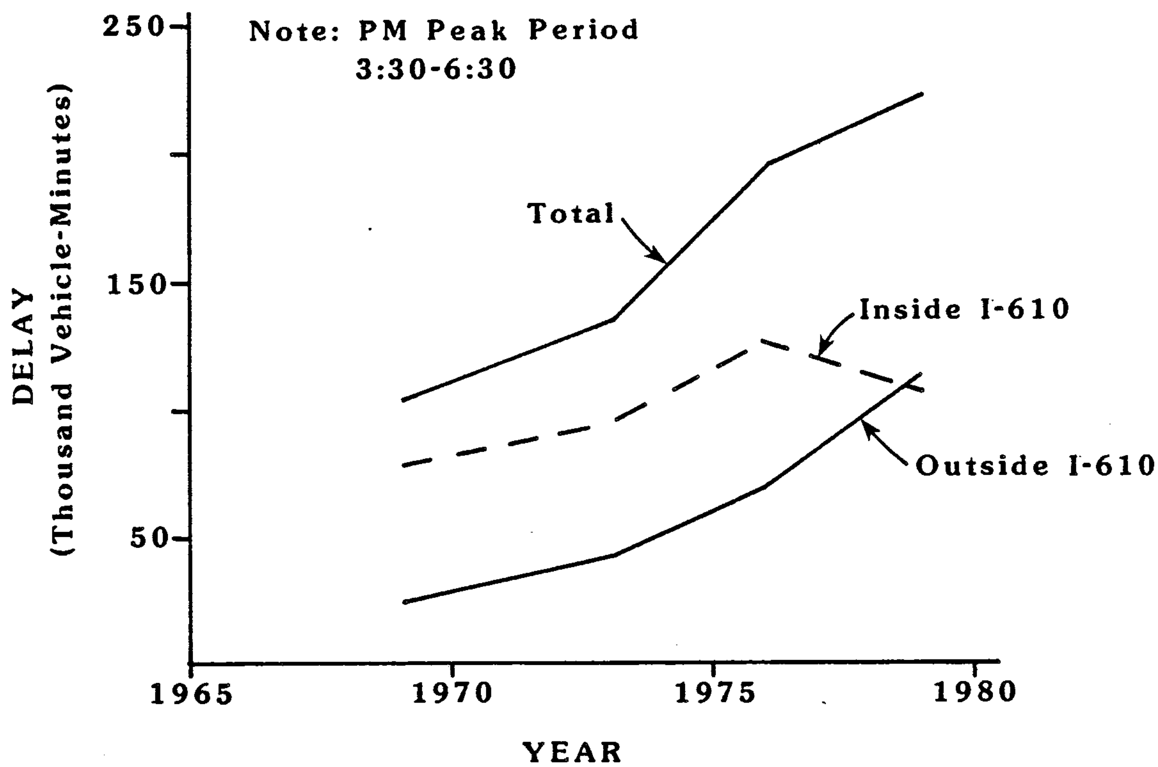
Source: References 1, 18.

Table A-2. Average Peak Period Delay By Freeway Segment Per Major Radial Freeway

Year	Inside I-610 (Veh-Mins)	I-610 to Beltway 8 (Veh-Mins)	Total (Veh-Mins)
1969	78,793	23,318	102,111
1973	93,674	41,207	134,881
1976	126,473	69,934	196,407
1979	109,745	111,730	221,475

Source: References 1, 4, 15, 16, 19.

completion of certain freeway sections and the traffic metering effect of I-610.



Note: The values presented are averages of the six freeways studied (I-10W, I-10E, US 59S, US 59N, I-45S, I-45N).

Source: References 1, 4, 15, 16, 19.

Figure A-1: Delay by Segments for Houston Freeways, P.M. Peak Period

An average daily traffic level of 15,000 vehicles per lane can be interpreted as the maximum volume for level of service C (17). Level-of-service D operation during the peak hour represents a less than desirable operating condition with speeds of approximately 40 mph. Figure A-2 quantifies the increase in congested freeway lane-miles in Harris County between 1965 and 1980. Although it is not known what percentage of the freeway system exceeding 15,000 vehicles per day per lane is an "acceptable" measure, it can be assumed that the 10 percent value in 1970 did not suggest county-wide deficiencies; however, the 45 percent in 1980 would appear to suggest such deficiencies did exist.

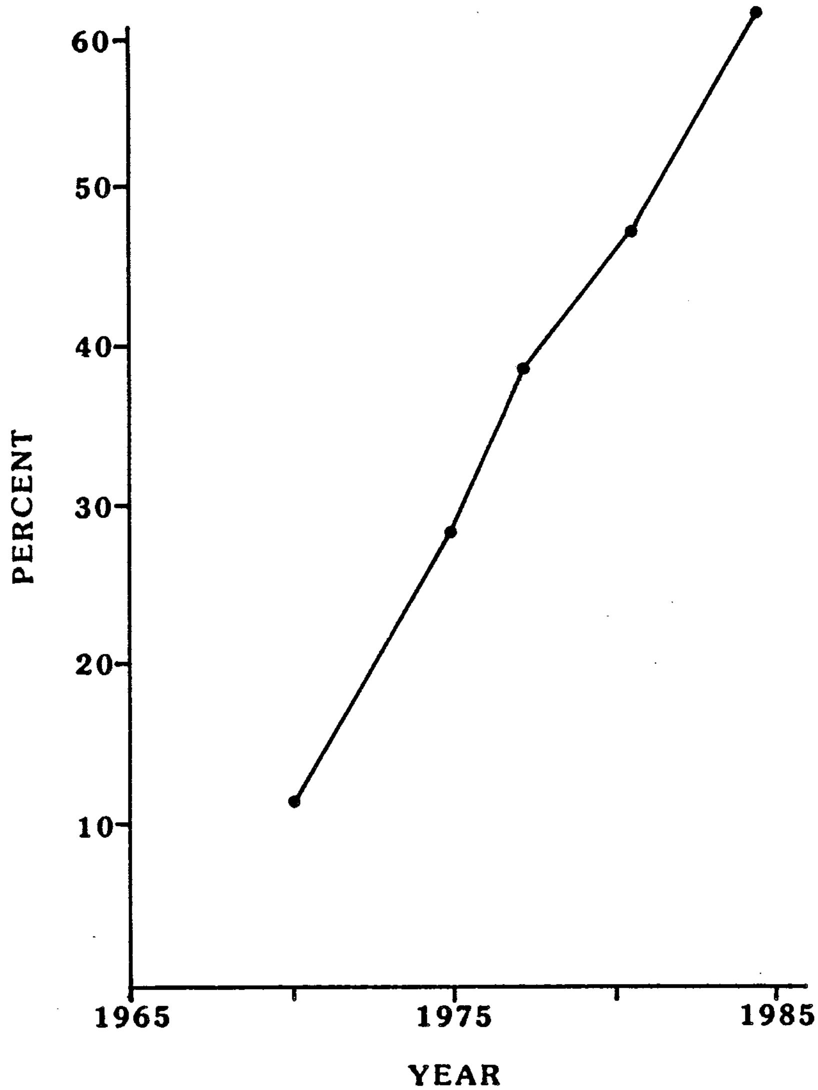


Figure A-2. Percent of Freeway Lane-Miles With More Than 15,000 ADT for Harris County (Houston), 1970 too 1985

The data available to the study team did not allow the determination of a specific date at which Houston's traffic problems became critical. For purposes of the overall analysis, however, this was not required. Mobility in Houston could be characterized as "reasonably good" beyond 1970. Peak-period speeds on freeways and major arterials were fairly high, and traffic delay was not a major concern. By the late 1970s, however, peak-period travel delay had doubled from 1970 levels, and volume per lane values reflected two or more hours of congested operation during both the morning and evening peak periods. Congested freeway lane-miles in Harris County

(Figure A-1) increased from 10 percent in 1970 to 40 percent in 1978. When rural areas of Harris County were subtracted from the analysis, the 1978 congested urban freeway mileage approached 50 percent.

Mobility Indicators

The data on mobility decline for Houston indicated that an "unacceptable" level of transportation service was reached somewhere in the 1975-1976 time frame. That assumption allowed quantitative measures of impending congestion problems to be developed and compared for the major urban areas of Texas. The following, listed in apparent order of reliability and usefulness, represent guidelines that can be used to determine if congestion in an urban area is becoming critical.

Traffic Per Lane

As shown previously, 15,000 vehicles per day per lane for freeways represents the beginning of LOS D operation. Once traffic has entered that range, congestion is becoming critical. As a measure of approaching congestion, the 13,000 vehicles per day per lane value used by the Federal Highway Administration in the highway needs estimate (20) would appear to represent a more appropriate value; that standard also was attained in Houston during the period where mobility was becoming unacceptable.

The corresponding measure for urban arterial streets would be approximately 4500 vpd/lane. This value also occurs in Houston about the mid-1970s and is in general agreement with accepted traffic engineering standards for arterial street operations.

- Urban Area Average Traffic Volumes
  - Freeway: 13,000 vehicles per lane per day
  - Principal Arterial: 4,500 vehicles per lane per day

Percentage of Congested Freeway

The percentage of the freeway system operating under congested conditions (15,000 vehicles per day per lane or more) was determined to be another descriptor of congestion and mobility levels. Those data for the Houston area were presented previously (Figure A-2). From that information, it appears that, once 30 percent of the lane-miles are operating at or above 15,000 vehicles per day, mobility has become significantly impaired.

- Percentage of County Freeway System with ADT Greater than 15,000 Per Lane: 30 percent.

k-Factor

As congestion increases, the peak hour begins to spread into a peak period and congestion exists for longer periods of time. The result is that the percentage of daily traffic that occurs in the peak hour, or k-factor, declines. Decreasing k-factor values are thus, indicative of the rising off-peak traffic volumes and the lengthening of the peak period. Both of these occurrences are associated with increasing freeway congestion.

Using the k-factor as a measure is complicated due to data availability; k-factors are readily available only at a limited number of locations, and those locations may or may not be where intense congestion occurs. For example, many sections of roadway in Houston have k-factors in the range of 7 percent, data not reflected by the average value in Figure 5.

- Systemwide Freeway k-Factor (percent of ADT in the peak-hour): 9.2 percent.

These measures are only some of the variables examined during the previous mobility study (4). While all of the measures have limitations due to the reliability and accuracy of the data base, these indicators are illustrative of urban travel conditions. They are also available without any new data collection requirements, which allows the use of historical traffic data collected during the usual urban planning process. A single variable may not be indicative of the traffic congestion in an urban area, but if all of the measures are examined, the relative mobility levels should become apparent.