ESTIMATES OF RELATIVE MOBILITY IN MAJOR TEXAS CITIES

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ABSTRACT

The major urban areas in Texas have recently experienced a period of unprecedented growth. Along with that growth came significant increases in traffic congestion with corresponding declines in urban mobility. Maintaining moblilty is essential if continued economic growth is to be realized. This study uses available data to assess the seriousness of congestion in the major urban areas and to estimate the relative levels of mobility that exist in major Texas cities.

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Statewide Data

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SUMMARY

All major Texas cities are facing increasing problems in maintaining mobility. Maintaining that mobility is essential if a high quality of life is to be provided along with a climate conducive to continued economic growth.

Congestion can increase rapidly as evidenced in Houston during the 1970's. In that decade, Houston changed from a city with a very high mobility level to, perhaps, the most congested city in the United States. This occurred since, during a period where travel demand continued to increase rapidly, the rate of growth in new roadway construction decreased significantly.

The rapidity with which mobility can be lost has to be a cause of concern for all the major Texas cities. To maintain mobility and continue to accommodate growth will require a large scale commitment of funds to transportation improvements. While area-wide congestion may not yet be severe in all urban areas, significant traffic problems do exist at various locations within all of the urban areas.

The data base for identifying relative congestion levels has significant limitations. It appears that the following represent measures that should not be allowed to occur in an urban area. Once these measures have been met or exceeded, severe congestion is present in the urban area.

- Daily traffic volume per lane
  - Freeway: 13,000
  - Arterial: 4,500
- Percentage of freeway system with ADT/lane ≥ 15000: 30%
- Systemwide freeway K factor: 9.2%

- Land area within 30 minutes of CBD in peak hour: 300 square miles, equivalent to approximately a 20 mph average speed.

These measures were used to compare and rate the various cities. The results are summarized in Figures S-1 and S-2. Figure S-1 shows the relative congestion levels in the study cities. Figure S-2 shows how many years the various cities are "behind" Houston and the congestion standard based on existing conditions and extrapolated growth rates. Figures S-1 and S-2 were derived using 1980 data; this implies, for example, that in 1982 Dallas is probably only 3 more years away from reaching the congestion standard.

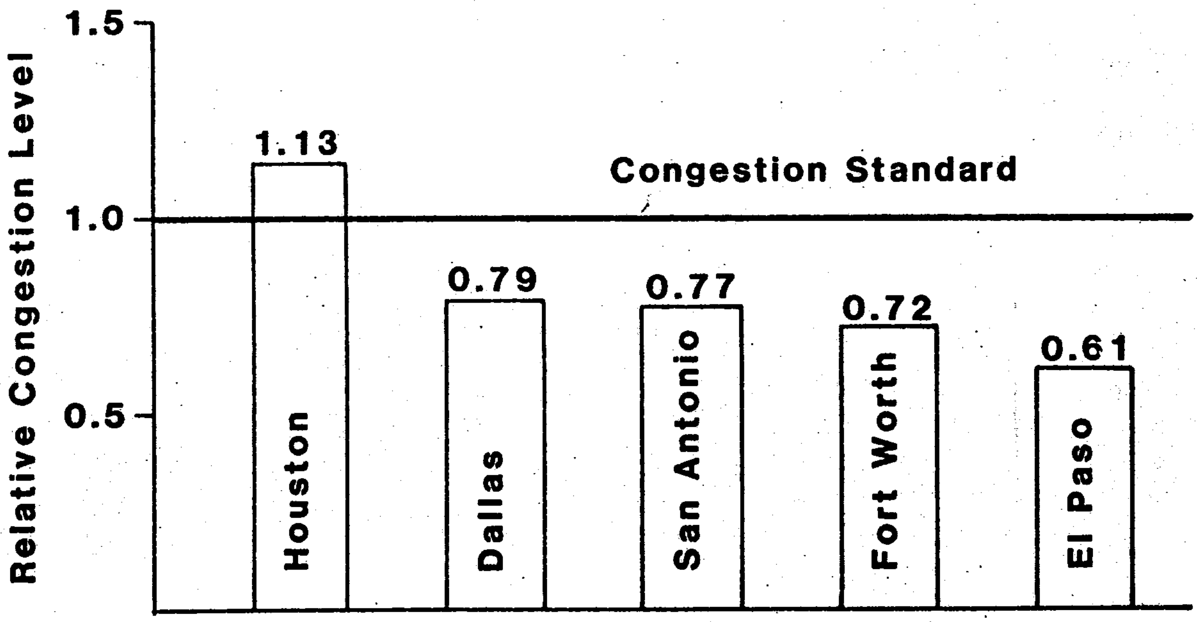

Figure S-1: Relative Congestion Levels in Major Texas Cities, 1980

Houston has already crossed into the serious congestion situation. Indeed, the Regional Mobility Plan developed in Houston is designed to "bring" Houston back to a congestion level roughly equivalent to the standards developed in this study. If historical trends continue, Dallas and San Antonio will surpass the congestion standards in the mid 1980's, and congestion will continue to increase in Fort Worth and El Paso.

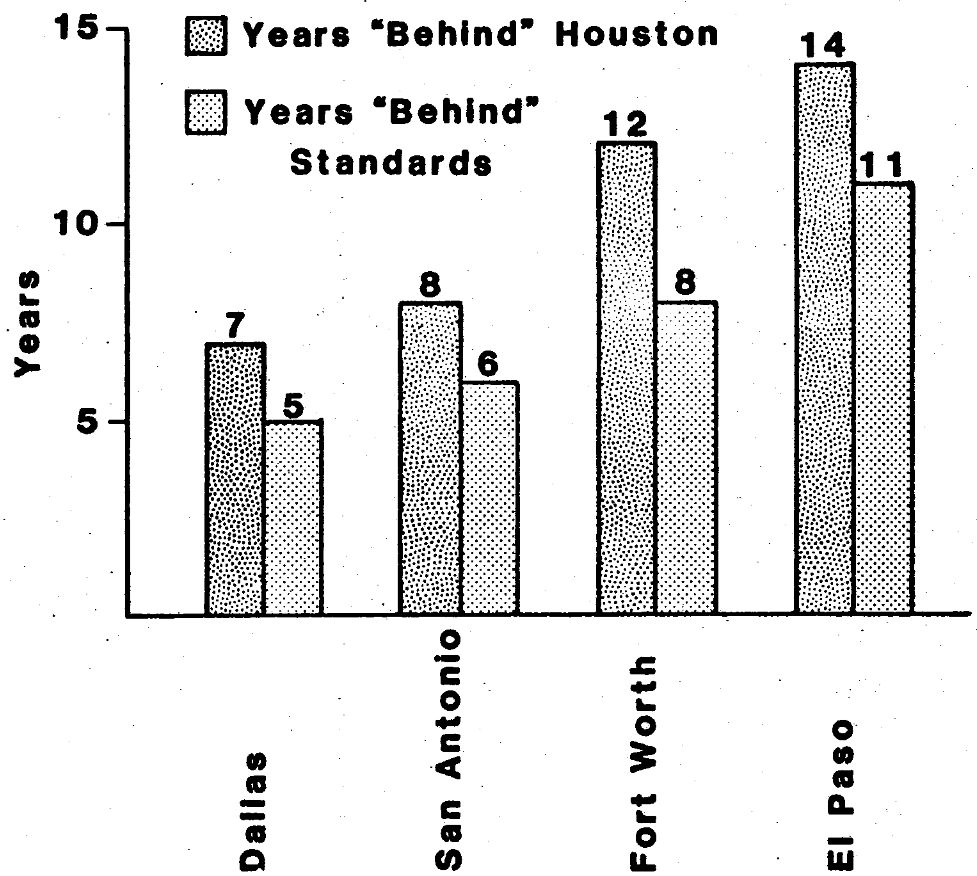

Figure S-2: Number of Years Until the Congestion Levels Characterized by the Congestion Standard and Houston are Attained in Other Major Texas Cities, 1980.

All of the major urban cities will be confronted with significant problems during the 1980's in an effort to just maintain -- not necessarily improve -- mobility. To maintain that mobility, the rate of new facility construction in the 1980's will have to be greater than that experienced in the 1970's.

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 moblility problem in major Texas cities. The report provides a quantification of those mobility levels. This information should be of value in identifying and prioritizing roadway needs.

Key Words: Mobility, Congestion, Transportation Planning

DISCLAIMER

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INTRODUCTION

Major urban areas in Texas have, historically, had outstanding levels of mobility. Even in the most congested of Texas cities -- Houston -- mobility actually improved during the 1950's and most of the 1960's. There is little doubt that the high level of mobility present in major Texas cities has been a prime reason that these cities have experienced tremendous growth. It follows that, unless ways are found to maintain mobility and a high quality of life, the rate of future growth in the larger cities may be adversely affected.

Significant losses in mobility did occur during the 1970's. These losses occurred for two primary reasons. First, the rate of growth in highway construction slowed; for example, in the Houston area lane-miles of freeway were expanded at an annual rate of 15.1% from 1960 to 1970 and at an annual rate of 2.4% from 1970 to 1980. Second, growth in vehicle-miles of travel accelerated with the migration to the Sunbelt; for example, daily vehicle-miles of travel in the Houston area increased by 74% from 1960 to 1970 and increased by 104% from 1970 to 1980. Thus, absolute demand increased at a greater rate during the same time period in which supply, or roadway capacity, was increasing at a decreasing rate.

The result, quite obviously, 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 1960's, in a period of only ten years one of those cities -- Houston -- had become, perhaps, the most congested city in the United States; and other major Texas cities are not that far behind the congestion levels that exist today in Houston.

The decline in mobility carries with it a substantial cost resulting from congestion. A recent study (1)* performed in Houston estimated that in 1981

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*Denotes number of reference listed at the end of the main text.

congestion cost Houstonians $1.9 billion. It can certainly be argued that the level of congestion that exists in Houston today, and which is continuing to increase, is not acceptable. Significant transportation improvements are needed to "bring back" a higher level of mobility. It can be further argued that 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.

The major urban areas in Texas face a challenge to maintain acceptable levels of mobility. This is a challenge that will require large-scale capital expenditures; the Regional Mobility Plan (1) recently developed in Houston estimates that over the next 15 years it will be necessary to expend $16.2 billion just to "recreate" the level of mobility that existed in 1974. Expenditures of slightly over $1 billion per year will go a long ways toward alleviating a problem that is now costing $1.9 billion per year and is getting worse.

Unless large-scale commitments of funds are made in the major Texas cities, mobility will continue to decline along with the quality of life. Permitting this to occur will certainly have an adverse impact on the spectacular economic growth that has been taking place in major Texas cities.

STUDY OBJECTIVES

It is evident to most observers that congestion has increased and mobility has declined in the major urban areas in Texas. The primary intent of this study is to provide a quantification of this occurrence. The following represent the major objectives of the study.

- Develop quantitative measures that can be used to define "acceptable" levels of urban mobility and compare existing conditions in major cities to those measures of acceptability.
- Document the relative levels of mobility that now exist in major Texas cities.

STUDY CITIES

This study addresses the larger urban centers in Texas. Travel data are analyzed for Houston, Dallas, Fort Worth, San Antonio, and El Paso. These are the largest cities in the state and are also the cities included in another major research study (Study 2-10-74-205) addressing freeway travel; considerable data are available through that related study. Locations of these study cities are shown in Figure 1.

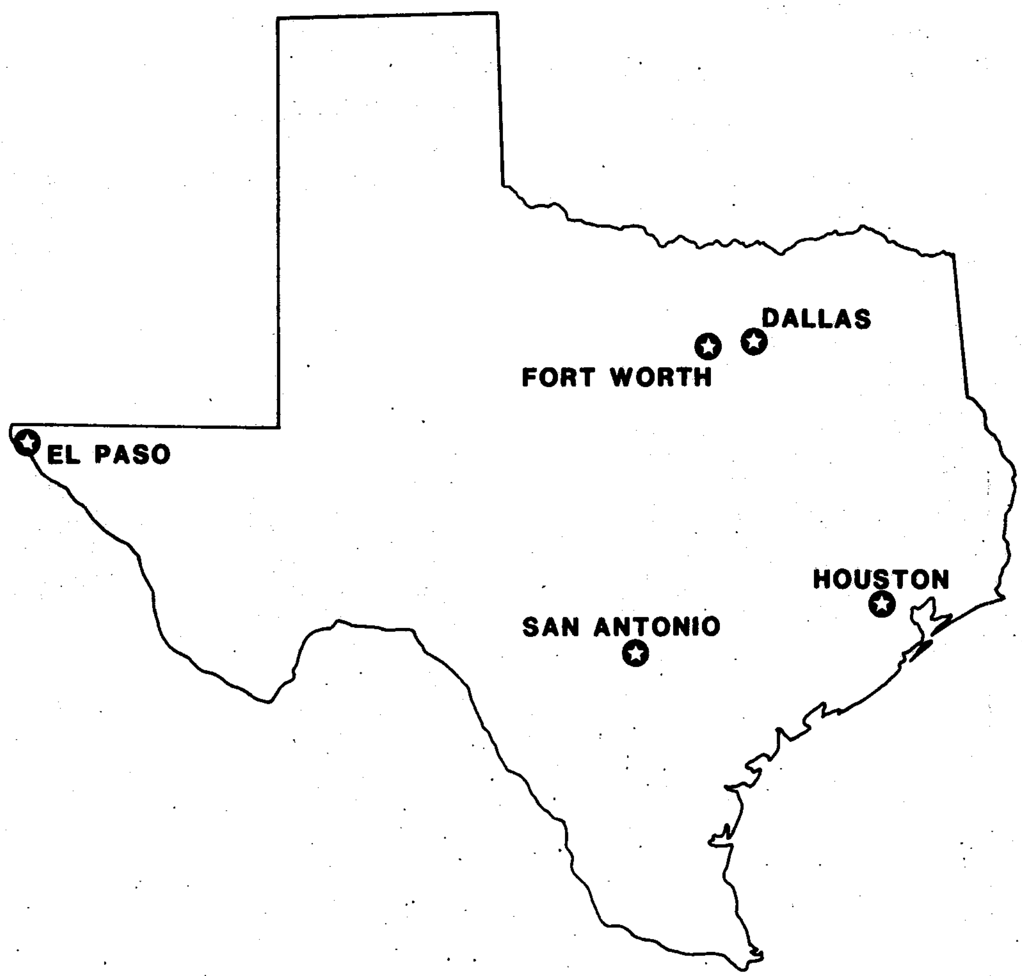


Figure 1: Location of Study Cities

THE DATA BASE

Good, highly reliable data are not available from which to develop extremely accurate estimates of mobility in the various urban areas. The same data are not available for all urban areas, and the data that are available have not necessarily been collected in the same manner or using the same definitions. Some of the limitations of the data base are highlighted in this section.

As a result, in reviewing the findings of this study, it must be realized that the data base is not perfect. It is felt that the quantitative measures used in this study do provide a reasonably accurate measure of the overall mobility in each urban area, however.

The measures presented in this report are intended to describe general mobility and congestion for an entire urban area. Simply because the measures might suggest that area wide congestion may not be critical for a specific city does not mean that, at specific locations within that urban area, intense congestion does not occur on a regular basis. All of the major urban areas considered in this study do have such locations.

It should also be noted that, in order to develop travel numbers that can be compared between urban areas, it was necessary for the research staff to estimate several numbers. 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 (e.g., while counties might initially appear to be a good unit of measure, variations in county size as well as percent urbanization significantly reduce the attractiveness of the county data for assessing urban area mobility). As a result, some data developed in this study, such as the definition of urban area, do not necessarily correlate directly to the definitions that may be used and preferred by planning agencies in the individual study cities.

Statewide Data

Much of the traffic volume data used in this analysis is collected at automatic traffic recorder (ATR) stations by the State Department of Highways and Public Transportation (SDHPT). The average daily traffic (ADT) and peak-hour factor (phf), as determined from the ATR stations, are published annually by SDHPT for many locations on Texas freeways. Other traffic counts consisting of volumes only are presented on the Annual Texas Traffic Map prepared by SDHPT in Austin. These count data were used in calculating delay time in several major urban areas.

Several aggregations of roadway mileage are compiled by SDHPT for all the study cities. Examples of the way in which the data are presented are included in Appendix A. SDHPT's Planning and Research Division (D-10) has recently completed traffic modeling schemes for the Houston-Galveston and Dallas-Fort Worth areas that present road-miles and vehicle-miles of travel for all functional classes of roadway. The regions are divided into several sectors which can be grouped into boundaries for the Houston, Dallas and Fort Worth urban areas. The relative accuracy of these data are discussed later, but the point must be made that these data are only available for one year. There are no similar data from which to develop trends for this particular measure of travel and capacity. This same problem currently exists in the case of the Highway Performance Monitoring System (HPMS). The Planning and Research Division (D-10) is required to use this form to report on urban Texas roadways to the Federal Highway Administration. This system compiles road miles and vehicle-miles by functional classification for all roads in Texas urban areas. Fortunately, though, in the future it will be updated every two years and will become a more useful planning tool.

Two groupings of roadway data are compiled by D-10 on a yearly basis for all Texas counties. The Form TT tables are grouped into city and rural areas with only those roads inside incorporated city limits included in the city tables. The deficiency with this system is that it does not include the unincorporated suburbs, which in many cases may be as important as the cities. These tables include only those miles maintained by SDHPT and are grouped by administrative classifications (e.g., Federal-Aid Primary, Federal-Aid Urban, etc.) rather than the more desirable, at least for this analysis, functional classification which categorizes roads by the volume of traffic that can be carried. The Interstate category is presented in the TT tables and the RI2-TLOG (discussed below) which might allow the two to be compared, but the defined urban boundaries are not always the same. Freeway miles other than Interstate and principal arterial mileage are nearly impossible to ascertain from the TT tables because each administrative classification may include different types of roadway.

Tne RI2-TLOG includes all SDHPT-maintained mileage arranged by functional classification for each year since 1976. Within each county the functional roadway classifications are grouped according to several ranges of urban area population (e.g., 5,000-10,000, over 50,000 etc.) as well as rural areas. The biggest hindrance to the effective use of either the TT or RI2-TLOG table is the fact that these tables do not include all mileage of a certain roadway type. The state-maintained mileage of freeways and expressways is fairly close to the actual total in most cities, but the percentage drops for other roadway types. Thus, knowing only state-maintained mileage doesn't result in an accurate reflection of overall urban mobility.

The State Department of Highways and Public Transportation's Motor Vehicle Division supplied countywide vehicle registration data for the study areas. These were modified to reflect urban area use in this study by using ratios of urbanized area to total county area and population.

Houston Data

The Houston-Galveston Regional Transportation Study (HGRTS) provided considerable data on roadway capacity and travel in the Houston urban area. Most of this material is published in the HGRTS Newsletter (see Appendix A). The HGRTS Study Office provided estimates of the land area comprising the Houston urban area based on a minimum population density of 1000 persons per square mile. The population and registered vehicle values for the urban area were interpolated from population and vehicle data for the City of Houston and Harris County. HGRTS Travel and Time and Speed Maps were utilized, along with SDHPT traffic counts, to analyze vehicle delay time.

The Planning and Research Division (D-10) transportation planning model and the HPMS derived slightly higher numbers for roadway capacity and travel than HGRTS. The different methods of determining an urban area boundary contributed to the discrepancy. The RI2-TLOG and TT tables were useful in confirming the growth pattern of the HGRTS data, but again the designations of urban area were not derived in the same manner.

Dallas and Fort Worth Data

The main source of transportation data for this study was the North Central Texas Council of Governments (NCTCOG) and the Regional Planning Office of SDHPT in Arlington. The NCTCOG Major Thoroughfare Link (MTL) File provides road miles, lane miles and vehicle miles of travel by functional classification for all roads in the Intensive Study Area (ISA) which includes Dallas County, Tarrant County and parts of the surrounding counties.

A map of trip end distributions was used to derive the urban area boundaries. The road mileage and travel were then estimated from the MTL File. The file (example in Appendix A) has three groupings of urbanized area (Central Business District, Outer Business District, Suburbs) plus a rural category. The Dallas and Fort Worth urban area boundaries contain portions of the rural designation in addition to the urban designation. The RI2-TLOG and TT tables were consulted to check the trends developed from the MTL.

Population estimates were derived from data provided by NCTCOG. The resulting population densities were checked against the other study cities to assure that both the population and area estimates were reasonable.

Other roadway data and a review of the values developed in this study for the Dallas and Fort Worth areas were supplied by the SDHPT Regional Planning Office in Arlington.

El Paso Data

The Metropolitan Planning Organization (MPO) and the Planning Section of the Department's District 24 provided transportation data for the El Paso area in addition to that available at the state level. The MPO provided data on vehicle registration, population and vehicle travel, and also assisted in the determination of the impact of Cuidad Juarez on travel values in the El Paso area. That area has a population of approximately 750,000, making any numbers derived for just the El Paso area suspect.

District 24 provided information on roadway capacity and travel which were used along with the data from the Planning and Research Division (D-10) in Austin. One travel time and speed study (1976-77) has been conducted for the El Paso area by SDHPT.

San Antonio Data

The San Antonio-Bexar County Urban Transportation Study (SABCUTS) Long Range Transportation Plan was used in addition to those estimates available from SDHPT's Planning and Research Division for roadway travel and capacity in San Antonio. The SABCUTS data were used in estimating the urban area vehicle miles of travel (VMT) and the number of registered vehicles. The HPMS and R12-TLOG tables were used to estimate roadway mileage growth over the study period. These two sources were combined with daily traffic volume derived from the Texas Traffic Map to estimate the VMT change for each year.

Population and land area figures from the City of San Antonio Planning Department were utilized in determining values for the urban area. County maps were also used in estimating the extent of the urban area. As in Dallas and Fort Worth, the population density was used as a check for reasonable values for these numbers.

Overview

An intent of this section is to point out that, while a variety of data sources exist, those sources are not necessarily comparable. To develop reasonably comparable numbers for use in this study, it was necessary to make numerous assumptions and develop estimates based on the limited available data. The data base leaves much to be desired; the measures on congestion and mobility developed in the study should be representative of the overall urban area. However, it should be recognized that an error range certainly does exist.

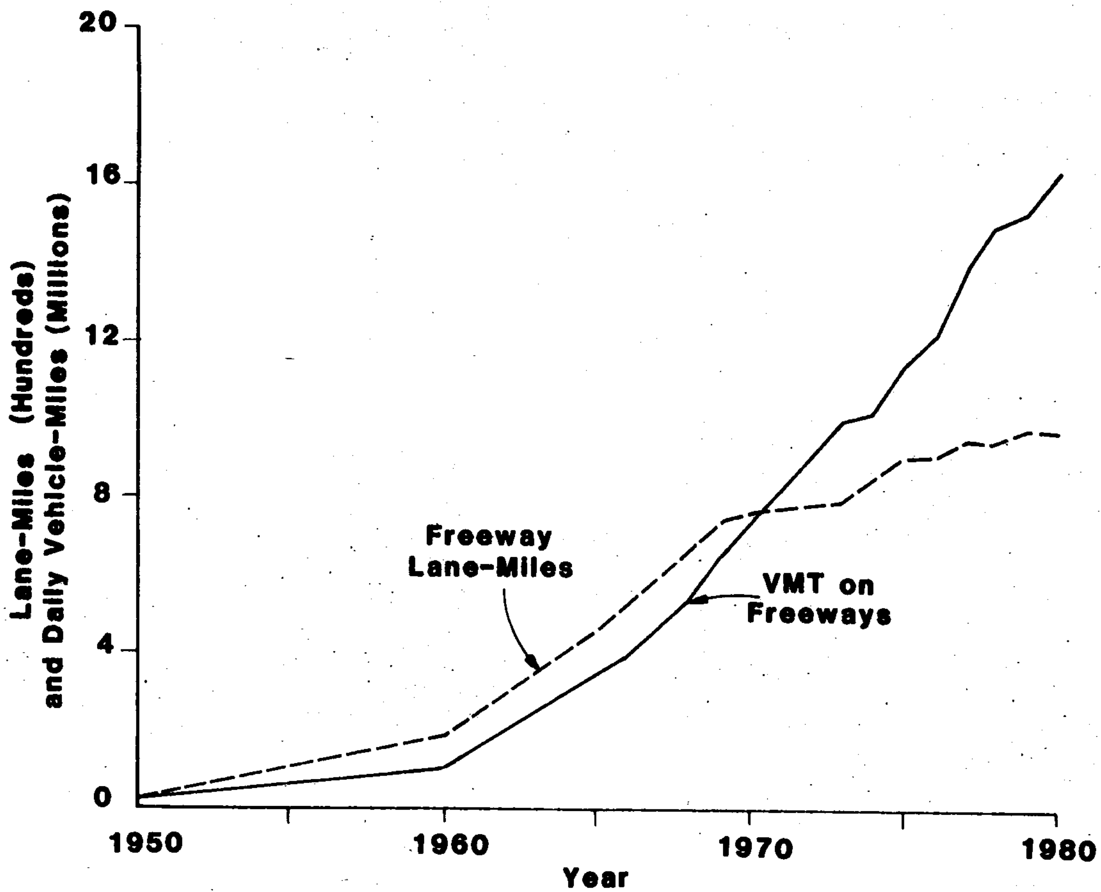
THE MOBILITY DECLINE, THE CASE OF HOUSTON

The decline in mobility in the Houston area is traced for two reasons. First, the rapidity with which that decline occurred is alarming and emphasizes that major actions are needed in all major urban areas to maintain mobility. Second, the Houston experience can be used to provide a basis for developing some quantitative measures of the seriousness of urban congestion.

The disparity increases in freeway lane-miles and increases in freeway travel during the 1970's in Houston, referred to in the introduction to this report, is quantified in Figure 2. The rate of new freeway construction in the 1970's was one-sixth of that of the 1960's. If freeways had been built at the 1960-1970 rate throughout the 70's, Houston would have had 1900 lane-miles of freeway in 1980 instead of 960. On the other hand, the absolute increase in freeway travel during the 1970's was substantial; from 1960 to 1970 daily freeway VMT increased by 6.3 million, while from 1970 to 1980 daily freeway VMT increased by 9.0 million.

The data in Table 1 further illustrate the problems that developed in the 1970's. As a result of the reduced rate of new freeway construction and the continued increase in travel demand, daily travel per lane mile of freeway increased at an annual rate of 5.9 percent, from 9600 in 1970 to 17,000 in 1980 (2). That 1980 level, the average for the entire freeway system, is equivalent to the accepted measure for level-of-service (LOS) D operation. Although population increased at a significant rate during the 1960's and 1970's (3), vehicle registrations increased at almost twice the population rate. In 1980, Houston had 1.27 million registered vehicles and 959 lane-miles of freeway, or 4 feet of freeway lane per registered vehicle.

Average daily traffic (ADT) per lane represents the most readily available indicator of the condition of freeway operation. Permanent count data at the Automatic Traffic Recorder Stations (4) in the Houston urban area were evaluated



Source: Reference 2

Figure 2: Lane Miles of Freeway and Freeway Vehicle-Miles of Travel, Houston, 1950-1980

as a means of assessing general trends; since there are only a limited number of such stations and since they are not necessarily located at the more critical traffic areas, these counters do not provide a highly accurate measure of urban congestion. Figure 3 shows trends in the ATR data, broken down by the location in the urban area relative to Loop I-610. The numerous drops in the graph are due, in part, to the opening of new ATR stations in relatively less travelled freeway sections. The solid line at 15,000 vpd/lane indicates the maximum volume associated with LOS C as determined in the interim Highway

Table 1: City of Houston Growth Trends

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

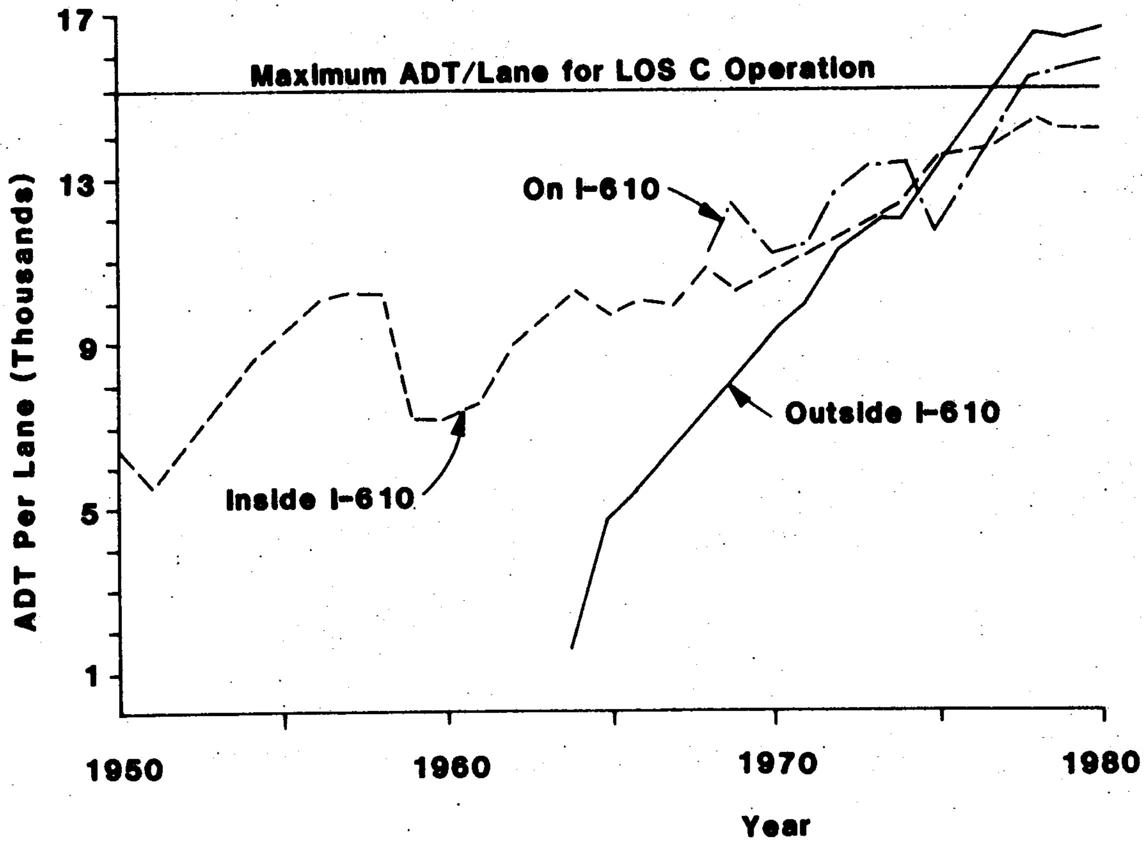
[1]VMT-Vehicle Miles of Travel

[2]As of April 1

Source: References 2,3

Capacity Manual (5). Since 1970, the ADT at all count stations has increased by 3.7 percent per year; outside of I-610 these counts increased at an annual rate of almost 6 percent.

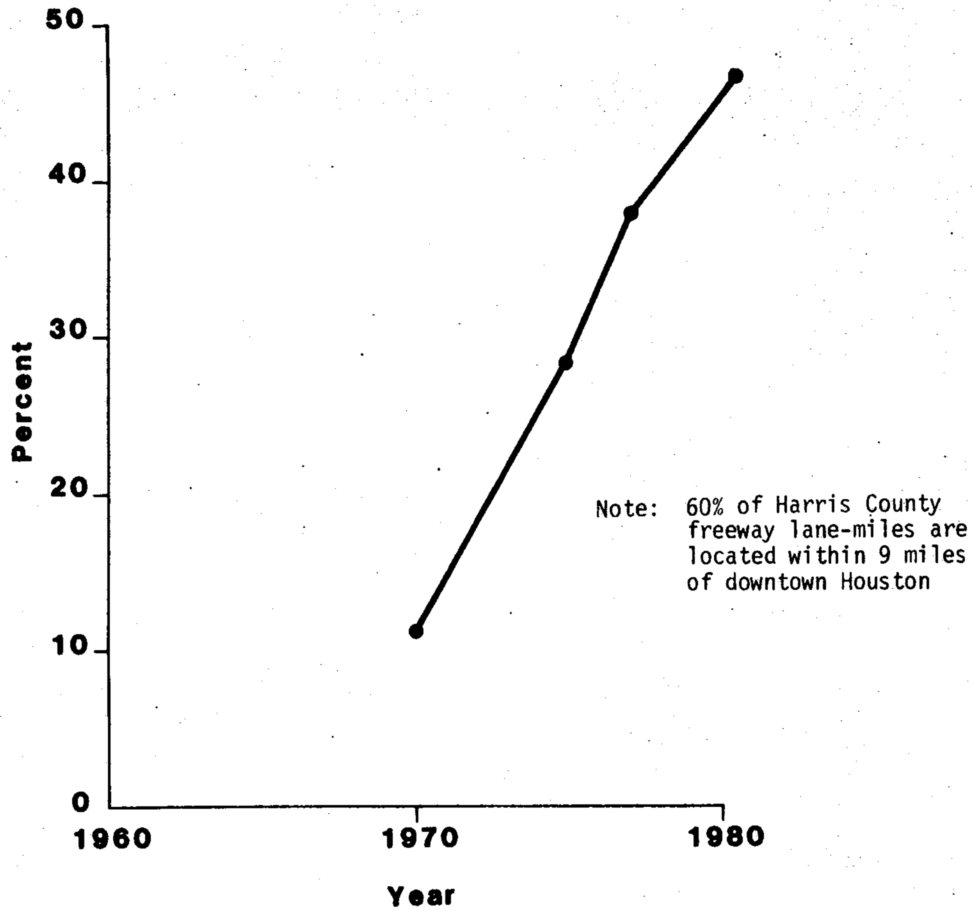
All of the lines plotted in Figure 3 are, in 1980, either in excess of or nearly at 15,000 vpd/lane; this represents the beginning of LOS D operation. An entire freeway system operating at an average LOS D means that many segments of that system are operating at LOS E or F, an operating level well below design standards.



Source: Reference 4

Figure 3: Trends in Traffic Counts at Automatic Traffic Recorder Stations, Houston, 1950-1980

The data in Figure 2 suggest that the rate of increase in new freeway construction slowed perceptibly in 1970 while demand continued to increase. The result was increased travel volumes per lane. Figure 4 shows the percentage of the freeway lane-miles in Houston operating at 15,000 vpd or more from 1970 to 1980. In 1970, only 11 percent of the lane-miles were in this category; in 1975 28 percent of the lane-miles exceeded that measure, and in 1980 this measure was exceeded on 45 percent of the system. Although it is not known what percentage of the system exceeding 15,000 vpd/lane is an "acceptable" measure, it



Source: References 2, 4, 6

Figure 4: Percent of Freeway Lane-Miles with Daily VMT Greater Than 15,000 - Harris County

might be assumed that the 11 percent in 1970 did not suggest large-scale deficiencies; however, the 45 percent in 1980 would appear to suggest such deficiencies exist.

A more comprehensive description of travel trends in Houston and Harris County is provided in Tables 2 through 5. While neither the Houston nor the Harris County numbers are directly relatable to urban area values, the numbers in the tables do reflect general travel conditions in the area.

As would be expected, along with the increases in travel per lane came

Table 2: City of Houston Freeway and Expressway Travel Trends

Year	Freeway Travel in VMT Per Day* (1000's)	Total Travel in VMT Per Day (1000's)	Freeway Travel in % of Total*	Freeway Route Mileage*	Freeway Lane Mileage*	Travel Per Mile of Freeway and Expressway		Travel Per Lane-Mile of Freeway and Expressway	
						Freeway Travel* (1000's)	Total Travel (1000's)	Freeway Travel* (1000's)	Total Travel (1000's)
1950	201	5,250	3.8	4.0	24.0	50.19	1313.50	8.36	218.75
1955	620	7,700	8.1	19.2	100.2	32.29	401.04	6.19	76.85
1960	1,044	10,200	10.2	31.6	187.2	33.04	322.79	5.58	54.49
1965	3,425	13.750	24.9	72.5	456.2	47.24	189.66	7.51	30.14
1966	3,900	14,400	27.0	81.0	529.0	48.15	177.78	7.37	27.22
1967	4,600	15,500	29.7	90.8	591.6	50.66	170.71	7.78	26.20
1968	5,338	16,575	32.2	99.1	667.2	53.87	167.73	8.00	24.84
1969	6,462	17,700	36.5	109.3	745.8	59.12	161.94	8.67	23.73
1970	7,320	18,800	38.9	111.8	760.6	65.47	168.16	9.62	24.72
1971	8,081	19,975	40.5	112.6	768.6	71.77	177.40	10.51	25.99
1972	9,100	21,400	42.5	114.3	781.6	79.62	187.23	11.64	27.38
1973	9,900	23,250	42.6	115.7	795.6	85.57	200.95	12.44	29.22
1974	10,161	23,800	42.7	121.9	854.0	83.36	195.24	11.90	27.87
1975	11,366	26,250	43.3	126.5	898.4	89.72	207.51	12.65	29.22
1976	12,118	28,275	42.9	126.5	904.9	95.79	223.50	13.39	31.25
1977	13,918	32,747	42.5	135.2	955.5	102.94	242.21	14.57	34.27
1978	14,965	35,212	42.5	135.2	955.5	110.69	260.44	15.66	36.85
1979	15,269	35,927	42.5	137.1	970.7	111.37	262.05	15.73	37.01
1980	16,308	38,372	42.5	135.6	958.7	120.27	282.98	17.01	40.03

* Includes Expressways

Source: Reference 2

Table 3: Harris County Freeway and Expressway Travel Trends

Year	Freeway Travel in VMT Per Day* (1000's)	Total Travel in VMT Per Day (1000's)	Freeway Travel in % of Total*	Freeway Route Mileage*	Freeway Lane Mileage*	Travel Per Mile of Freeway and Expressway		Travel Per Lane-Mile of Freeway and Expressway	
						Freeway Travel* (1000's)	Total Travel (1000's)	Freeway Travel* (1000's)	Total Travel (1000's)
1950	250	7,600	3.3	8.4	41.6	29.76	904.76	6.01	182.69
1955	810	11,000	7.4	37.6	173.8	21.54	292.55	4.66	63.29
1960	1,392	14,500	9.6	66.6	331.2	20.90	217.72	4.23	43.78
1965	4,300	19,500	22.1	125.1	706.6	34.37	155.88	6.09	27.60
1966	4,850	20,400	23.9	144.0	830.4	33.68	141.67	5.84	24.57
1967	5,675	21,900	25.8	153.8	893.0	36.90	142.39	6.36	24.52
1968	6,509	23,400	27.8	162.1	960.6	40.15	144.36	6.72	24.16
1969	7,835	24,975	31.4	172.3	1047.2	45.47	144.95	7.48	23.85
1970	9,115	26,475	36.5	181.4	1102.0	50.25	145.95	8.27	24.03
1971	10,323	28,000	37.0	185.5	1129.6	55.65	150.94	9.14	24.79
1972	11,486	29,776	38.6	193.1	1163.4	59.70	154.76	9.87	25.59
1973	12,348	32,089	38.5	194.4	1177.4	63.71	165.58	10.49	27.25
1974	12,823	32,476	39.5	202.6	1247.2	63.29	160.29	10.28	26.04
1975	14,456	35,203	41.1	207.2	1291.8	69.77	179.90	11.19	27.25
1976	15,447	37,918	40.7	207.2	1298.3	74.55	183.00	11.90	29.21
1977	16,811	40,990	41.0	207.2	1298.3	81.13	197.83	12.95	31.57
1978	17,881	43,033	41.5	208.2	1304.3	85.88	206.69	13.71	32.99
1979	18,278	44,354	41.2	211.5	1314.7	87.25	211.71	13.90	33.74
1980	18,758	46,795	40.1	210.1	1306.0	89.28	222.73	14.36	35.83

* Includes Expressways

Source: Reference 2

Table 4: City of Houston Mobility Trends

Year	Annual Average Population (1000's)	Annual Average Registered Vehicles (1000's)	Daily Freeway Travel per Capita*	Total Daily Vehicle Travel per Capita	Daily Freeway Travel per Vehicle*	Total Daily Vehicle Travel per Vehicle	Population Ratios		Vehicle Ratios	
							Per Mile of Freeway* (1000's)	Per Lane Mile of Freeway* (1000's)	Per Mile of Freeway* (1000's)	Per Lane Mile of Freeway* (1000's)
1950	596[1]	240	0.3	8.8	0.8	21.9	149.00	24.83	60.00	10.00
1955	692[1]	375	0.8	10.0	1.7	20.5	39.95	7.66	19.63	3.74
1960	938[1]	480	1.1	10.9	2.2	21.3	29.68	5.01	15.19	2.56
1965	1084	625	3.1	12.5	5.5	22.0	15.13	2.41	8.62	1.37
1966	1114	650	3.5	12.8	6.0	22.2	13.93	2.13	8.03	1.23
1967	1144	690	4.0	13.4	6.7	22.5	12.78	1.96	7.60	1.17
1968	1174	730	4.5	14.0	7.3	22.7	11.91	1.77	7.37	1.09
1969	1207	753	5.3	14.6	8.6	23.5	11.08	1.62	6.89	1.01
1970	1240	777	5.9	15.2	9.4	24.2	11.09	1.63	6.95	1.02
1971	1268	800	6.4	15.8	10.1	25.0	11.26	1.65	7.64	1.12
1972	1296	850	7.0	16.5	10.7	25.2	11.55	1.69	8.05	1.18
1973	1330	900	7.4	17.5	11.0	25.8	11.80	1.72	8.47	1.23
1974	1377	940	7.4	17.3	10.8	25.3	11.69	1.67	8.37	1.19
1975	1440	1000	7.9	18.2	11.4	26.3	11.99	1.69	8.62	1.21
1976	1491	1075	8.1	19.0	11.3	26.3	11.79	1.65	8.50	1.19
1977	1517	1170	9.2	21.6	11.9	28.0	11.22	1.59	8.65	1.22
1978	1543	1203	9.7	22.8	12.4	29.3	11.41	1.61	8.90	1.26
1979	1569	1234	9.7	22.9	12.4	29.1	11.44	1.62	9.00	1.27
1980	1604	1272	10.2	23.9	12.8	30.2	11.83	1.67	9.38	1.33

* Includes Expressways

[1] As of April 1

Source: References 2, 3, 7

Table 5: Harris County Mobility Trends

Year	Annual Average Population (1000's)	Annual Average Registered Vehicles (1000's)	Daily Freeway Travel per Capita*	Total Daily Vehicle Travel per Capita	Daily Freeway Travel per Vehicle *	Total Daily Vehicle Travel per Vehicle	Population Ratios		Vehicle Ratios	
							Per Mile of Freeway* (1000's)	Per Lane Mile of Freeway* (1000's)	Per Mile of Freeway* (1000's)	Per Lane Mile of Freeway* (1000's)
1950	807[1]	289	0.3	9.4	0.9	26.3	96.07	19.14	34.40	6.95
1955	1025[1]	444	0.8	10.7	1.8	24.8	27.26	5.90	11.81	2.55
1960	1243[1]	604	1.1	11.7	2.3	24.0	18.66	3.75	9.07	1.82
1965	1465	806	2.9	13.3	5.3	24.2	11.71	2.07	6.44	1.14
1966	1520	850	3.2	13.4	5.7	24.0	10.56	1.83	5.90	1.02
1967	1580	898	3.6	13.9	6.3	24.4	10.27	1.77	5.84	1.01
1968	1640	953	4.0	14.3	6.8	24.6	10.12	1.69	5.88	0.98
1969	1700	1015	4.6	14.7	7.7	24.6	9.87	1.62	5.89	0.97
1970	1757	1078	5.2	15.1	8.5	24.6	9.69	1.59	5.94	0.98
1971	1812	1149	5.7	15.5	9.0	24.4	9.77	1.60	6.19	1.02
1972	1867	1234	6.2	15.9	9.3	24.1	9.70	1.60	6.41	1.06
1973	1936	1321	6.4	16.6	9.3	24.3	9.99	1.64	6.82	1.12
1974	2016	1396	6.4	16.1	9.2	23.3	9.95	1.62	6.89	1.12
1975	2091	1479	6.9	16.8	9.8	23.8	10.09	1.62	7.14	1.14
1976	2157	1585	7.2	17.6	9.7	23.9	10.41	1.66	7.65	1.22
1977	2221	1715	7.6	18.5	9.8	23.9	10.72	1.71	8.28	1.32
1978	2289	1785	7.8	18.8	10.0	24.1	10.99	1.75	8.57	1.37
1979	2359	1854	7.8	18.8	9.9	23.9	11.26	1.79	8.85	1.41
1980	2427	1922	7.9	19.3	9.9	24.3	11.55	1.86	9.15	1.47

* Includes Expressways

[1] As of April 1

Source: References 2, 3, 7

increases in delay time in both the peak and off-peak periods (8). Data from six radial freeways (Figure 5) -- North (I-45), Eastex (US 59), East (I-10), Gulf (I-45), Southwest (US 59), and Katy (I-10) -- were used to compute the delay values shown in Figure 6 and Table 6.

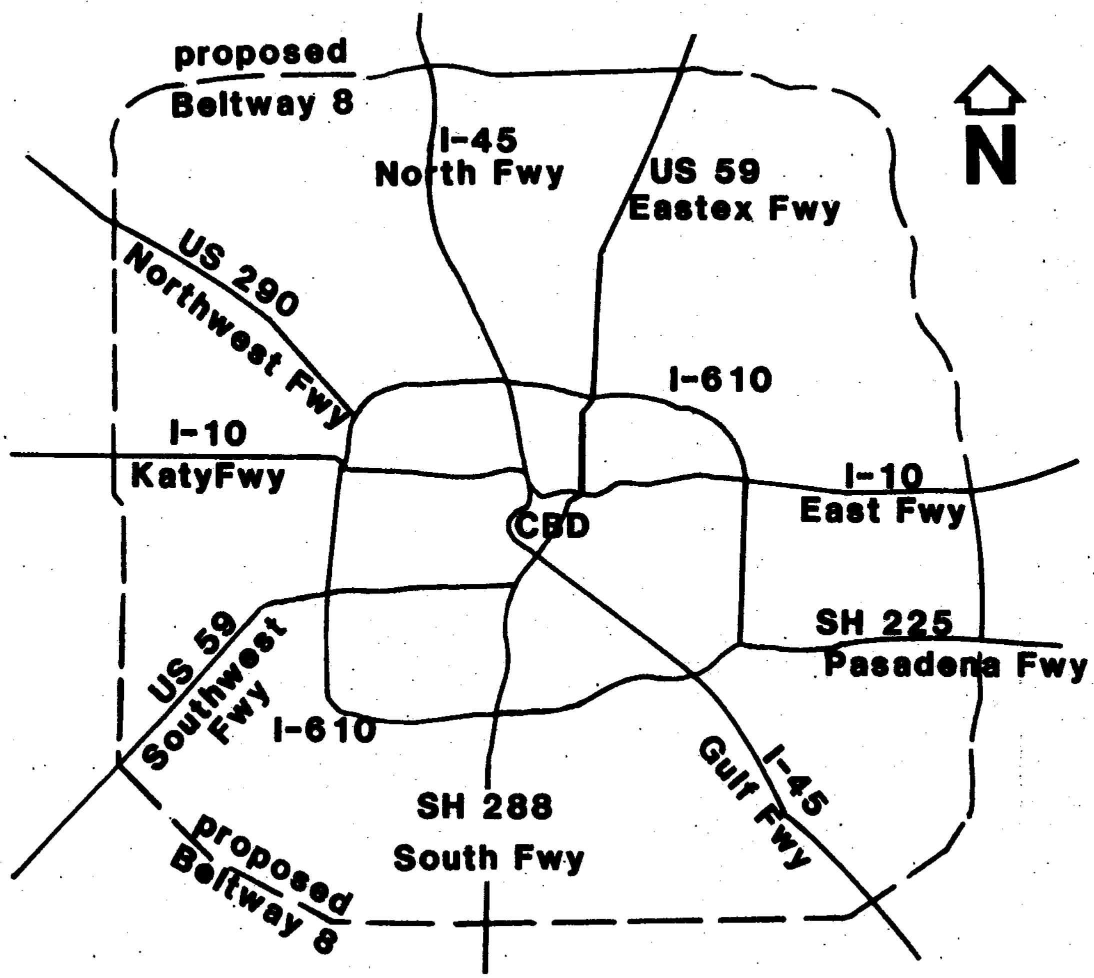
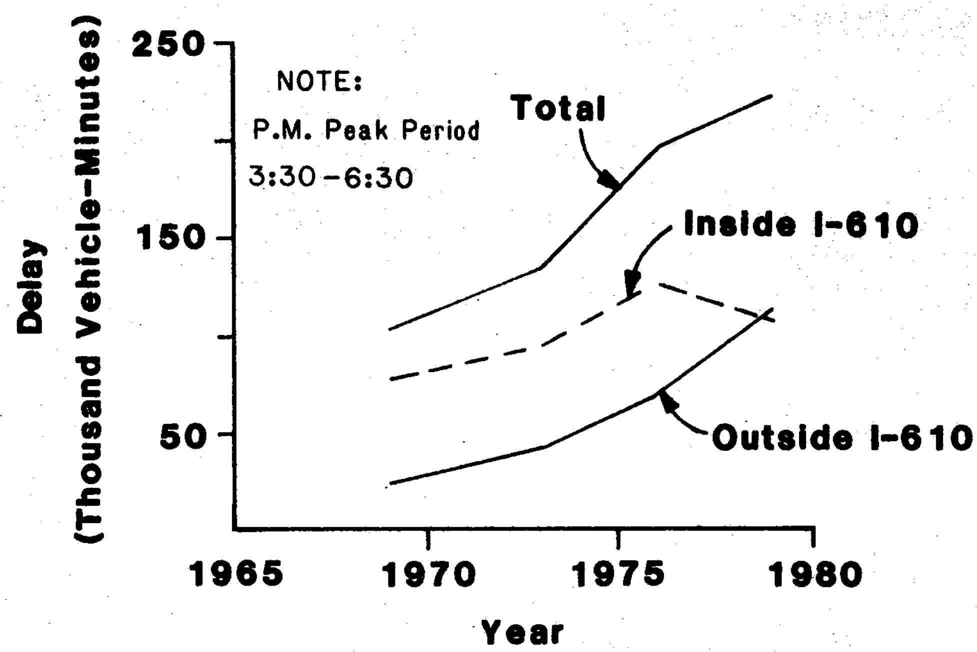


Figure 5: Major Houston Area Roadways



Note: The values presented are averages of the six freeways studied. The data for each freeway are presented in Appendix C.

Source: References 2, 4, 6, 8, Appendices B and C

Figure 6: Delay by Segments for Houston Freeways, P.M. Peak Period

Table 6: Average Peak Period Delay by Freeway Segement Per Major Radial Freeway

Year	Inside I-160 (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 2,4,6,8, Appendices B and C

The most dramatic increase in delay appears in the I-610 to Beltway 8 segment where delay increased by 380 percent from 1969 to 1979. The decrease in delay inside I-610 after 1975 might be attributed to several factors, including data reliability, the completion of certain freeway sections, and the traffic metering effect of I-610.

Overview

It is not possible or necessary to pinpoint a specific date at which the traffic problems in Houston became critical. The evidence presented seems to confirm that the Houston urban area was provided with a reasonably good level of transportation service as late as 1970. Peak-period delay was not excessive and travel speeds were fairly high. Freeways, for the most part, operated at acceptable levels of service. By 1978, however, the situation had changed noticeably. Data derived for Figure 4 indicated that nearly 40 percent of the entire freeway system countywide would be considered operating at LOS D in 1978. When the rural areas of the county are subtracted from the analysis and only urban freeway mileage is used, this number approaches 50 percent. Total delay time on six major radial freeways had more than doubled in 10 years, severely affecting many travel patterns. "Rush hour" had become "peak-period," and drivers at almost any daylight hour could encounter congestion. These numbers appear to suggest that the "acceptable" level of transportation service in Houston ceased to exist somewhere in the 1975-1976 time frame. That assumption allows quantitative measures of relative mobility and congestion to be developed and then compared for the different urban areas in Texas. Those analyses are presented in the following two major sections of this report.

MEASURES OF URBAN MOBILITY AND CONGESTION

An objective of this study is to identify quantitative measures that can be used to assess relative mobility levels. Houston is used as the source for this data, assuming that travel conditions in the Houston area were "acceptable" in 1970, not "acceptable" in 1980, and crossed into the "not-acceptable" range in the 1975-1976 period (refer to previous section of this report).

The measures developed in this section describe the general mobility level in an urban area; just because the general mobility may be acceptable does not mean that significant congestion does not occur at specific locations within the urban area. It is also intended that the measures developed from the Houston data base be generally applicable to other urban areas. As a result, the measures need to use data that are generally collected or available for all urban areas in Texas.

Importance of Arterial Streets

The discussion to this point has centered on the freeway system. However, the primary arterial system is also an integral part of the mobility provided by the system. As a result, the arterial system is included as part of the mobility analysis. Estimates of urban area and lane-miles, as obtained from the Houston-Galveston Regional Transportation Study (2), are presented in Tables 7 and 8.

While this is necessary to better define overall urban moblility, since much of the arterial system is not on the state system, data for the arterials are not as reliable as the freeway data. Again, however, the arterial street values presented in the study do appear to be generally reflective of conditions in the urban areas.

Table 7: Urban Houston Area Travel and Capacity Values

Year	Approx. Urban Area (Sq. Mi.)	Freeway Lane-Miles LM/M^2	Primary Arterial Lane-Miles LM/M^2	Freeway VMT (1000) VMT/M^2	Primary Arterial VMT (1000) VMT/M^2	Freeway VMT Per Lane-Mile	Primary Arterial VMT Per Lane-Mile
1980	1,350	1,256 0.93	1,655 1.23	18,404 13,630	8,566 6,350	14,653	5,176
1979	1,300	1,265 0.97	1,586 1.22	17,952 13,810	7,691 5,920	14,191	4,849
1978	1,250	1,182 0.95	1,518 1.21	16,405 13,120	7,228 5,780	13,879	4,762
1977	1,200	1,176 0.98	1,449 1.21	15,648 13,404	6,924 5,770	13,306	4,778
1976	1,150	1,212 1.05	1,381 1.20	14,407 12,530	6,346 5,520	11,887	4,595
1975	1,100	1,143 1.04	1,312 1.19	13,192 11,990	5,874 5,340	11,542	4,477
1974	1,050	1,098 1.05	1,301 1.24	11,716 11,160	5,504 5,240	10,670	4,231
1973	1,000	1,029 1.03	1,313 1.31	11,241 11,240	5,610 5,610	10,924	4,273
1972	950	1,015 1.07	1,270 1.34	10,499 11,050	5,410 5,690	10,344	4,260

Note: LM/M^2 = lane miles per square mile
VMT/M^2 = vehicle-miles of travel per square mile

Source: Reference 2

Measures of Congestion

Numerous measures were evaluated to quantify relative congestion and mobile ity levels. Data availability and comparability greatly influenced that evaluation. Some of the more significant measures are reviewed in this section.

Table 8: Urban Houston Area Mobility Trends

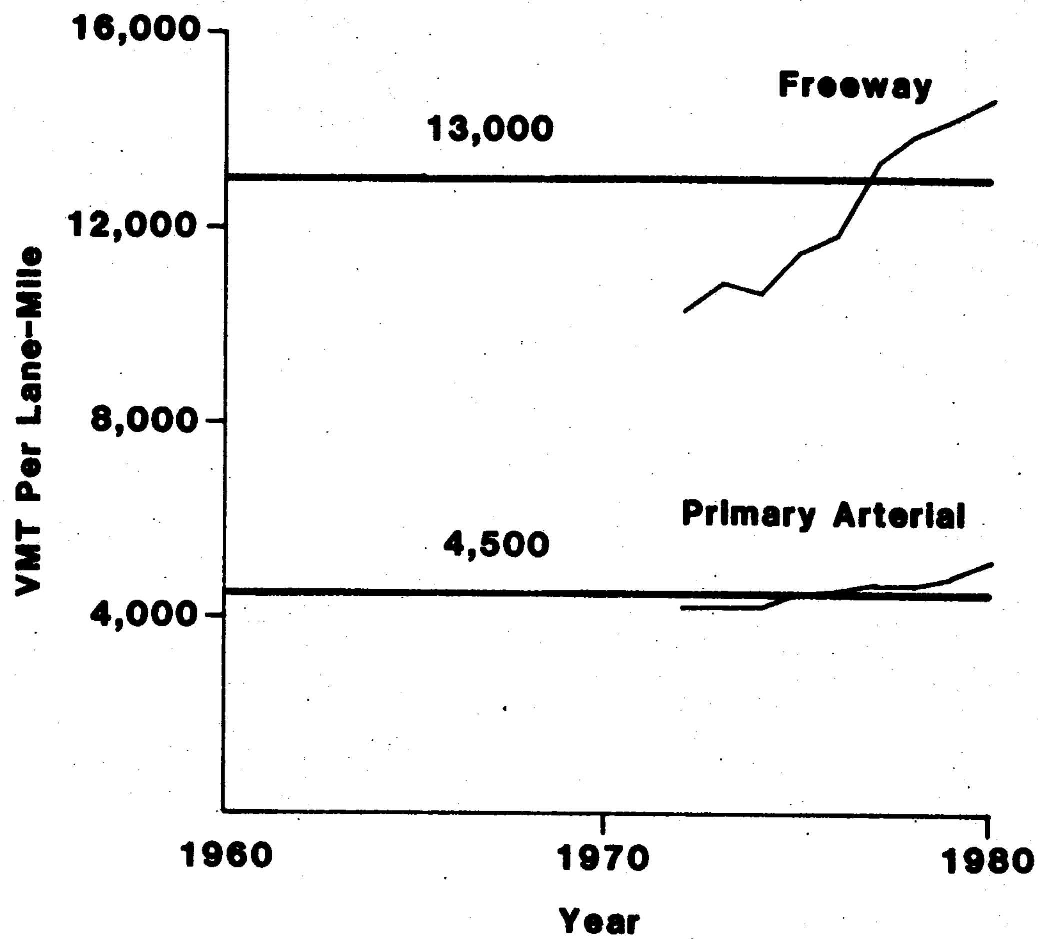
Year	Annual Average Population (1000's)	Annual Average Registered Vehicles (1000's)	Total Travel in VMT Per Day (1000's)	Daily Freeway Travel per Capita	Total Daily Travel per Capita	Daily Freeway Travel per Vehicle
1980	2,209	1,700	44,412	8.3	20.1	10.8
1979	2,159	1,669	42,110	8.3	19.5	10.8
1978	1,998	1,533	38,957	8.2	19.5	10.7
1977	1,958	1,492	37,196	8.0	19.0	10.5
1976	1,865	1,394	34,136	7.7	18.3	10.3
1975	1,788	1,291	31,462	7.4	17.6	10.2
1974	1,726	1,174	29,168	6.8	16.9	10.0
1973	1,668	1,132	28,892	6.7	17.3	9.9
1972	1,623	1,078	27,000	6.5	16.6	9.7

Source: References 2,3

Traffic Per Lane

As shown previously, 15,000 vehicles per day per lane (vpd/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 vpd/lane value used by the Federal Highway Administration in the needs estimate (9) would appear to represent a more appropriate value; that standard also was attained in Houston during the period where mobility was becoming unacceptable (Figure 7).

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



Source: Reference 2

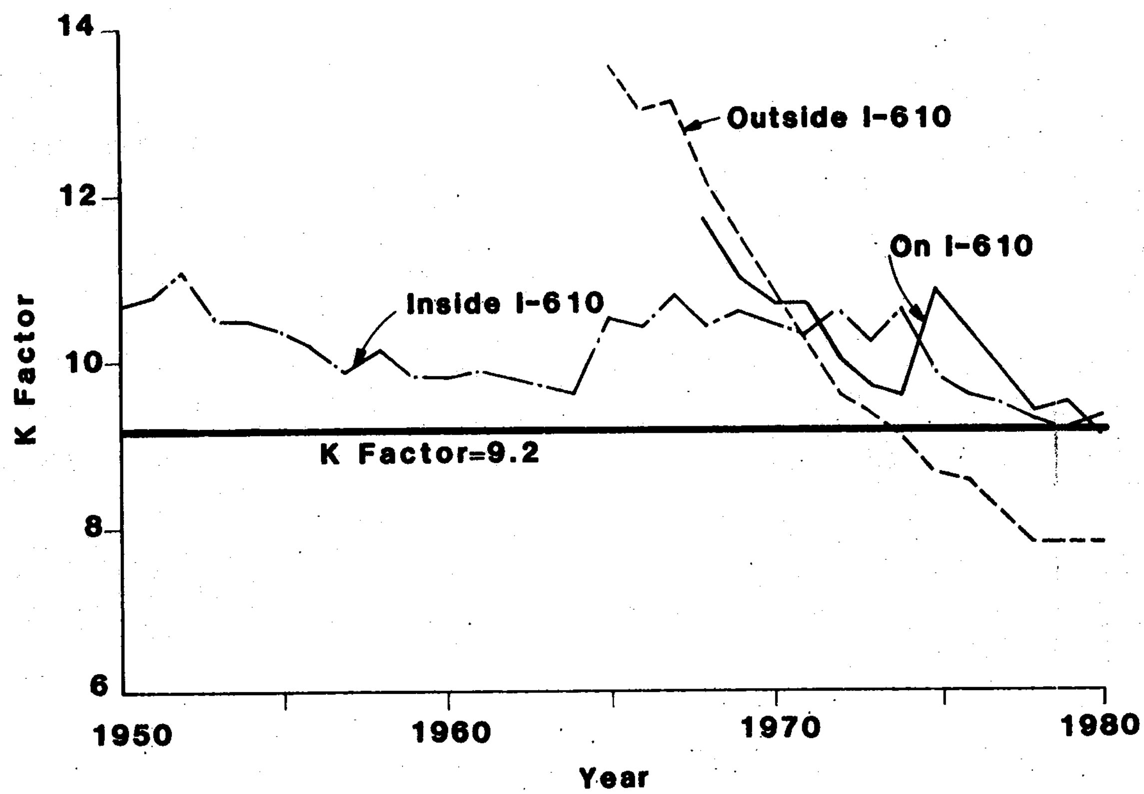
Figure 7: Freeway and Primary Arterial Travel Per Lane-Mile - Urban Harris County

Percentage of Congested Freeway

The percentage of the freeway system operating under congested conditions (15,000 vpd/lane or more) might be another description of congestion and mobility levels. Those data for the Houston area were presented previously (Figure 4). From that information, it appears that, once 30 percent of the lane-miles are operating at or above 15,000 vpd, mobility has become significantly impaired.

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. The decreasing K factor values in Figure 8 are 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.



Source: Reference 4

Figure 8: K Factor Values for the Houston Freeways

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 in Figure 8. A count location added in 1975 on I-610 with a high K factor value further confuses the trend line.

From the data in Figure 8, it appears that a systemwide freeway peak-hour factor of approximately 9.2 percent defines the limits of acceptable mobility.

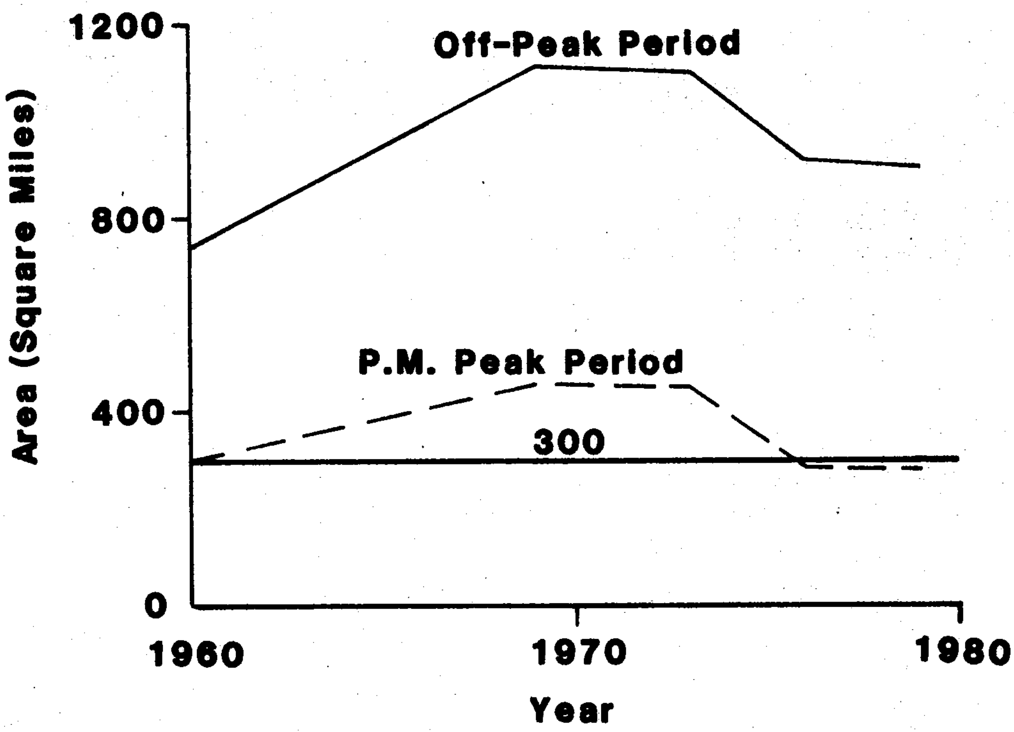
Peak-Hour Travel Distance

The distance a motorist can travel from downtown in the peak hour is an additional measure of the level of urban mobility. Travel time and speed maps (7) were used to derive Figure 9. That figure shows the square miles of land area located within 30 minutes of downtown. It appears that approximately 300 square miles, equivalent to a radius of about 10 miles, represents a reasonable minimum acceptable standard. This implies an average travel speed of 20 mph for the first half-hour of any peak-hour trip from downtown.

Overview of Congestion Measures

Using data from Houston, an attempt has been made to develop several quantitative measures that can be used to identify when an urban area is approaching serious congestion. All of the measures developed have limitations due to the accuracy and reliability of the data base.

Many different measures were evaluated as part of this study. Only those that appeared to be most useful in assessing congestion levels were presented in this section. The following, listed in apparent order of reliability and usefulness,



Source: Reference 8

Figure 9: Area Within 30 Minutes of Houston CBD

represent guidelines that can be used to determine if congestion in an urban area is becoming critical.

- Traffic volumes per lane
  - Freeway: 13,000
  - Arterial: 4,500
- Percentage of freeway system with ADT $\geq$ 15,000 per lane: 30%
- Systemwide freeway K factor: 9.2%
- Land area within 30 minutes of CBD in peak hour: 300 square miles (equivalent to approximately 20 mph travel speed).

In the next section of this report, these measures are compared for the major urban areas in Texas. In making this comparison, care should be exercised in placing too much emphasis on any one variable. Rather, the comparison should be based on several of the measures.

RELATIVE CONGESTION AND MOBILITY IN TEXAS CITIES

The initial sections of this report have primarily pertained to the Houston area. The mobility decline for that area was traced, and the Houston data were used to quantify measures of congestion and mobility for an urban area. In this section, measures of travel and mobility for the larger Texas cities -- Houston, Dallas, Fort Worth, San Antonio, and El Paso -- are presented and compared to each other as well as the congestion measures developed previously.

The Urban Freeway Systems

The geographical estimate of the 1980 urban area as well as the freeway system in each of the urban areas is shown in Figures 10 through 13. The difficulty in estimating that area has been referred to previously in this report. Estimates of the square miles of urban area are shown in Table 9.

Table 9: Growth of Major Texas Urban Areas

Year	Urban Area (Square Miles)			
	Houston	Dallas	Fort Worth	San Antonio
1980	1,350	1,250	760	675
1979	1,300	1,210	735	650
1978	1,250	1,175	710	625
1977	1,200	1,140	685	600
1976	1,150	1,105	660	580
1975	1,100	1,075	635	560

These estimates were obtained from a variety of sources, including registration, population, traffic models and other transportation data. They are not necessarily statistically accurate but instead represent a "best guess" as to the

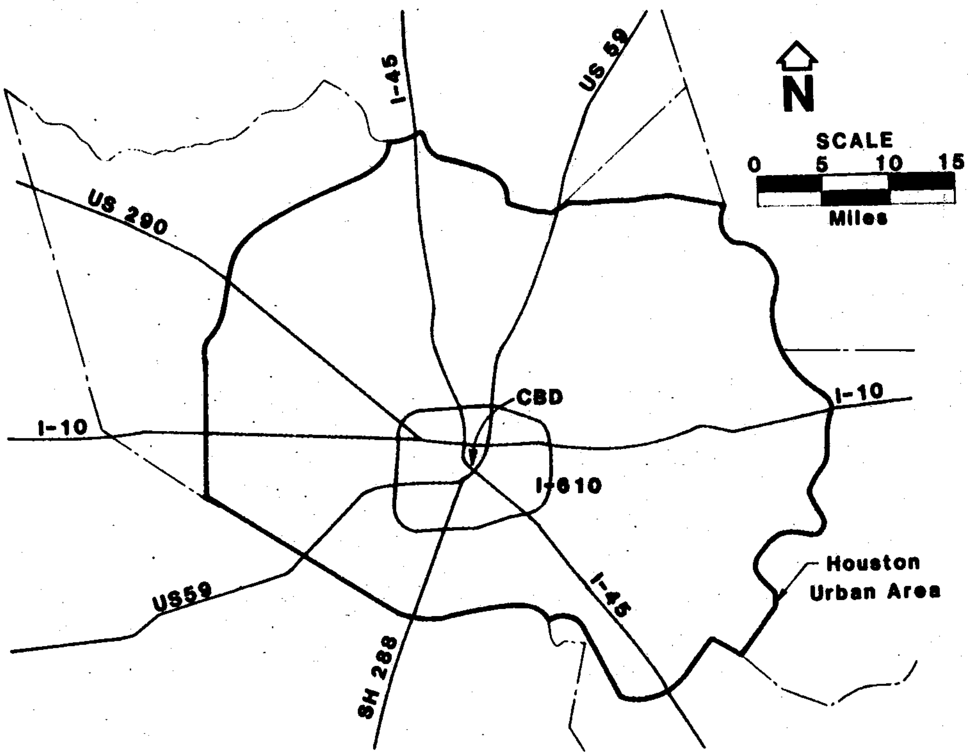


Figure 10: Houston Urban Area Boundary

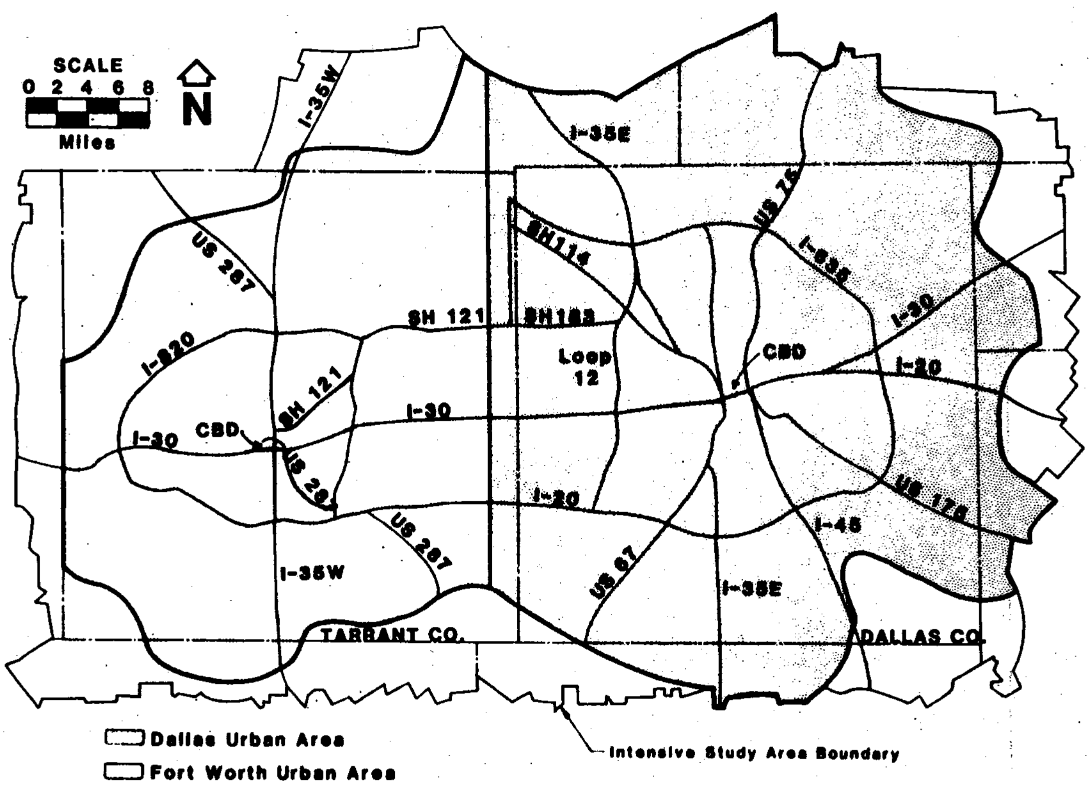


Figure 11: Dallas and Fort Worth Urban Area Boundaries

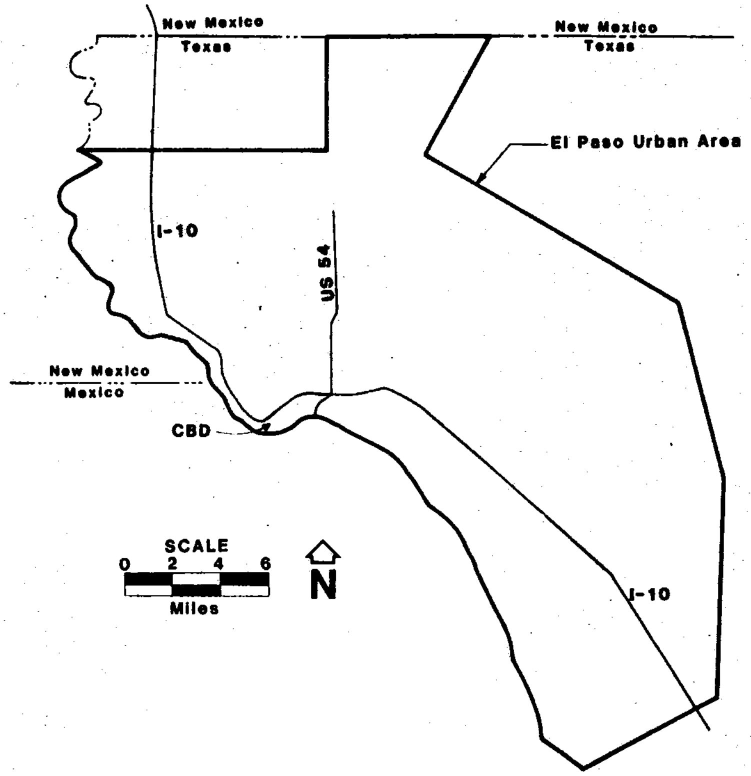


Figure 12: El Paso Urban Area Boundary

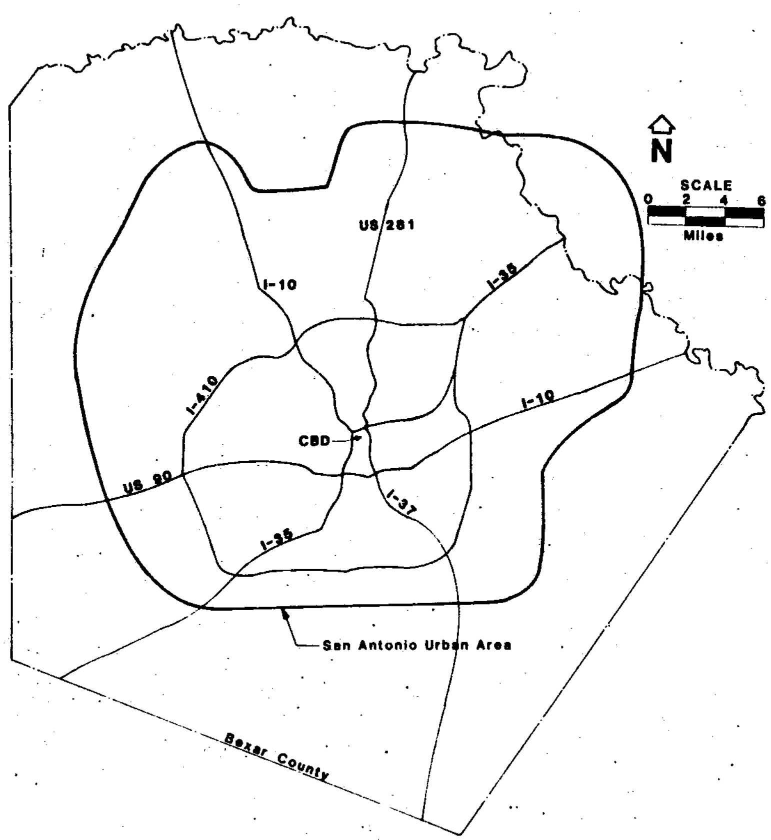


Figure 13: San Antonio Urban Area Boundary

shape and size of the urbanized area. Little factual data is available in a usable form that will allow such a map to be drawn on a quantitative basis. It is the opinion of the authors that the maps are fairly consistent from one city to the next and any error made in establishing the boundaries is present to the same degree for all areas. Table 9 does not include any measure of the El Paso Urban Area because of the presence of more than 750,000 persons across the U.S.-Mexico border in Ciudad Juarez. While that is part of the overall urban area, its development patterns and travel patterns are considerably different than those of U.S. cities. The urban boundary shown for El Paso is, therefore, used to calculate roadway capacity and travel as well as the other factors, but not ratios pertaining to square miles of urban area.

Data Comparison

A wider range of data have been collected pertaining to mobility in the different urban areas. These data are presented in Tables 10 through 17. Most of the data presented are derived using city and/or county data to estimate data for the urban area as defined in this study.

Some of these data are used subsequently in comparing the mobility levels. Other data are presented for informational purposes. In reviewing and comparing these data, the reader is again cautioned that the measures such as size of urban area and some travel data relating to the non state-maintained roadway system are not necessarily highly accurate.

Comparison of Mobility Indicators

In the previous section of this report, a series of quantitative indicators were developed. Once conditions in an urban area approach these indicators, reason exists to believe that serious congestion problems will exist in the near future.

Table 10: Freeway Capacity and Travel in Major Urban Areas

Year	Houston		Dallas		El Paso		Ft. Worth		San Antonio	
	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)
1980	1,256	18,404	1,486	15,013	297	2,155	856	7,535	748	7,116
1979	1,265	17,952	1,465	14,618	276	1,976	827	7,143	736	6,681
1978	1,182	16,405	1,448	13,696	276	1,788	793	6,658	684	5,880
1977	1,176	15,648	1,430	12,840	262	1,664	753	6,101	677	5,475
1976	1,212	14,407	1,395	11,553	260	1,544	731	5,670	671	5,078
1975	1,143	13,192	1,351	10,446	260	1,416	719	5,273	662	4,756

Source: References 2,10,11,12,13,14,15,16

Table 11: Principal Arterial Capacity and Travel in Major Urban Areas

Year	Houston		Dallas		El Paso		Ft. Worth		San Antonio	
	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)
1980	1,655	8,566	1,475	5,729	717	2,610	746	3,253	869	3,792
1979	1,586	7,691	1,434	5,402	717	2,409	741	3,149	842	3,522
1978	1,518	7,228	1,395	5,079	710	2,300	724	3,002	807	3,269
1977	1,449	6,924	1,374	4,839	696	2,172	710	2,872	767	3,005
1976	1,381	6,346	1,348	4,492	684	2,070	691	2,727	759	2,896
1975	1,312	5,874	1,318	4,149	674	1,945	665	2,562	741	2,750

Source: References 2,10,11,12,13,14,15,16

Table 12: Daily VMT Per Lane on Freeways and Principal Arterials in Major Urban Areas

Year	Houston		Dallas		El Paso		Ft. Worth		San Antonio	
	Freeway	Prin. Art.	Freeway	Prin. Art.	Freeway	Prin. Art.	Freeway	Prin. Art.	Freeway	Prin. Art.
1980	14,653	5,176	10,103	3,884	7,526	3,640	8,802	4,360	9,514	4,364
1979	14,191	4,849	9,978	3,767	7,160	3,360	8,637	4,249	9,078	4,183
1978	13,879	4,762	9,459	3,641	6,478	3,239	8,396	4,147	8,596	4,051
1977	13,306	4,778	8,979	3,522	6,351	3,121	8,102	4,045	8,087	3,918
1976	11,887	4,595	8,282	3,332	5,938	3,026	7,756	3,947	7,568	3,816
1975	11,542	4,477	7,732	3,148	5,446	2,886	7,334	3,853	7,184	3,711

Source: References 2,10,11,12,13,14,15,16

Table 13: Freeway and Principal Arterial VMT Per Square Mile of Urban Area

Year	Houston		Dallas		El Paso*		Ft. Worth		San Antonio	
	Freeway	Prin. Art.	Freeway	Prin. Art.	Freeway	Prin. Art.	Freeway	Prin. Art.	Freeway	Prin. Art.
1980	13,630	6,350	12,010	4,583			9,914	4,280	10,542	5,618
1979	13,810	5,920	12,081	4,464			9,718	4,284	10,278	5,418
1978	13,120	5,780	11,656	4,323			9,377	4,288	9,408	4,230
1977	13,404	5,770	11,263	4,244			8,907	4,193	9,125	5,008
1976	12,530	5,520	10,455	4,065			8,591	4,132	8,755	4,993
1975	11,990	5,340	9,717	3,860			8,304	4,035	8,493	4,911

*Not estimated due to discrepancies caused by the presence of Ciudad Juarez

Source: References 2,10,12,13,14,15,16

Table 14: Freeway and Principal Arterial Lane-Miles Per Square Mile of Urban Area

Year	Houston		Dallas		El Paso*		Ft. Worth		San Antonio	
	Freeway	Prin. Art.	Freeway	Prin. Art.	Freeway	Prin. Art.	Freeway	Prin. Art.	Freeway	Prin. Art.
1980	0.93	1.23	1.19	1.18			1.13	0.98	1.11	1.29
1979	0.97	1.22	1.21	1.19			1.13	1.01	1.13	1.30
1978	0.95	1.21	1.23	1.19			1.12	1.02	1.09	1.29
1977	0.98	1.21	1.25	1.21			1.10	1.04	1.13	1.28
1976	1.05	1.20	1.26	1.22			1.11	1.05	1.16	1.31
1975	1.04	1.19	1.26	1.23			1.13	1.05	1.18	1.32

*Not estimated due to discrepancies caused by the presence of Ciudad Juarez

Source: References 2,10,12,13,14,15,16

Table 15: Daily Freeway Travel Per Capita in Major Urban Areas

Year	Houston		Dallas		El Paso		Ft. Worth		San Antonio	
	Pop (1000)	Freeway VMT Per Capita	Pop. (1000)	Freeway VMT Per Capita	Pop. (1000)	Freeway VMT Per Capita	Pop. (1000)	Freeway VMT Per Capita	Pop. (1000)	Freeway VMT Per Capita
1980	2,209	8.3	1,642	9.1	428	5.0	924	8.2	913	7.8
1979	2,159	8.3	1,597	9.2	418	4.7	893	8.0	893	7.5
1978	1,998	8.2	1,572	8.7	405	4.4	865	7.7	873	6.7
1977	1,958	8.0	1,542	8.3	393	4.2	836	7.3	855	6.4
1976	1,865	7.7	1,528	7.6	382	4.0	810	7.0	837	6.1
1975	1,788	7.4	1,515	6.9	373	3.8	753	7.0	817	5.8

Source: References 2,3,10,11,12,13,14,15,16,18,19,20

Table 16: Total Daily Travel Per Capita in Major Urban Areas

Year	Houston		Dallas		El Paso		Ft. Worth		San Antonio	
	Total VMT (1000)	Total VMT Per Capita	Total VMT (1000)	Total VMT Per Capita	Total VMT (1000)	Total VMT Per Capita	Total VMT (1000)	Total VMT Per Capita	Total VMT (1000)	Total VMT Per Capita
1980	44,412	20.1	34,258	20.9	6,497	15.2	18,381	19.9	18,117	19.8
1979	42,110	19.5	33,211	20.8	6,114	14.6	17,771	19.9	17,136	19.2
1978	38,957	19.5	31,559	20.1	5,741	14.2	16,868	19.5	15,567	17.8
1977	37,196	19.0	30,088	19.5	5,395	13.7	15,550	18.6	14,606	17.1
1976	34,136	18.3	27,794	18.2	5,070	13.3	14,418	17.8	13,867	16.6
1975	31,462	17.6	25,788	17.0	4,757	12.8	12,876	17.1	13,186	16.1

Source: References 2,3,10,11,12,13,14,15,16,17,18,19,20

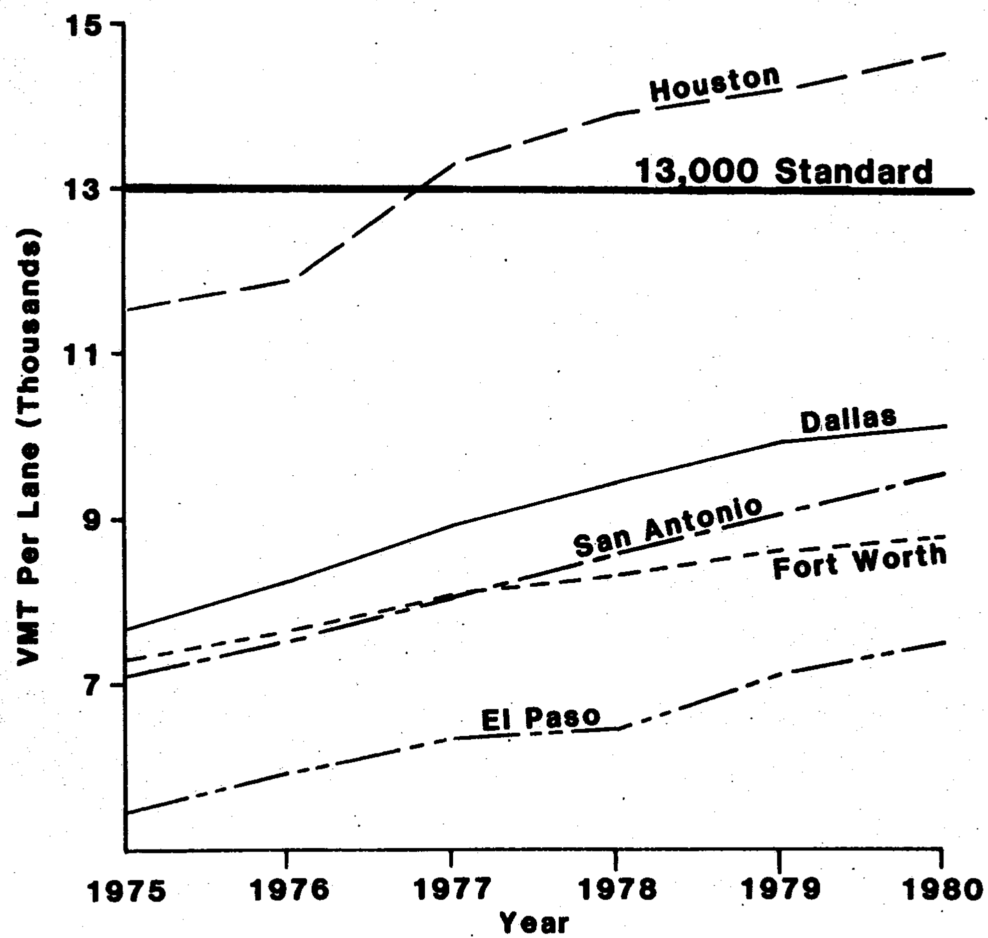
Table 17: Daily Freeway Travel Per Registered Vehicle in Major Urban Areas

Year	Houston		Dallas		El Paso		Ft. Worth		San Antonio	
	Reg. Veh. (1000)	Freeway VMT Per Vehicle	Reg. Veh. (1000)	Freeway VMT Per Vehicle	Reg. Veh. (1000)	Freeway VMT Per Vehicle	Reg. Veh. (1000)	Freeway VMT Per Vehicle	Reg. Veh. (1000)	Freeway VMT Per Vehicle
1980	1,700	10.8	1,340	11.2	264	8.2	780	9.7	682	10.4
1979	1,655	10.8	1,292	11.3	257	7.7	761	9.4	640	10.4
1978	1,533	10.7	1,253	10.9	250	7.2	739	9.0	603	9.8
1977	1,492	10.5	1,211	10.6	242	6.9	701	8.7	569	9.6
1976	1,394	10.3	1,169	9.9	232	6.7	655	8.7	537	9.5
1975	1,284	10.3	1,131	9.2	219	6.5	617	8.5	513	9.3

Source: References 2,10,11,12,13,14,15,16,21

Traffic Per Lane

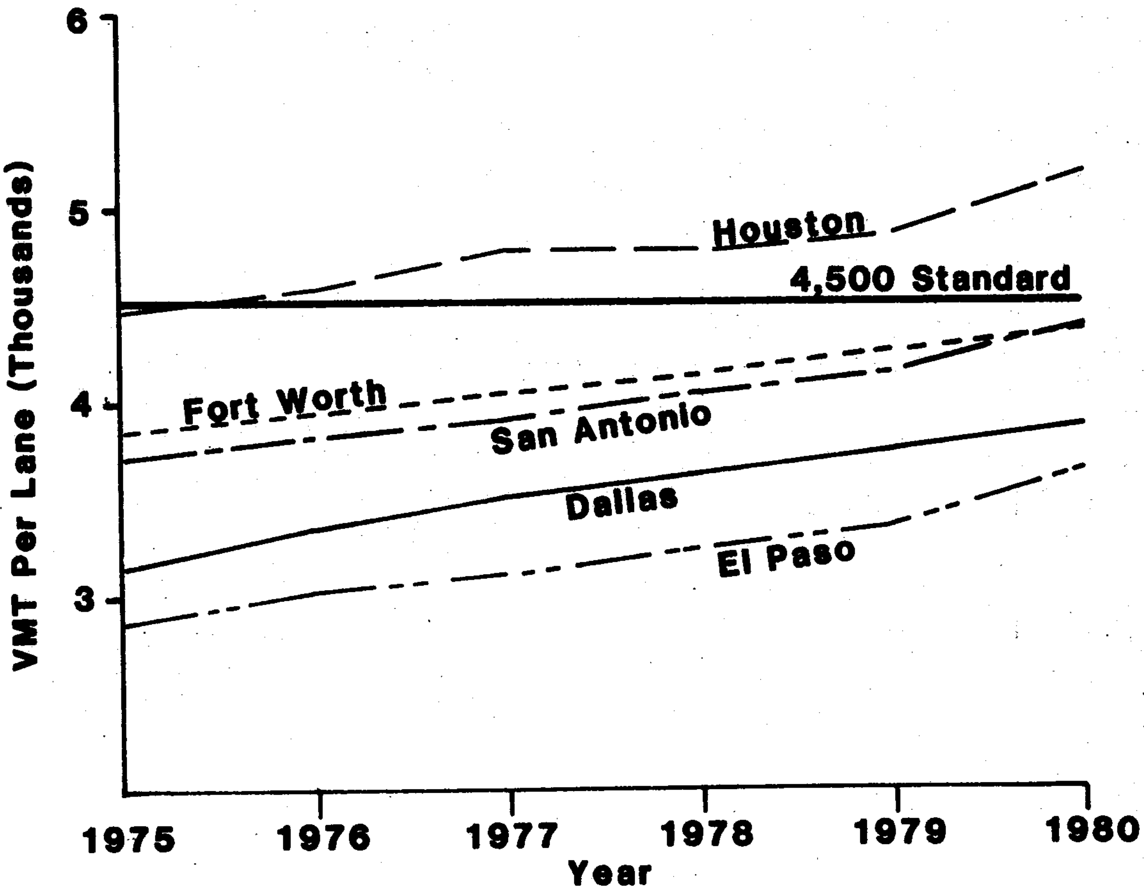
Figures 14 and 15 show trends in daily travel per lane for both freeways and arterial streets. The congestion standards developed previously in this report are also shown in those figures.



Source: References 2,10,11,12,13,14,15,16

Figure 14: Daily Travel Per Lane-Mile of Freeway

The freeway data, in terms of both VMT and lane-miles, are some of the more reliable data used in this study. As shown in Figure 14, Houston crossed the suggested congestion standard in about 1976. Extrapolation of the historical trend data indicates that both Dallas and San Antonio can be expected to meet



Source: References 2,10,11,12,13,14,15,16

Figure 15: Daily Travel Per Lane-Mile of Principal Arterial

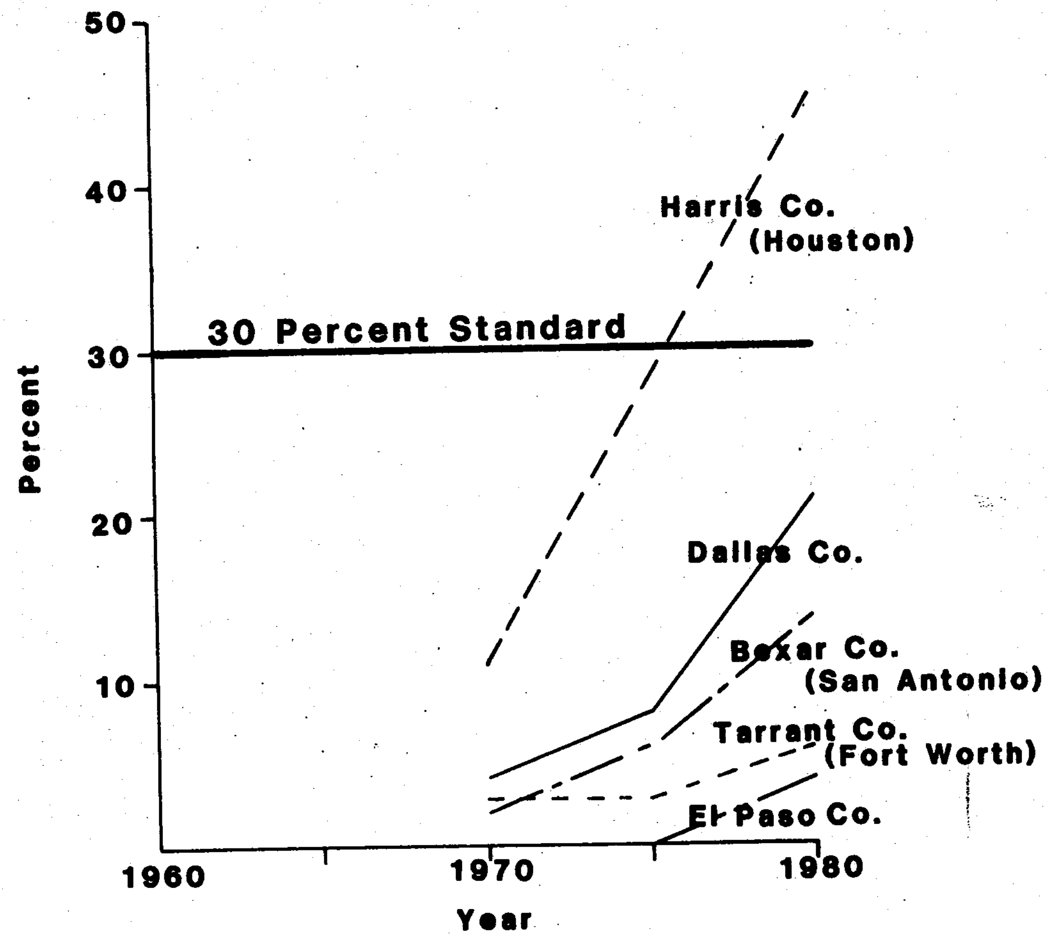
the congestion standards in the mid-1980's. While Fort Worth and El Paso have lower VMT per lane values, that ratio for both cities continues to increase.

The arterial data are shown in Figure 15. The relative rankings of Fort Worth, San Antonio, and Dallas are different than those shown in the freeway rankings. However, VMT per lane is increasing in all cities, with Fort Worth and San Antonio approaching the standard.

Combining the freeway and arterial data provides, perhaps, the best indicator of relative mobility. That analysis is presented in the final part of this section.

Percentage of Congested Freeway

Figure 16 shows the percentage of freeway lane-miles with daily traffic volumes in excess of 15,000. These data are shown on a county, rather than an urban area, basis.



Source: References 2, 4, 6

Figure 16: Percent of Freeway Lane-Miles with ADT Greater than 15,000

Harris County (Houston) exceeded the 30 percent standard in the mid-1970's and has been increasing rapidly. In 1980, the percentage of freeway lane-miles in Harris County exceeding 15,000 ADT was twice as great as any other county.

Of particular importance in this analysis is that the area covered is the county and not the urban boundary. Some allowance must be made for this difference, especially in the Dallas area. The 1980 Dallas urban area is almost half again as large as is Dallas County, resulting in the percentage of congested freeway being somewhat high. The percent of freeway lane-miles operating above 15,000 would, therefore, be somewhat lower if calculated on an urban area basis. In the other four counties the opposite is true because the defined urban area is less than the county area.

While Houston surpassed the suggested standard in the 1970's, both Dallas and San Antonio will exceed this standard in the 1980's. This percentage continues to increase in both Fort Worth and El Paso.

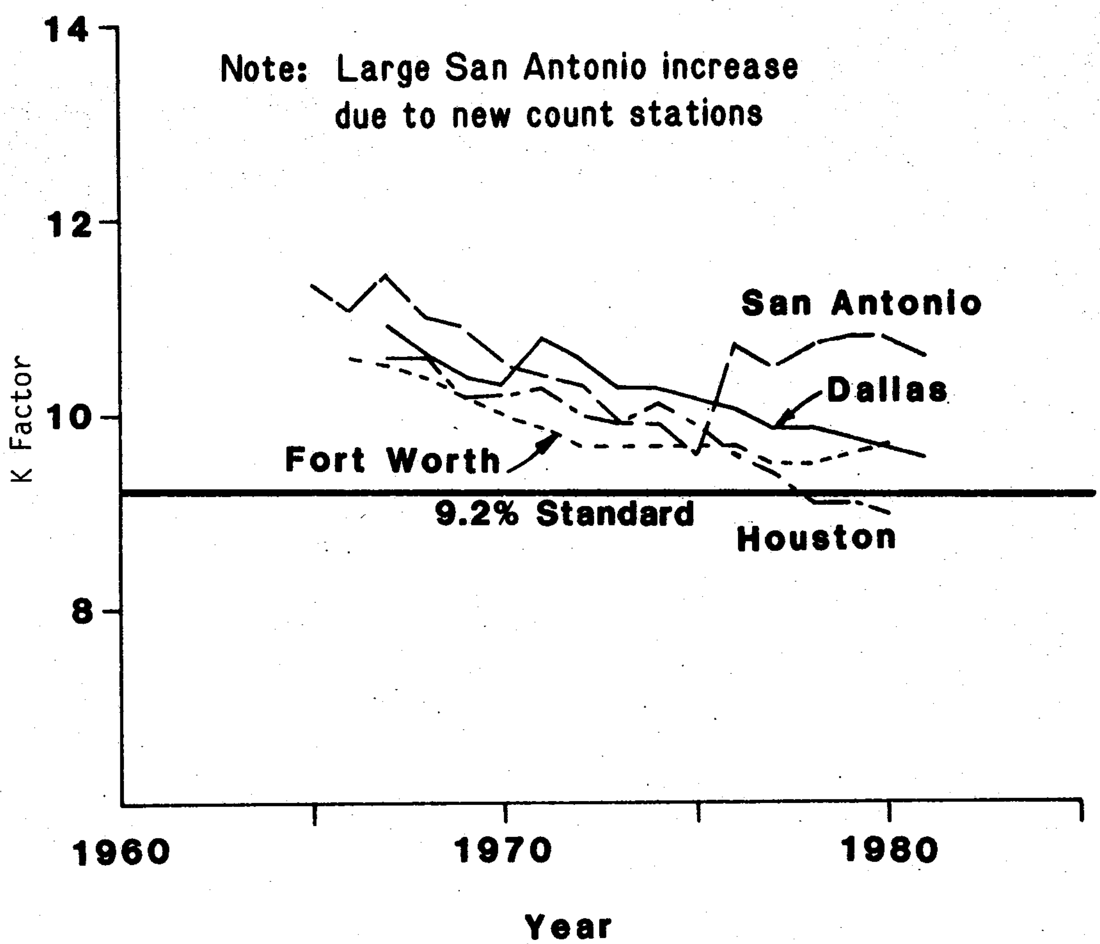
K Factor

Figure 17 is derived from data collected by the State Department of Highways and Public Transportation at the Automatic Traffic Recorder (ATR) stations (3). As has been discussed previously, the abrupt changes in these values are the result of new ATR's being put into operation at relatively low volume sections of roadway.

It is apparent from Figure 17 that, using the available data, good estimates of relative congestion cannot be derived from the K factor values. The absolute number of stations as well as the change in the total number of counters, combined with the impacts of where the counters are located relative to intense traffic demand, adversely affects the usefulness of this measure. Nevertheless, the trend data in Figure 17 confirm the fact that congestion is continuing to intensify.

Peak-Hour Travel Distance

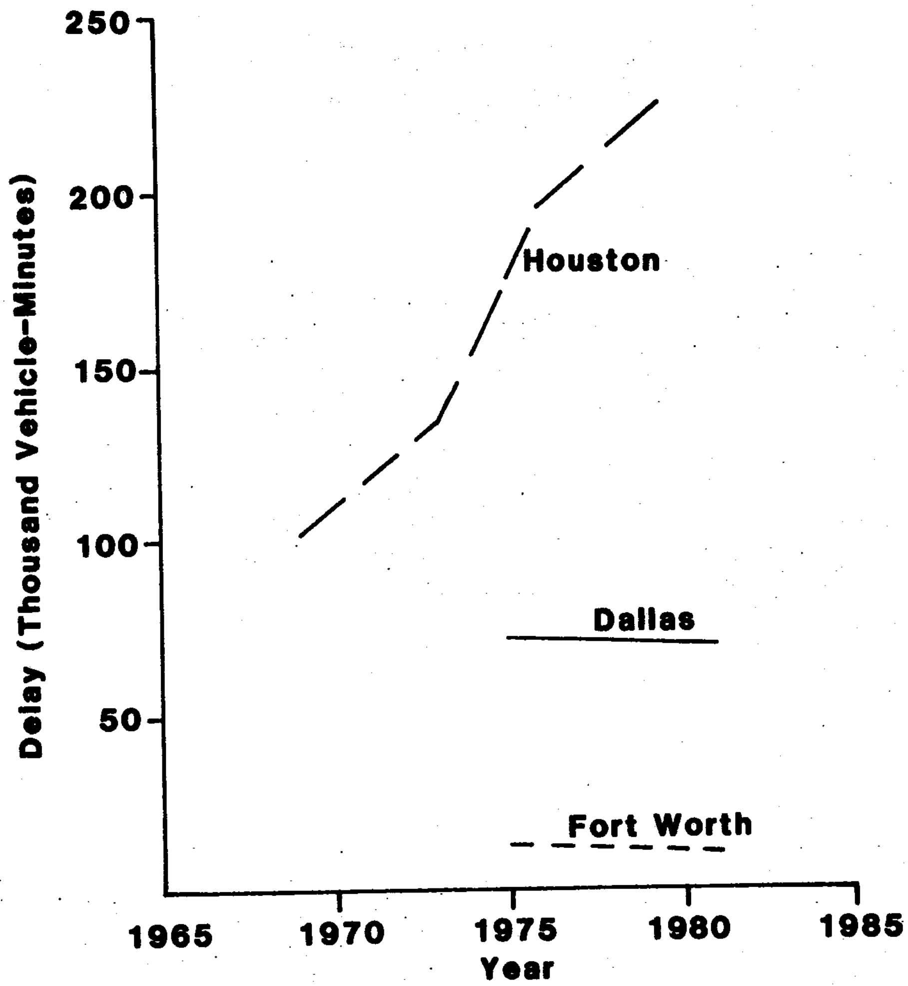
Another, although possibly least accessible, method of determining congestion is delay time, in vehicle-minutes, per freeway. Travel time and speed studies



Source: Reference 4

Figure 17: Peak-Hour Factors at SDHPT Permanent Traffic Count Stations

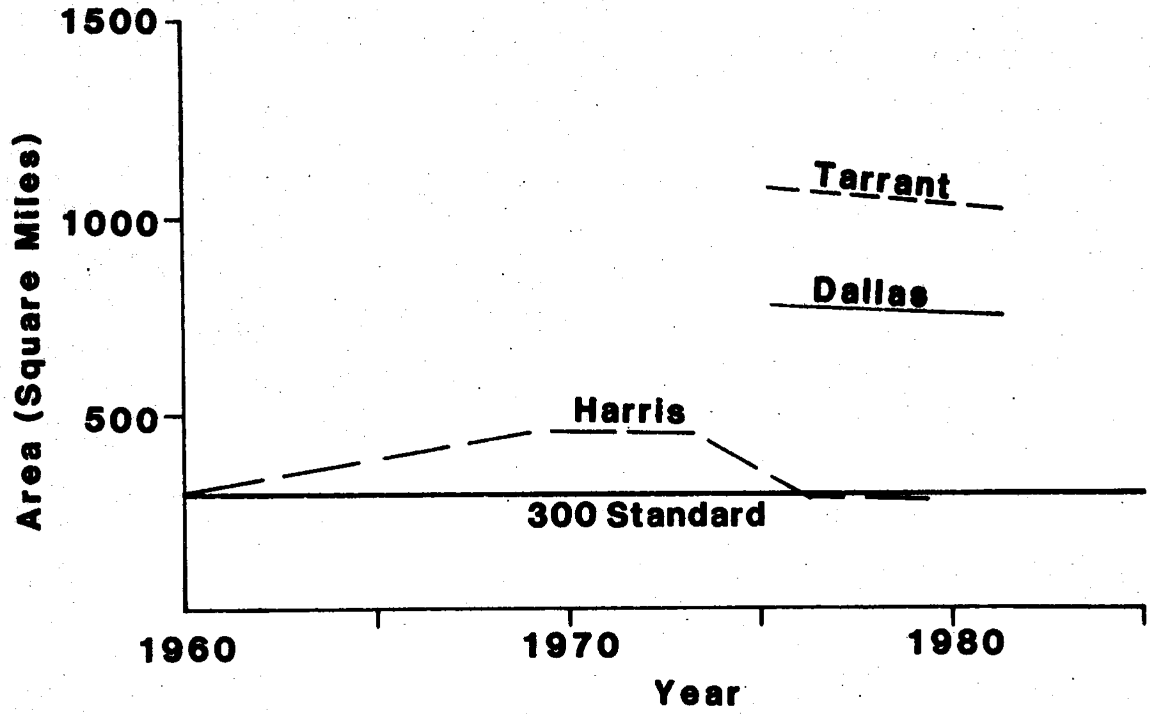
are necessary to obtain the data used in this type of analysis. The assembly of those data requires many hours of data collection and planning and is not carried out in all major urban areas on a regular basis. Figure 18 displays the relevant data for those areas in which two or more recent travel time studies have been conducted. Appendix B presents an example of the calculations used to derive Figure 18. Appendix C gives the quantitative values for each freeway examined in Houston, Dallas and Fort Worth. The rises in congestion in Dallas and Fort Worth, based on Figure 18, have not been as rapid as the increases in Houston.



Source: References 2,4,6,8,22

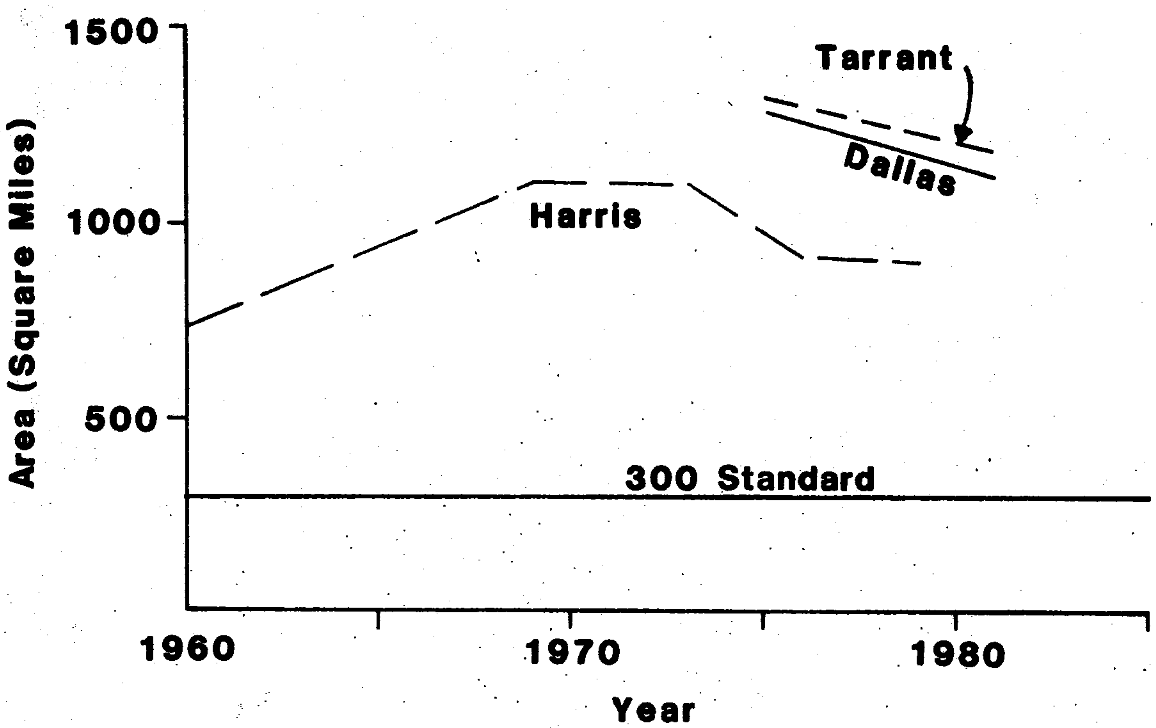
Figure 18: Delay per Freeway P.M. Peak Period

Figures 19 and 20 show the square miles of urban area that can be reached from the downtown in 30 minutes. Again, the data are limited. The figures do emphasize the increases in congestion for Houston and show the trend toward more congestion in Dallas and Fort Worth.



Source: References 8, 22

Figure 19: Area Within 30 Minutes of CBD During Peak-Hour



Source: References 8, 22

Figure 20: Area Within 30 Minutes of CBD During Off-Peak Periods

CONCLUSIONS

All of the major urban areas in Texas are facing increasing traffic congestion problems. In spite of the relative mobility rankings for the various cities, all of the urban areas experience significant traffic problems at specific locations.

In comparing the different urban areas, the measures of traffic per lane mile appear to be most useful. Since the freeways typically carry about twice as much VMT per mile as do the arterials, the freeway values were given twice the weighting of the arterials. All the values were then normalized with the standard congestion measure being set equal to 1.0.

The results of the analyses are shown in Figure 21. That figure shows that Houston is already (in 1980) 13 percent above the congestion/mobility standard developed in this report. Congestion in San Antonio and Dallas was approximately 80 percent of the standard, while Fort Worth was 72 percent and El Paso 61 percent of the standard.

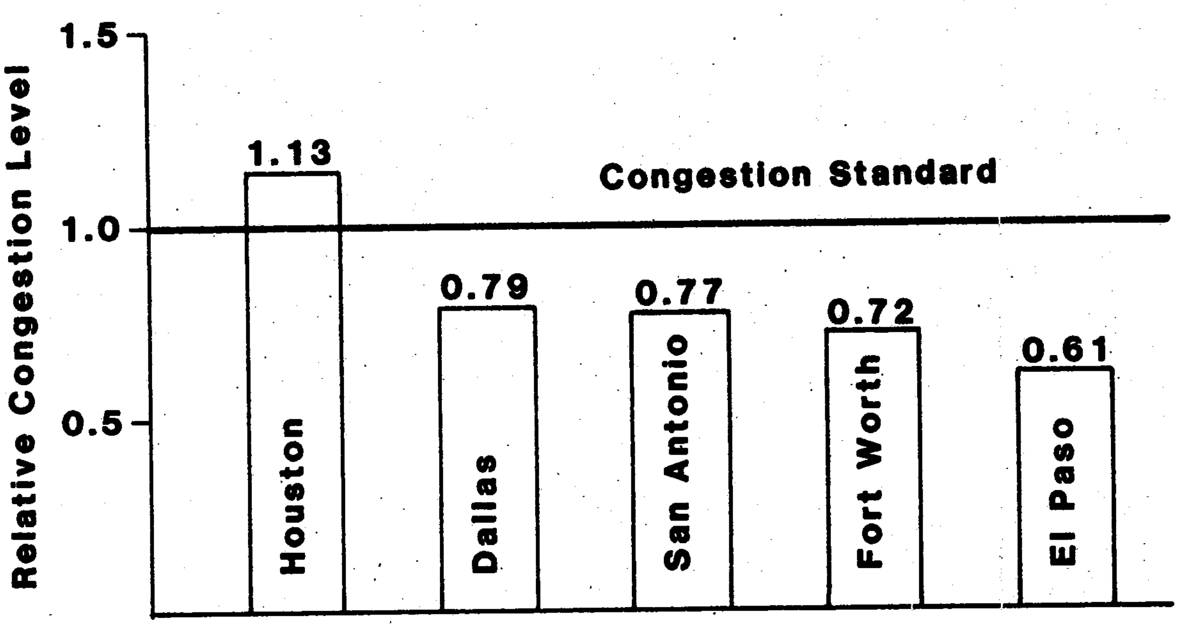


Figure 21: Relative Congestion Levels of the Five Study Areas, 1980 Data

Figure 22 shows a further comparative analysis of the 1980 data. The historical growth rate in VMT per lane and percent of freeway lane-miles with an ADT in excess of 15,000 were used to assess how far "behind" Houston the different cities are as well as how far "behind" the congestion/mobility standard the various cities are. The bars in that figure indicate the number of years each area has until it equals the mobility/congestion standard. In assessing the number of years until the standard is reached, it would be noted that the analyses reflect 1980 data; all of the cities should already be 2 years closer to that standard.

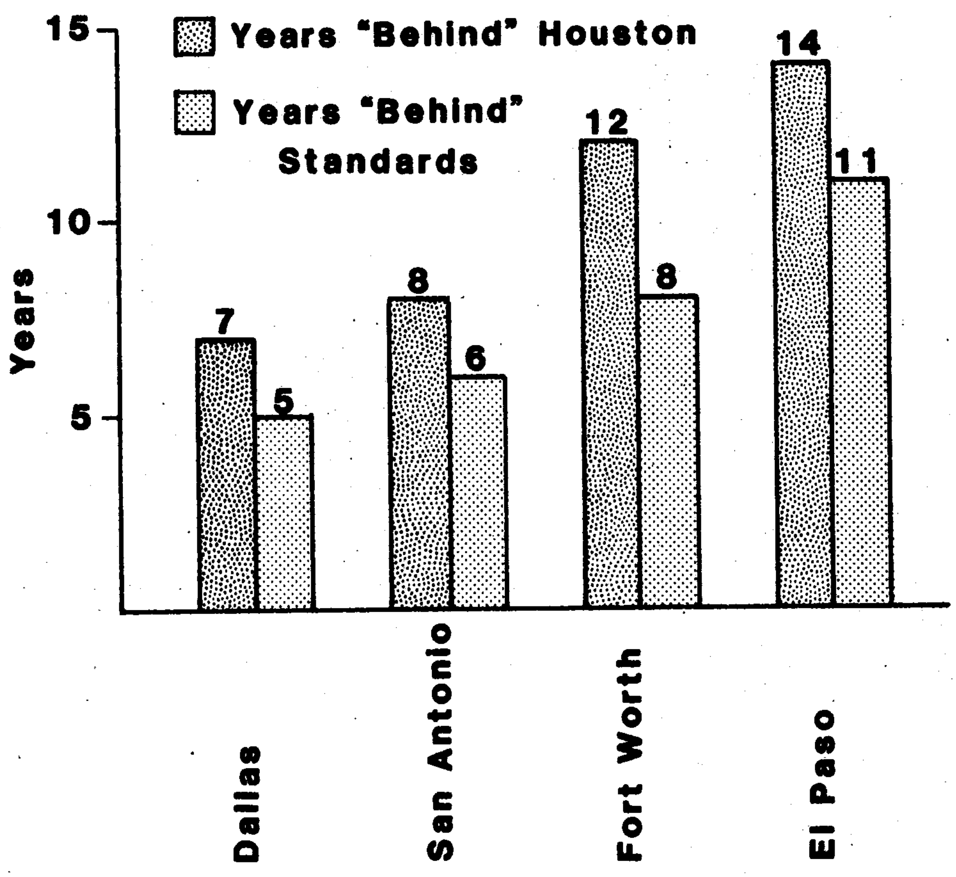


Figure 22: Time Until Standard and Houston Congestion Levels are Attained, 19E0 Data

All of the major urban areas are confronted with significant traffic problems. This document provides an indication of the relative criticality of the problem in the different cities.

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2. Houston-Galveston Regional Transportation Study Office, "Various Houston/ Harris County Data."

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

12. Planning Office - District 15, State Department of Highways and Public Transportation, "Various Bexar County Data."

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18. North Central Texas Council of Governments, "Population Estimates for the North Central Texas Region."

19. City of San Antonio, Department of Planning, "Population Estimates for San Antonio and Bexar County."

20. City of El Paso, Metropolitan Planning Organization, "Demographic Analysis of El Paso City and County."

21. State Department of Highways and Public Transportation, Motor Vehicle Division, "Motor Vehicle Registration Data-- By County."

22. State Department of Highways and Public Transportation, Regional Planning Office --Arlington and North Central Texas Council of Governments, "Travel Time Study -- 1975 and 1981."

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APPENDIX A

Examples of Information Used in Study

URBAN AREA		FUNCTIONAL CLASS 1	2	3	4	5	6	7	TOT
GEORGETOWN									
	MILES	7.680	0.0	6.983	3.235	7.882	0.0	38.650	64.430
	%	11.920	0.0	10.838	5.021	12.233	0.0	59.988	100.000
	V.M.	222519.	0.	54398.	18484.	5607.	0.	18938.	319947.
GLADEWATER									
	MILES	0.0	0.0	7.139	2.690	6.817	0.0	50.470	67.116
	%	0.0	0.0	10.637	4.008	10.157	0.0	75.198	100.000
	V.M.	0.	0.	63665.	3313.	8663.	0.	24730.	100372.
GONZALES									
	MILES	0.0	0.0	4.464	6.562	8.687	0.0	34.820	54.533
	%	0.0	0.0	8.186	12.033	15.930	0.0	63.851	100.000
	V.M.	0.	0.	30416.	19842.	4855.	0.	17062.	72174.
GRAHAM									
	MILES	0.0	0.0	5.134	9.049	6.217	0.0	30.210	50.610
	%	0.0	0.0	10.144	17.880	12.284	0.0	59.692	100.000
	V.M.	0.	0.	23603.	26358.	8183.	0.	14300.	72444.
GRAPEVINE									
	MILES	0.0	7.049	10.078	4.596	9.944	0.0	55.760	87.427
	%	0.0	8.063	11.527	5.257	11.374	0.0	63.779	100.000
	V.M.	0.	145567.	138551.	27887.	11747.	0.	27322.	351075.
GREENVILLE									
	MILES	6.093	0.0	13.553	15.136	6.510	0.0	143.310	184.607
	%	3.303	0.0	7.342	8.199	3.526	0.0	77.630	100.000
	V.M.	105603.	0.	93327.	74373.	15096.	0.	107879.	396777.
	MILES	0.0	0.0	0.0	0.600	0.0	0.0	0.0	0.600
	%	0.0	0.0	0.0	100.000	0.0	0.0	0.0	100.000
	V.M.	0.	0.	0.	0.	0.	0.	0.	0.
HARLINGEN-SANBENITO									
	MILES	0.0	12.759	24.055	29.977	42.356	0.0	256.600	365.747
	%	0.0	3.488	6.577	8.196	11.581	0.0	70.158	100.000
	V.M.	0.	224737.	251312.	115904.	70009.	0.	234687.	896649.
HENDERSON									
	MILES	0.0	0.0	15.125	14.076	14.242	0.0	76.860	120.303
	%	0.0	0.0	12.572	11.700	11.838	0.0	63.889	100.000
	V.M.	0.	0.	100573.	36497.	11860.	0.	58029.	206959.
HEREFORD									
	MILES	0.0	0.0	6.312	4.268	6.772	0.0	73.760	91.112
	%	0.0	0.0	6.926	4.684	7.433	0.0	80.955	100.000
	V.M.	0.	0.	56179.	15864.	24047.	0.	55002.	151091.
HILLSBORO									
	MILES	1.133	0.0	3.720	4.245	5.796	0.0	45.570	60.514
	%	1.955	0.0	6.147	7.015	9.578	0.0	75.305	100.000
	V.M.	24024.	0.	20307.	12318.	6451.	0.	22263.	85363.
HONDO									
	MILES	0.0	0.0	3.216	12.121	5.234	0.0	33.800	54.371
	%	0.0	0.0	5.915	22.293	9.626	0.0	62.165	100.000
	V.M.	0.	0.	20657.	35395.	3829.	0.	16562.	76443.
HOUSTON									
	MILES	130.415	92.510	408.485	1019.033	802.848	0.0	7268.140	9721.431
	%	1.342	0.952	4.202	10.482	8.259	0.0	74.764	100.000
	V.M.	13803443.	6149875.	7774530.	9618969.	2921201.	0.	9948458.	50216476.
HUNTSVILLE									
	MILES	7.522	0.0	17.180	5.427	6.265	0.210	72.580	109.184
	%	6.889	0.0	15.735	4.971	5.738	0.192	66.475	100.000
	V.M.	137043.	0.	103045.	14902.	5468.	177.	52848.	313482.

Highway Performance Monitoring System, 1978 Edition

FUNCTIONAL CLASSIFICATION

FUNCTION

1. Interstate
2. Other Urban Freeway and Expressway
3. Rural Principal Arterials
3. Urban Connecting Links of Rural Arterials
3. Other Urban Principal Arterials
4. Minor Arterial Road or Street
5. Rural Major Collector or Urban Collector Street
6. Rural Minor Collectors
7. Local Road or Street

STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION
TRANSPORTATION PLANNING DIVISION
IN COOPERATION WITH THE U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
ROADWAY DATA TABLES

MILES AND AVERAGE DAILY VEHICLE MILES OF ROADS IN CITIES IN EACH HIGHWAY SYSTEM BY HIGHWAY DISTRICTS AND COUNTIES

FARM OR RANCH TO MARKET ROADS

COUNTY	FAP MILES	FAP VEHICLE MILES	FAU MILES	FAU VEHICLE MILES	FAS MILES	FAS VEHICLE MILES	NON FA MILES	NON FA VEHICLE MILES	TOTAL MILES	TOTAL VEHICLE MILES
DISTRICT 12										
AUSTIN					3.996	6,349	1.283	1,400	5.281	7,749
BRAZORIA	3.028	19,644	12.100	405,194	10.344	37,479	.815	338	26.287	462,655
FORT BEND			15.485	162,554	9.289	20,443	1.014	3,267	25.788	186,264
GALVESTON	5.507	27,618	76.463	572,376	5.646	41,901			87.616	641,895
HARRIS	5.468	77,601	24.844	630,686	3.385	37,979	1.362	7,190	35.059	753,456
MATAGORDA			.732	4,803					.732	4,803
MONTGOMERY			.874	1,256	6.435	23,547	4.125	8,259	11.434	33,062
WALLER					7.791	17,171	2.073	2,726	9.864	19,897
TOTAL	14.003	124,863	130.498	1,776,869	46.888	184,869	10.672	23,180	202.061	2,109,781
DISTRICT 13										
CALHOUN			4.300	15,640	.818	1,015			5.118	16,655
COLORADO					4.353	11,781	1.383	2,774	5.736	14,555
DEWITT			3.608	6,374			1.612	2,658	5.220	9,032
FAYETTE					2.137	2,836	.363	194	2.500	3,030
GONZALES			2.395	5,440	2.227	2,164	.582	122	5.204	7,726
JACKSON			1.997	3,994	2.469	3,089			4.466	7,083
LAVACA			.544	703	2.505	3,356	.193	87	3.242	4,146
VICTORIA	.650	11,765	2.949	27,538			1.005	2,574	4.604	41,877
WHARTON			6.822	26,263			.038	67	6.860	26,330
TOTAL	.650	11,765	24.615	85,952	14.569	24,241	5.176	8,476	44.950	130,434
DISTRICT 14										
BASTROP					1.066	1,413	.486	1,120	1.552	2,533
BLANCO					1.328	1,064			1.328	1,064
BURNET					5.369	16,004	.576	176	5.945	16,180
CALDWELL			3.968	7,913	.844	2,097			4.812	10,010
GILLESPIE			1.086	4,467					1.086	4,467
HAYS			5.474	51,456	2.387	4,848			7.861	56,304
LEE					3.068	8,498	.461	148	3.529	8,646
LLANO					1.316	634	.893	2,368	2.209	3,002
MASON					2.234	2,907			2.234	2,907
TRAVIS			13.170	159,910	10.392	93,989			23.562	253,899
WILLIAMSON			5.677	22,372	6.345	29,053	1.803	1,918	13.825	53,343
TOTAL			29.375	246,216	34.349	180,567	4.219	5,730	67.943	432,353

MILES AND AVERAGE DAILY VEHICLE MILES OF ROADS IN CITIES IN EACH HIGHWAY SYSTEM BY HIGHWAY DISTRICTS AND COUNTIES

STATE HIGHWAYS

COUNTY	FAP MILES	FAP VEHICLE MILES	FAU MILES	FAU VEHICLE MILES	FAS MILES	FAS VEHICLE MILES	NON FA MILES	NON FA VEHICLE MILES	TOTAL MILES	TOTAL VEHICLE MILES
DISTRICT 12										
AUSTIN	6.841	47,433			6.121	10,724			12.962	58,157
BRAZORIA	39.484	399,766	17.588	227,419	11.401	129,379	.209	1,993	68.682	758,557
FORT BEND	22.969	393,877	3.008	19,193	2.802	4,865			28.779	417,935
GALVESTON	32.129	349,195	31.168	276,841			1.375	220	64.672	626,256
HARRIS	83.707	5,652,038	70.282	1,498,773	2.017	23,561	5.747	208,537	161.753	7,382,909
MATAGORDA	4.678	46,283	2.817	34,877	2.025	9,743			9.520	90,903
MONTGOMERY	12.570	163,303	9.615	123,052	.992	4,820	1.927	2,247	25.104	293,422
WALLER					9.393	89,161			9.393	89,161
TOTAL	202.378	7,051,895	134.478	2,180,155	34.751	272,253	9.258	212,997	380.865	9,717,300
DISTRICT 13										
CALHOUN	5.045	43,455	5.429	32,875	1.537	4,310			12.611	85,640
COLORADO	2.053	19,501			3.940	29,405	.902	2,563	6.895	51,469
DEWITT	4.402	35,837	3.191	14,248	3.852	11,455			11.445	61,540
FAYETTE	7.104	44,719			6.988	13,948	.760	1,627	14.852	60,294
GONZALES	6.222	35,426	4.167	14,559	2.603	4,536			12.992	54,521
JACKSON	1.377	14,450	3.264	20,142	3.384	11,634	.963	2,238	8.988	45,634
LAVACA	5.231	31,261	3.374	12,718	2.594	5,848			11.199	49,827
VICTORIA	10.884	118,236	5.275	91,619	.694	9,022			16.853	218,877
WHARTON	3.527	25,261	5.934	44,771	.076	532			9.507	70,564
TOTAL	46.445	370,146	30.604	230,932	25.668	90,890	2.625	6,398	105.342	698,366
DISTRICT 14										
BASTROP	10.698	67,647			5.173	17,576	2.012	1,218	17.883	86,441
BLANCO	4.247	14,510			1.572	2,006	1.100	236	6.919	16,752
BURNET	7.347	46,000							7.847	46,000
CALDWELL	5.782	37,473	1.510	5,927	.825	3,189			8.117	46,589
GILLESPIE	4.587	33,312	5.259	23,844					9.846	62,156
HAYS	2.237	27,311	3.060	42,392	3.396	7,335			8.693	77,020
LEE	3.347	36,051			1.680	2,794			5.027	38,845
LLANO	2.975	18,025			.691	1,127			3.666	19,152
MASON	2.765	8,135							2.765	8,135
TRAVIS	39.635	1,124,797	26.863	605,043	11.010	27,340	1.553	1,599	79.061	1,758,769
WILLIAMSON	25.310	265,470	8.291	60,887	.967	2,697	3.218	21,689	37.786	350,743
TOTAL	109.430	1,683,721	44.983	738,093	25.314	64,064	7.883	24,732	187.610	2,510,610

FORM TT-CITY

STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION
TRANSPORTATION PLANNING DIVISION
IN COOPERATION WITH THE U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
ROADWAY DATA TABLES

DATA DATE DECEMBER 31, 1980
RUN DATE FEB. 9, 1982
PROGRAM NO 120262

MILES AND AVERAGE DAILY VEHICLE MILES OF ROADS IN CITIES IN EACH HIGHWAY SYSTEM BY HIGHWAY DISTRICTS AND COUNTIES

	INTERSTATE HIGHWAYS		METROPOLITAN HIGHWAYS		HIGHWAY TOTALS		CITY STREETS		GRAND TOTAL	
COUNTY	FAI MILES	FAI VEHICLE MILES	FAU MILES	FAU VEHICLE MILES	MILES	VEHICLE MILES	MILES	VEHICLE MILES	MILES	VEHICLE MILES
DISTRICT 12										
AUSTIN	2.511	48,288			20.754	114,194	65.480	12,376	86.234	126,570
BRAZORIA			4.967	23,698	99.936	1,244,910	646.452	429,813	746.388	1,674,723
FORT BEND	1.658	38,667	.700	3,710	56.925	646,576	309.609	191,490	366.534	838,066
GALVESTON	16.928	465,512	8.422	38,978	177.638	1,772,641	901.423	953,847	1079.061	2,726,488
HARRIS	103.295	13,234,994	90.580	1,444,516	390.687	22,815,875	7813.044	19,522,507	8203.731	42,338,382
MATAGORDA			1.468	4,795	11.720	100,501	129.702	71,140	141.422	171,641
MONTGOMERY	4.300	161,912	.292	657	41.130	489,053	236.124	111,718	277.254	600,771
WALLER	1.641	33,477			20.898	142,535	101.510	23,684	122.408	166,219
TOTAL	130.333	13,982,850	106.429	1,516,354	819.688	27,326,285	10203.344	21,316,575	11023.032	48,642,860
DISTRICT 13										
CALHOUN			.570	2,770	18.299	105,065	96.820	46,484	115.119	151,549
COLORADO	.931	10,783			13.562	76,607	71.880	13,584	85.442	90,191
DEWITT			.236	191	16.901	76,763	150.575	40,868	167.476	117,631
FAYETTE	.534	5,492			17.886	68,816	71.210	13,460	89.096	82,276
GONZALES			1.264	1,509	19.460	63,756	78.383	22,210	97.843	85,966
JACKSON					13.454	52,717	53.681	17,617	67.135	70,334
LAVACA			.196	774	14.637	54,747	104.969	30,780	119.606	85,527
VICTORIA			2.385	11,360	23.842	272,114	335.684	388,124	359.526	660,238
WHARTON			1.646	2,492	20.013	99,386	109.763	70,247	129.776	169,633
TOTAL	1.465	16,275	6.297	19,096	158.054	864,171	1072.965	649,374	1231.019	1,513,545
DISTRICT 14										
BASTROP					19.435	88,974	88.590	16,742	108.025	105,716
BLANCO					8.247	17,816	23.694	4,514	31.941	22,330
BURNET					13.792	62,180	101.000	19,089	114.792	81,269
CALDWELL			.846	662	13.775	57,261	69.626	32,516	83.401	89,777
GILLESPIE			.331	285	11.263	66,908	43.967	21,000	55.230	87,908
HAYS	9.516	229,053	1.928	4,556	27.698	367,741	85.954	72,430	113.652	440,171
LEE					8.556	47,491	27.710	5,238	36.266	52,729
LLANO					5.875	22,154	52.410	9,936	58.285	32,090
MASON					4.999	11,042	26.883	5,552	31.882	16,594
TRAVIS	19.455	1,292,045	20.024	234,387	142.102	3,539,100	1410.696	3,020,905	1552.798	6,560,005
WILLIAMSON	14.556	326,968	2.065	1,470	68.232	732,524	173.484	61,149	241.716	793,673
TOTAL	43.527	1,848,066	25.194	241,360	324.174	5,013,191	2104.014	3,269,041	2428.188	8,282,232

Harris County

1980 RI2 TLOG -- SUMMARY OF LANE MILES AND VEHICLE MILES

------------------------------ THD COUNTY NUMBER=102 _TYPE_=COUNTY BY URB_RURL BY FUNCT_CL ------------------------------

URB_RURL	FUNCT_CL	_FREQ_	LANE_MIL	ROAD_MI	VEH_MI
1 RURAL AREAS	1 INTERSTATE	17	54.216	12.184	353,539
1 RURAL AREAS	3 PRINCIPAL ARTERIALS	32	76.410	24.265	295,973
1 RURAL AREAS	5 MAJOR COLLECTOR	158	185.382	80.424	512,442
1 RURAL AREAS	6 MINOR COLLECTOR	10	5.690	2.845	11,494
5 URBANIZED 50,000 & OVER	1 INTERSTATE	301	871.378	130.415	14,936,910
5 URBANIZED 50,000 & OVER	2 FREEWAY & EXPRESSWAY	245	479.947	85.965	6,227,914
5 URBANIZED 50,000 & OVER	3 PRINCIPAL ARTERIALS	582	1161.160	323.801	6,702,669
5 URBANIZED 50,000 & OVER	4 MINOR ARTERIAL	443	970.506	343.432	3,781,613
5 URBANIZED 50,000 & OVER	5 MAJOR COLLECTOR	66	71.856	30.848	164,200

------------------------------ THD COUNTY NUMBER=102 _TYPE_=COUNTY BY URB_RURL ------------------------------

URB_RURL	FUNCT_CL	_FREQ_	LANE_MIL	ROAD_MI	VEH_MI
1 RURAL AREAS		217	321.698	119.718	1,173,448
5 URBANIZED 50,000 & OVER		1637	3554.847	914.461	31,813,307

------------------------------ THD COUNTY NUMBER=102 _TYPE_=COUNTY BY FUNCT_CL ------------------------------

URB_RURL	FUNCT_CL	_FREQ_	LANE_MIL	ROAD_MI	VEH_MI
	1 INTERSTATE	318	925.594	142.599	15,290,449
	2 FREEWAY & EXPRESSWAY	245	479.947	85.965	6,227,914
	3 PRINCIPAL ARTERIALS	614	1237.570	348.066	6,998,642
	4 MINOR ARTERIAL	443	970.506	343.432	3,781,613
	5 MAJOR COLLECTOR	224	257.238	111.272	676,642
	6 MINOR COLLECTOR	10	5.690	2.845	11,494

------------------------------ THD COUNTY NUMBER=102 _TYPE_=BY COUNTY ------------------------------

URB_RURL	FUNCT_CL	_FREQ_	LANE_MIL	ROAD_MI	VEH_MI
		1854	3876.545	1034.179	32,986,755

ANNUAL AVERAGE HOURLY VOLUMES
BY DAYS OF WEEK--1980

TABLE 1

STATION -- S140

LOCATION- US 59, 0.6 MI W OF IH 610, S. HOUSTON

HOUR	SUN.	MON.	TUE.	WED.	THR.	FRI.	SAT.
12-AM	5,155	2,556	2,620	2,858	3,109	3,266	5,023
01-02	3,889	1,549	1,602	1,654	1,894	1,997	3,588
02-03	3,664	1,236	1,275	1,320	1,541	1,685	3,193
03-04	1,918	821	901	888	975	1,047	1,783
04-05	1,237	973	1,017	1,004	1,050	1,078	1,397
05-06	1,104	3,168	3,156	3,191	3,140	3,107	1,877
06-07	1,820	10,353	10,554	10,801	10,496	10,269	3,654
07-08	2,470	11,809	12,032	12,228	12,007	11,830	5,375
08-09	3,502	11,673	11,857	12,161	11,938	11,843	7,292
09-10	5,385	11,419	11,693	11,897	11,766	11,722	9,237
10-11	7,048	11,629	11,846	11,971	11,805	12,140	10,707
11-12	7,960	12,479	12,678	12,855	12,620	13,035	11,874
12-PM	9,448	12,509	12,523	12,663	12,497	13,426	12,347
01-02	9,790	12,609	12,611	12,769	12,606	13,292	12,046
02-03	9,855	12,906	12,947	13,239	12,957	13,619	11,844
03-04	9,962	13,672	13,592	13,879	13,511	13,561	11,606
04-05	9,723	12,864	12,990	12,886	12,635	12,468	11,211
05-06	9,790	12,002	12,174	12,161	11,951	11,735	10,816
06-07	9,428	11,621	12,044	12,178	11,822	11,799	10,754
07-08	8,263	10,130	10,722	11,038	10,962	11,676	10,066
08-09	7,150	7,940	8,314	8,621	8,704	9,493	8,151
09-10	6,392	7,078	7,620	7,939	8,080	8,509	7,598
10-11	6,025	5,994	6,708	7,130	7,044	7,879	7,275
11-12	4,207	4,526	4,965	5,144	5,389	7,020	6,665
TOTAL	145,185	203,516	208,441	212,475	210,499	217,496	185,379
PERCENT OF AADT	73.5	103.0	105.5	107.6	106.6	110.1	93.8

ANNUAL AVERAGE WEEK TOTAL -- 1,382,991

AADT -- 197,533

STATION — S140

HIGH HCURS FOR THE YEAR 1980

TABLE 2

AADT - 197,533

ORDINAL HIGH HOUR	DATE	DAY	HOUR	VOLUME	PERCENT DIRECTIONAL DISTRIBUTION	K FACTOR
1ST	2-22	FRIDAY	2- 3PM	15,400	51	7.8
2ND	2-22	FRIDAY	1- 2PM	15,280	51	7.7
3RD	2-22	FRIDAY	12- 1PM	14,940	51	7.6
4TH	2-22	FRIDAY	3- 4PM	14,830	56	7.5
5TH	2-27	WEDNESDAY	3- 4PM	14,810	55	7.5
6TH	3-28	FRIDAY	3- 4PM	14,800	56	7.5
7TH	4- 2	WEDNESDAY	3- 4PM	14,790	55	7.5
8TH	4- 1	TUESDAY	3- 4PM	14,770	55	7.5
9TH	5-30	FRIDAY	3- 4PM	14,720	55	7.5
10TH	3- 3	MONDAY	3- 4PM	14,670	55	7.4
15TH	1-25	FRIDAY	3- 4PM	14,600	56	7.4
20TH	3-31	MONDAY	3- 4PM	14,560	56	7.4
25TH	3-13	THURSDAY	3- 4PM	14,510	55	7.3
30TH	5-15	THURSDAY	3- 4PM	14,500	55	7.3
35TH	5- 2	FRIDAY	3- 4PM	14,470	56	7.3
40TH	4- 7	MONDAY	3- 4PM	14,410	55	7.3
45TH	4-29	TUESDAY	3- 4PM	14,370	56	7.3
50TH	9- 3	WEDNESDAY	3- 4PM	14,350	55	7.3
75TH	2-28	THURSDAY	3- 4PM	14,260	54	7.2
100TH	10- 7	TUESDAY	3- 4PM	14,160	54	7.2
125TH	3-14	FRIDAY	1- 2PM	14,070	53	7.1
150TH	9-12	FRIDAY	12- 1PM	14,020	54	7.1
175TH	12-23	TUESDAY	2- 3PM	13,980	52	7.1
200TH	12-16	TUESDAY	3- 4PM	13,910	55	7.0

AVERAGE DAILY TRAFFIC VOLUMES BY MONTH, DAY OF WEEK AND SEASON — TABLE 3

FOR YEAR--1980

STATION -- S140

LOCATION- US 59, 0.6 MI W OF IH 610, S. HOUSTON

MONTH AND SEASON	(SUN)	(MON)	(TUE)	(WED)	(THR)	(FRI)	(SAT)	AVERAGE DAY (SUN THRU SAT) VOLUME	PERCENT AADT	AVERAGE WEEKDAY (MON - THR) VOLUME	PERCENT AADT	AVERAGE WEEKDAY (MON - FRI) VOLUME	PERCENT AADT
DECEMBER	142,682	201,690	206,674	211,284	188,502	206,500	183,377	191,529	97.0	202,037	102.3	202,930	102.7
JANUARY	132,925	198,027	185,014	205,610	203,010	213,227	185,315	189,018	95.7	197,915	100.2	200,977	101.7
FEBRUARY	147,265	205,415	210,850	213,620	212,682	221,642	183,537	199,287	100.9	210,641	106.6	212,841	107.7
(WINTER)	(140,957)	(201,711)	(200,846)	(210,171)	(201,398)	(213,790)	(184,076)	(193,278)	(97.8)	(203,531)	(103.0)	(205,583)	(104.1)
MARCH	149,602	209,268	208,175	211,520	209,462	226,360	191,306	200,813	101.7	209,606	106.1	212,957	107.8
APRIL	142,492	212,705	215,854	216,324	221,297	217,477	184,447	201,513	102.0	216,545	109.6	216,731	109.7
MAY	149,112	195,250	214,225	216,180	214,322	226,316	190,992	200,913	101.7	209,994	106.3	213,258	108.0
(SPRING)	(147,069)	(205,741)	(212,751)	(214,675)	(215,027)	(223,384)	(188,915)	(201,080)	(101.8)	(212,048)	(107.3)	(214,315)	(108.5)
JUNE	149,486	205,134	211,472	209,602	214,072	220,210	188,655	199,804	101.1	210,070	106.3	212,098	107.4
JULY	146,107	202,107	210,130	212,902	218,420	201,442	179,957	195,866	99.2	210,889	106.8	209,000	105.8
AUGUST	142,240	208,012	211,322	214,092	215,930	220,166	174,874	198,090	100.3	212,339	107.5	213,904	108.3
(SUMMER)	(145,944)	(205,084)	(210,975)	(212,199)	(216,141)	(213,939)	(181,162)	(197,920)	(100.2)	(211,099)	(106.9)	(211,667)	(107.2)
SEPTEMBER	142,507	192,562	210,358	213,440	214,825	216,955	187,310	196,851	99.7	207,796	105.2	209,628	106.1
OCTOBER	150,182	205,180	212,575	213,020	215,124	223,556	187,792	201,061	101.8	211,474	107.1	213,891	108.3
NOVEMBER	146,096	208,335	208,340	213,062	196,302	210,795	186,590	195,645	99.0	206,509	104.5	207,366	10[illegible].0
(FALL)	(146,262)	(202,026)	(210,424)	(213,174)	(208,750)	(217,102)	(187,231)	(197,852)	(100.2)	(208,593)	(105.6)	(210,295)	(106.5)
								1[illegible],533	100.0	208,818	105.7	210,465	106.5

Houston-Galveston Regional Transportation Study

1980 Roadway Mileage and Vehicle Travel by Functional Classification

LOCATION	ARTERIALS: Interstate Highways Miles	Interstate Highways DVM*	Other Fwys. & Expwys. Miles	Other Fwys. & Expwys. DVM*	Other Principals Miles	Other Principals DVM*	Minor Arterials Miles	Minor Arterials DVM*	COLLECTORS: Major Collectors Miles	Major Collectors DVM*	Minor Collectors Miles	Minor Collectors DVM*	Frontage Roads Miles	Frontage Roads DVM*	LOCALS Miles	LOCALS DVM*	TOTAL Miles	TOTAL DVM*
BRAZORIA																		
Urban	–	–	7.3	145,285	28.9	441.389	54.5	271.983	–	–	53 4	95.900	3.0	6.000	550.1	80,000	697 2	1.040.557
Rural	–	–	–	–	66 2	564 081	79.5	486.020	198.3	559.401	170 6	146.735	–	–	858 2	84.270	1,372.8	1.840.507
Total	–	–	7.3	145,285	95.1	1.005 470	134.0	758.003	198.3	559.401	224.0	242.635	3.0	6.000	1.405.3	164.270	2.070 0	2.881.064
CHAMBERS																		
Urban	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Rural	34 2	666.269	2.2	10.680	4 2	53.501	22.2	92.649	100.3	146.516	94 9	36.057	65.5	6.550	275 0	41.031	598 5	1.053.253
Total	34 2	666.269	2.2	10.680	4 2	53.501	22.2	92.649	100.3	146.516	94 9	36.057	65.5	6.550	275 0	41.031	598 5	1.053.253
FORT BEND																		
Urban	–	–	8.5	292.650	18 9	346 051	26.6	257.820	–	–	59.0	134.832	8 4	42,000	347.6	71,939	469.0	1.145.292
Rural	2 7	61.080	23.0	445.830	33 5	262.537	47.7	221.185	90 4	235.937	133.8	132.810	6.3	2.000	651.3	64.870	988.7	1.426.249
Total	2.7	61.080	31.5	738.480	52.4	608.588	74.3	479.005	90.4	235.937	192 8	267.642	14 7	44.000	998.9	136.809	1.457.7	2.571.541
GALVESTON																		
Urban	20 1	637,400	3 1	49,900	57 4	853.601	117 1	876.927	–	–	92.4	213.542	38.3	57.450	793.1	188.100	1.121 5	2.876.920
Rural	3 7	165.000	–	–	9 4	81 867	39 6	197.771	60.1	145.285	26.6	17.502	5.5	9.350	202 4	20.200	347.3	636 980
Total	23 8	802.400	3.1	49.900	66 8	935 468	156.7	1.074 698	60.1	145.285	119 0	231.049	43.8	66.800	995 5	208.300	1.468 8	3.513 900
HARRIS																		
Urban	130 6	13.390.931	67.0	5,013.064	367 7	8 566,170	994 9	11,382.954	–	–	758 4	2.490.020	282.4	1.392,000	7.521.0	2.390.355	10 122 0	44.625 194
Rural	12.5	354.485	–	–	17 3	289.978	10.3	68.310	173.9	935.375	208 6	345.535	18.4	13.000	1.190 8	163.600	1.631 8	2.170.284
Total	143.1	13.745.416	67.0	5.013.064	385 0	8.856.148	1.005 2	11.451.264	173.9	935.375	967.0	2.835.555	300.8	1.405.000	8.711 8	2.553.955	11.753 8	46.795.477
LIBERTY																		
Urban	–	–	3.8	52.125	15 2	180.764	9.7	35.109	–	–	20.1	38.319	–	–	115.9	22.463	164.7	328.780
Rural	–	–	4.5	90.000	2.7	34.430	102.2	454.373	145.5	174.741	113.9	114.467	–	–	550 4	67.270	919.2	935 281
Total	–	–	8.3	142.125	17 9	215.194	111.9	489.482	145.5	174.741	134.0	152.786	–	–	665.3	89.733	1.083 9	1.264 061
MONTGOMERY																		
Urban	4.0	138.900	–	–	11.6	159.364	10.0	45.662	–	–	14.1	23.863	6.3	12.600	137.8	25.289	183.8	405 678
Rural	24.0	774.550	17.7	502.800	–	–	39.8	186.092	206.9	502.279	215.4	234.436	57.9	72.375	1.195.4	139.000	1.757.1	2.411.532
Total	28.0	913.450	17.7	502.800	11.6	159.364	49.8	231.754	206.9	502.279	229.5	258.299	64.2	84.975	1.333.2	164.289	1,940.9	2.817.210
WALLER																		
Urban	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Rural	11.1	231.100	2.8	15.064	23.3	196.380	4.5	15.875	100.5	116.618	83.1	65,427	9.0	900	511.1	48.477	745.4	689.771
Total	11.1	231,100	2.8	15.064	23.3	196.380	4.5	15.875	100.5	116.618	83.1	65,427	9.0	900	511.1	48.477	745.4	689.771
TOTAL H-GRIS																		
Urban	154.7	14,167,231	89.7	5,553,024	499.7	10,547.339	1,212.8	12,870,455	–	–	997.4	2,996,476	338.4	1,510,050	9,465.5	2,778,146	12,758.2	50,422,421
Rural	88.2	2,252,484	50.2	1,064,374	156.6	1,482,774	345.8	1,722,275	1,075.9	2,816,102	1,046.4	1,092,975	162.6	104,175	5,434.6	628,718	8,360.8	11,163 857
Total	242.9	16,419,715	139.9	6,617,398	656.3	12,030,113	1,558.6	14,592,730	1,075.9	2,816,102	2,044.3	4,089,451	501.0	1,614,225	14,900.1	3,406,864	21,119.0	61,586,278

*DVM - Average Daily Vehicle Miles of Travel

Note - All mileage data are as of December 31, 1980. Urban areas are defined as land inside urban-in-fact boundaries with a population density exceeding 1,000 persons per square mile and a total population of 5,000 or more.

STATION — S140

AADT PERCENT VARIATION BY YEARS

TABLE 4

YEAR	AADT	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979
1965	60,605															
1966	69,373	14.5														
1967	78,720	29.9	13.5													
1968	88,197	45.5	27.1	12.0												
1969	99,491	64.2	43.4	26.4	12.8											
1970	108,683	79.3	56.7	38.1	23.2	9.2										
1971	118,286	95.2	70.5	50.3	34.1	18.9	8.8									
1972	127,721	110.7	84.1	62.2	44.8	28.4	17.5	8.0								
1973	133,948	121.0	93.1	70.2	51.9	34.6	23.2	13.2	4.9							
1974	138,494	128.5	99.6	75.9	57.0	39.2	27.4	17.1	8.4	3.4						
1975	154,733	155.3	123.0	96.6	75.4	55.5	42.4	30.8	21.1	15.5	11.7					
1976	163,945	170.5	136.3	108.3	85.9	64.8	50.8	38.6	28.4	22.4	18.4	6.0				
1977	182,756	201.6	163.4	132.2	107.2	83.7	68.2	54.5	43.1	36.4	32.0	18.1	11.5			
1978	193,648	219.5	179.1	146.0	119.6	94.6	78.2	63.7	51.6	44.6	39.8	25.1	18.1	6.0		
1979	194,652	221.2	180.6	147.3	120.7	95.6	79.1	64.6	52.4	45.3	40.5	25.8	18.7	6.5	0.5	
1980	197,533	225.9	184.7	150.9	124.0	98.5	81.8	67.0	54.7	47.5	42.6	27.7	20.5	8.1	2.0	1.5

NCTCOG Major Thoroughfare Link File

1980 Network Information Pertaining to Freeways

NETWORK STRATIFICATION		PORTION OF INTENSIVE STUDY AREA (ISA)						
		DALLAS COUNTY			TARRANT COUNTY			REST OF ISA
AREA TYPE	NUMBER OF LANES	MILES	AVERAGE COUNT	CV*	MILES	AVERAGE COUNT	CV*	MILES
CBD	4	0.37	78148	0.24	0.75			
OBD	4	14.45	86276	0.32	4.78	76888	0.08	
SUBURB	4	42.61	37277	0.59	38.94	46164	0.36	11.76
RURAL	4	20.31	18701	0.23	32.00	15722	0.82	36.78
CBD	6	1.48	89460	0.52	0.72	94490	0.09	
OBD	6	23.00	78471	0.44	8.37	73439	0.26	
SUBURB	6	51.53	51157	0.50	57.15	49070	0.45	
RURAL	6	8.10	35944	0.39	12.72	36923	0.36	
CBD	8	0.38	113113	0.68				
OBD	8	15.88	116252	0.25	1.19	61714	0.07	
SUBURB	8	43.78	69317	0.58	12.01	41607	0.35	
RURAL	8	9.81	25455	0.09	5.10	29920	0.08	
OBD	10	2.43	149308	0.19				
SUBURB	10	0.51	160180	0.00				
OBD	12	0.14						

APPENDIX B

P.M. Peak-Period Delay

Appendix B: P.M. Peak-Period Delay

This Appendix documents the analyses used to obtain the travel delay estimates for six major Houston radial freeways. The results of this analysis are presented in Tables 6 and 7, Figure 5 and Appendix B. Travel time studies conducted by the Houston-Galveston Regional Transportation Study (HGRTS) Office (4) were utilized as were volume counts from automatic traffic recorders and traffic maps of the State Department of Highways and Public Transportation (3).

The freeways were divided into two sections, inside I-610 and between I-610 and the proposed Beltway 8. These are both circumferential facilities; I-610 is located 6 miles radius from the CBD and Beltway 8 is approximately 12 miles radius.

The average peak hour at each location was determined to be the 100th highest hour for the years 1969, 1973 and 1976 and the 75th highest hour for 1979 (1). The change in the hour used was necessitated by the changing traffic conditions, i.e., the decreasing variation in hourly volumes across the day. Instead of two distinct peaks with a low period between, there now exists a generally high volume of traffic across the entire day. The directional distribution factor from the Department's count stations was used to obtain the peak direction hourly volume (column 1)*. Estimates were generated from Department traffic maps for those segments of roadway not having automatic traffic count stations (3,7)

Southwest Freeway (US 59S)--- Inside I-610 Year 1979
75th highest hour----14,100
Directional distribution factor----0.51

14,100 X 0.51 = 7191 vehicles in P.M. peak hour, peak direction

HGRTS travel time maps (7) were used to calculate peak-hour delay. Measurements of travel time, both peak and off-peak, were taken at the intersection of each freeway and I-610 and Beltway 8. The difference in peak-period and off-peak travel times to these points is considered to be equal to the peak-hour delay per vehicle (column 2). There was no significant delay outside of Beltway 8 in any of the years examined. Volume was multiplied by the delay per vehicle to obtain peak-hour delay (column 3).

S.W. Fwy. - Inside I-610 1979

Peak-hour travel time to I-610	23.0
—Off-peak travel time to I-610	11.8
Peak-hour delay per vehicle	11.2 minutes

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* Refer to Tables C-1 through C-4 in Appendix C.

Peak-hour volume	X	Peak-hour delay	=	Total peak-hour delay
7191 vehicles	X	11.2 minutes	=	80,539 vehicle-minutes of delay

The evening peak-period in Houston typically lasts three hours with congestion during the peak hour equal to that of the total remaining portion of the peak-period. Peak-hour delay was therefore assumed to be one-half of the total peak-period delay for each year (column 4). Peak-period volume was obtained by comparing peak hourly traffic to peak-period volume for 1968 and 1978 (8) and assuming a straight line change in the ratio. this factor was used to expand the peak-hour volume to a peak-period volume (column 6).

S.W. Fwy. - Inside I-610 1979

Peak-hour delay = Remaining peak-period delay

= 11.2 minutes

Peak-hour volume	X	1979 ratio of peak-period to peak-hour	=	Peak-period volume
7191	X	2.81	=	20,207 vehicles

1976 ratio=2.75
1973 ratio=2.68
1969 ratio=2.59

Peak-period volume	—	Peak-hour volume	=	Remaining peak-period volume
20,207 vehicles	—	7,191 vehicles	=	13,016 vehicles

This number was multiplied by the remaining peak-period delay per vehicle (column 4) yielding the remaining peak-period delay (column 7). Total peak-period delay (column 8) was arrived at by the addition of peak-hour and remaining peak-period delay values. Tables 6 and 7 in the text summarizes the peak-period delay estimates by freeway segment for 1969, 1973, 1976 and 1979.

S.W. Fwy. - I-610 1979

Remaining peak-period volume	X	Remaining peak-period delay per vehicle	=	Remaining peak-period delay
13,016 vehicles	X	11.2 minutes	=	145,780 vehicle-minutes

Peak-hour delay	+	Remaining peak-period delay	=	Total peak-period delay
80,539 veh-mins	+	145,780 veh-mins	=	226,319 vehicle-minutes

APPENDIX C

P.M. Peak-Period Delay
Houston, Dallas, Fort Worth

Table C-1: 1969 P.M. Peak-Period Delay- Houston

Freeway	Segment	Peak Hour Volume (Veh) 1	Peak Hour Delay/Veh (Mins) 2	Peak Hour Delay (Veh-Mins)[1] 3	Remaining Peak Period Delay/Veh (Mins)[2] 4	Peak Period Volume (Veh) 5	Remaining Peak Period Volume (Veh)[3] 6	Remaining Peak Period Delay (Veh-Mins)[4] 7	Peak Period Total Delay (Veh-Mins)[5] 8
Southwest US 59S	Ins 610	5,060	7.2	36,432	7.2	13,105	8,045	57,924	94,356
	610-Belt	5,800	1.7	9,860	1.7	15,022	9,222	15,677	25,537
Katy I-10W	Ins 610	4,597	2.2	10,113	2.2	11,906	7,309	16,080	26,193
	610-Belt	6,297	4.2	26,447	4.2	16,309	10,012	42,050	68,497
North I-45N	Ins 610	6,329	4.1	25,949	4.1	16,392	10,063	41,258	67,207
	610-Belt	5,683	2.3	13,071	2.3	14,719	9,036	20,783	33,854
Eastex US 59N	Ins 610	6,045	4.5	27,203	4.5	15,655	9,610	43,245	70,448
	610-Belt	3,840	0.7	2,688	0.7	9,946	6,106	4,274	6,962
East I-10E	Ins 610	4,040	4.3	17,372	4.3	10,464	6,424	27,623	44,995
	610-Belt	4,892	0.1	489	0.1	12,670	7,778	778	1,267
Gulf I-45S	Ins 610	5,845	11.2	65,464	11.2	15,139	9,294	104,093	169,557
	610-Belt	3,660	0.4	1,464	0.4	9,478	5,818	2,327	3,791

[1] Col. 3 = Col. 1 x Col. 2
[2] Col. 4 = Col. 2 x 0.5
[3] Col. 6 = Col. 5 - Col. 1
[4] Col. 7 = Col. 4 x Col. 6
[5] Col. 8 = Col. 7 + Col. 3

Source: References 2, 4, 6, 8

Table C-2: 1973 P.M. Peak-Period Delay - Houston

Freeway	Segment	Peak Hour Volume (Veh) 1	Peak Hour Delay/Veh (Mins) 2	Peak Hour Delay (Veh-Mins)[1] 3	Remaining Peak Period Delay/Veh (Mins)[2] 4	Peak Period Volume (Veh) 5	Remaining Peak Period Volume (Veh)[3] 6	Remaining Peak Period Delay (Veh-Mins)[4] 7	Peak Period Total Delay (Veh-Mins)[5] 8
Southwest US 59S	Ins 610	5,435	8.6	46,741	8.6	14,566	9,131	78,527	125,268
	610-Belt	6,832	2.2	15,030	2.2	18,310	11,478	25,252	40,282
Katy I-10W	Ins 610	6,504	2.3	14,959	2.3	17,431	10,927	25,132	40,091
	610-Belt	6,102	6.4	39,053	6.4	16,353	10,251	65,606	104,659
North I-45N	Ins 610	6,624	8.8	58,291	8.8	17,752	11,128	97,926	156,217
	610-Belt	6,065	3.1	18,802	3.1	16,255	10,190	31,589	50,391
Eastex US 59N	Ins 610	5,688	1.1	6,257	1.1	15,244	9,556	10,512	16,769
	610-Belt	4,493	2.0	8,986	2.0	12,040	7,547	15,094	24,080
East I-10E	Ins 610	4,978	2.6	12,943	2.6	13,341	8,363	21,744	34,687
	610-Belt	3,471	2.1	7,289	2.1	9,303	5,832	12,247	19,536
Gulf I-45S	Ins 610	5,866	12.0	70,392	12.0	15,751	9,885	118,620	189,012
	610-Belt	4,422	0.7	3,095	0.7	11,852	7,430	5,201	8,296

[1]Col. 3 = Col. 1 x Col. 2
[2]Col. 4 = Col. 2 x 0.5
[3]Col. 6 = Col. 5 - Col. 1
[4]Col. 7 = Col. 4 x Col. 6
[5]Col. 8 = Col. 7 + Col. 3

Source: References 2, 4, 6, 8

Table C-3: 1976 P.M. Peak-Period Delay- Houston

Freeway	Segment	Peak Hour Volume (Veh) 1	Peak Hour Delay/Veh (Mins) 2	Peak Hour Delay (Veh-Mins)[1] 3	Remaining Peak Period Delay/Veh (Mins)[2] 4	Peak Period Volume (Veh) 5	Remaining Peak Period Volume (Veh)[3] 6	Remaining Peak Period Delay (Veh-Mins)[4] 7	Peak Period Total Delay (Veh-Mins)[5] 8
Southwest US 59S	Ins 610	7,124	7.7	54,855	7.7	19,591	12,467	95,996	150,851
	610-Belt	7,112	3.0	21,336	3.0	19,558	12,446	37,338	58,674
Katy I-10W	Ins 610	6,741	7.0	47,187	7.0	18,538	11,797	82,580	129,767
	610-Belt	6,139	7.7	47,270	7.7	16,882	10,743	82,721	129,991
North I-45N	Ins 610	6,063	5.2	31,528	5.2	16,673	10,610	55,172	86,700
	610-Belt	5,049	8.8	44,431	8.8	13,885	8,836	77,756	122,187
Eastex US 59N	Ins 610	6,326	7.9	49,975	7.9	17,397	11,071	87,461	137,436
	610-Belt	5,168	3.8	19,638	3.8	14,210	9,042	34,360	53,998
East I-10E	Ins 610	5,752	3.0	17,256	3.0	15,818	10,066	30,198	47,454
	610-Belt	5,210	1.9	9,899	1.9	14,328	9,118	17,324	27,223
Gulf I-45S	Ins 610	6,314	11.9	75,137	11.9	17,364	11,050	131,495	206,632
	610-Belt	5,562	1.8	10,012	1.8	15,294	9,732	17,518	27,530

[1] Col. 3 = Col. 1 x Col. 2
[2] Col. 4 = Col. 2 x 0.5
[3] Col. 6 = Col. 5 - Col. 1
[4] Col. 7 = Col. 4 x Col. 6
[5] Col. 8 = Col. 7 + Col. 3

Source: References 2, 4, 6, 8

Table C-4: 1979 P.M. Peak-Period Delay - Houston

Freeway	Segment	Peak Hour Volume (Veh) 1	Peak Hour Delay/Veh (Mins) 2	Peak Hour Delay (Veh-Mins)[1] 3	Remaining Peak Period Delay/Veh (Mins)[2] 4	Peak Period Volume (Veh) 5	Remaining Peak Period Volume (Veh)[3] 6	Remaining Peak Period Delay (Veh-Mins)[4] 7	Peak Period Total Delay (Veh-Mins)[5] 8
Southwest US 59S	Ins 610	7,191	11.2	80,539	11.2	20,207	13,016	145,780	226,319
	610-Belt	7,690	6.3	48,447	6.3	21,608	13,918	87,683	136,130
Katy I-10W	Ins 610	6,624	5.5	36,432	5.5	18,613	11,989	65,940	102,372
	610-Belt	5,788	9.0	52,092	9.0	16,263	10,475	94,276	146,368
North I-45N	Ins 610	6,192	3.5	21,672	3.5	17,398	11,206	39,221	60,893
	610-Belt	5,918	13.9	82,260	13.9	16,628	10,710	148,869	231,129
Eastex US 59N	Ins 610	6,061	5.4	32,729	5.4	17,031	10,970	59,238	91,967
	610-Belt	4,531	6.5	29,452	6.5	12,731	8,200	53,300	82,752
East I-10E	Ins 610	6,065	1.9	11,524	1.9	17,043	10,978	20,858	32,382
	610-Belt	5,760	2.6	14,976	2.6	16,186	10,426	27,108	42,084
Gulf I-45S	Ins 610	6,430	8.0	51,440	8.0	18,067	11,637	93,096	144,536
	610-Belt	5,978	1.9	11,358	1.9	16,798	10,820	20,558	31,916

[1] Col. 3 = Col. 1 x Col. 2
[2] Col. 4 = Col. 2 x 0.5
[3] Col. 6 = Col. 5 - Col. 1
[4] Col. 7 = Col. 4 x Col. 6
[5] Col. 8 = Col. 7 + Col. 3

Source: References 2, 4, 6, 8

Table C-5: 1975 P.M. Peak-Period Delay - Dallas

Freeway	Segment	Peak Hour Volume (Veh) 1	Peak Hour Delay/Veh (Mins) 2	Peak Hour Delay (Veh-Mins)[1] 3	Remaining Peak Period Delay/Veh (Mins)[2] 4	Peak Period Volume (Veh)[3] 5	Remaining Peak Period Volume (Veh) 6	Remaining Peak Period Delay (Veh-Mins)[4] 7	Peak Period Total Delay (Veh-Mins)[5] 8
US 75N									
	Ins L12	4,447	20.0	88,940	10.0	12,096	7,649	76,490	165,430
	L12-635	4,235	11.7	49,550	5.9	11,519	7,284	42,976	92,526
I-35E N									
	Ins L12	5,151	4.3	22,149	2.2	14,011	8,860	19,492	41,641
	L12-635	4,597	1.6	7,355	0.8	12,504	7,907	6,326	13,681
I-30W									
	Ins L12	3,587	1.7	6,098	0.9	9,757	6,170	5,553	11,651
	L12-Belt	3,377	0.2	675	0.1	9,185	5,808	581	1,256
I-35E S									
	Ins L12	5,832	0.7	4,082	0.4	15,863	10,031	4,012	8,094
	L12-635	2,878	----	------	----	------	------	------	-------
I-45S									
	Ins L12	2,697	4.6	12,406	2.3	7,336	4,639	10,670	23,076
	L12-635	1,593	1.4	2,230	0.7	4,333	2,740	1,918	4,148
I-30E									
	Ins L12	6,658	4.6	30,267	2.3	18,110	11,452	26,340	56,967
	L12-635	3,161	2.0	6,322	1.0	8,598	5,437	5,437	11,759

[1] Col. 3 = Col. 1 x Col. 2
[2] Col. 4 = Col. 2 x 0.5
[3] Col. 6 = Col. 5 - Col. 1
[4] Col. 7 = Col. 4 x Col. 6
[5] Col. 8 = Col. 7 + Col. 3

Source: References 2, 4, 6, 8

Table C-6: 1981 P.M. Peak-Period Delay - Dallas

Freeway	Segment	Peak Hour Volume (Veh) 1	Peak Hour Delay/Veh (Mins) 2	Peak Hour Delay (Veh-Mins)[1] 3	Remaining Peak Period Delay/Veh (Mins)[2] 4	Peak Period Volume (Veh) 5	Remaining Peak Period Volume (Veh)[3] 6	Remaining Peak Period Delay (Veh-Mins)[4] 7	Peak Period Total Delay (Veh-Mins)[5] 8
US 75N									
	Ins L12	4,400	12.2	53,680	6.1	12,496	8,096	49,386	103,066
	L12-635	4,520	14.7	66,444	7.4	12,837	8,317	61,546	127,990
I-35E N									
	Ins L12	5,630	2.8	15,764	1.4	15,989	10,359	14,503	30,267
	L12-635	5,215	1.3	6,780	0.7	14,811	9,596	6,717	13,497
I-30W									
	Ins L12	4,245	2.4	10,188	1.2	12,056	7,811	9,373	19,561
	L12-Belt	3,540	0.7	2,478	0.4	10,054	6,514	2,606	5,084
I-35E S									
	Ins L12	6,505	3.1	20,166	1.6	18,474	11,969	19,150	39,316
	L12-635	3,340	0.2	668	0.1	9,486	6,146	615	1,283
I-45S									
	Ins L12	3,290	1.2	3,948	0.6	9,344	6,054	3,632	7,580
	L12-635	1,905	0.3	572	0.2	5,410	3,505	701	1,273
I-30E									
	Ins L12	7,140	4.9	34,986	2.5	20,278	13,138	32,845	67,831
	L12-635	3,735	0.7	2,615	0.4	10,607	6,872	2,749	5,364

[1] Col. 3 = Col. 1 x Col. 2
[2] Col. 4 = Col. 2 x 0.5
[3] Col. 6 = Col. 5 - Col. 1
[4] Col. 7 = Col. 4 x Col. 6
[5] Col. 8 = Col. 7 x Col. 3

Source: References 2, 4, 6, 8

Table C-7: 1975 P.M. Peak-Period Delay - Fort Worth

Freeway	Segment	Peak Hour Volume (Veh) 1	Peak Hour Delay/Veh (Mins) 2	Peak Hour Delay (Veh-Mins)[1] 3	Remaining Peak Period Delay/Veh (Mins)[2] 4	Peak Period Volume (Veh) 5	Remaining Peak Period Volume (Veh)[3] 6	Remaining Peak Period Delay (Veh-Mins)[4] 7	Peak Period Total Delay (Veh-Mins)[5] 8
SH 121									
	Ins 820	2,490	1.4	3,486	0.7	6,773	4,283	2,998	6,484
I-30W									
	Ins 820	2,990	8.5	25,432	4.3	8,133	5,143	22,114	47,546
I-30E									
	Ins 820	3,755	0.9	3,380	0.5	10,214	6,459	3,229	6,609
I-35W N									
	Ins I-20	2,890	0.3	867	0.2	7,861	4,971	994	1,861
I-35W S									
	Ins 820	3,620	2.0	7,240	1.0	9,846	6,226	6,226	13,466
US 287S									
	Ins 820	1,380	1.0	1,380	0.5	3,754	2,374	1,187	2,567

[1] Col. 3 = Col. 1 x Col. 2
[2] Col. 4 = Col. 2 x 0.5
[3] Col. 6 = Col. 5 - Col. 1
[4] Col. 7 = Col. 4 x Col. 6
[5] Col. 8 = Col. 7 + Col. 3

Source: References 2, 4, 6, 8

Table C-8: 1981 P.M. Peak-Period Delay - Fort Worth

Freeway	Segment	Peak Hour Volume (Veh) 1	Peak Hour Delay/Veh (Mins) 2	Peak Hour Delay (Veh-Mins)[1] 3	Remaining Peak Period Delay/Veh (Mins)[2] 4	Peak Period Volume (Veh) 5	Remaining Peak Period Volume (Veh)[3] 6	Remaining Peak Period Delay (Veh-Mins)[4] 7	Peak Period Total Delay (Veh-Mins)[5] 8
SH 121	Ins 820	2,890	1.1	3,176	0.6	8,208	5,318	3,191	6,367
I-30W	Ins 820	3,450	3.5	12,070	1.8	9,798	6,348	11,426	23,496
I-30E	Ins 820	4,125	1.0	4,125	0.5	11,715	7,590	3,795	7,920
I-35W N	Ins I-20	3,260	1.6	5,215	0.8	9,258	5,998	4,798	10,013
I-35W S	Ins 820	3,815	2.5	9,538	1.3	10,835	7,020	9,126	18,664
US 287S	Ins 820	1,880	0.8	1,505	0.4	5,339	3,459	1,384	2,889

[1] Col. 3 = Col. 1 x Col. 2
[2] Col. 4 = Col. 2 x 0.5
[3] Col. 6 = Col. 5 - Col. 1
[4] Col. 7 = Col. 4 x Col. 6
[5] Col. 8 = Col. 7 + Col. 3

Source: References 2, 4, 6, 8