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16. Abstract

This report is the second in a series which will document two phases of a research project conducted by the Texas Transportation Institute entitled, "Evaluating Urban Freeway Guide Signing". The research was sponsored by the Texas Department of Highways and Public Transportation in cooperation with the U.S. Department of Transportation, Federal Highway Administration.

The first part of this report describes traffic operation field studies conducted on urban freeways in Dallas and Houston. Major signing modifications were made to the freeway guide signing by state forces exogenous to the research effort. Before and after studies considering lane volumes, lane changes and erratic maneuvers were collected and evaluated. Some specific and a few general conclusions and recommendations were offered.

The second part of this report will document research conducted on various aspects of urban freeway guide signing. This report describes the results and findings of a physical inventory of freeway guide signing in ten cities in the United States. Four of these cities inventoried were: Dallas, Ft. Worth, Houston and San Antonio. The six out-of-state cities were: Atlanta, Chicago, Denver, Kansas City, Los Angeles and New Orleans.

Data were collected on numerous physical design features including: number of sign panels, number of concurrent routes, and bits of information. Message content and meaningfulness, as such, were not evaluated. A "bit" of information on a freeway guide sign was defined as a route number, destination name, or any one of 12 other similar message items.

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OPERATIONAL STUDIES
OF
URBAN FREEWAY GUIDE SIGNING SYSTEMS

by

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Preliminary
Research Report 220-2

Research Study Number 2-18-77-220

Sponsored by the Texas
State Department of Highways and Public Transportation
In Cooperation with the
U.S. Department of Transportation
Federal Highway Administration

Texas Transportation Institute
Texas A&M University
College Station, Texas

August 1979

SUMMARY

This report is the second in a series which will document research conducted on various aspects of urban freeway guide signing in Texas. This report is divided into two sections. The first section is concerned with the operational studies of urban freeway guide signing systems and the second section is concerned with an analysis of existing urban freeway guide signing systems in selected cities in the United States. The first section describes two studies made to determine the operational impacts of the implementation of new freeway guide signing systems. A third study is included which describes a small-scale accident analysis of a select population of unfamiliar drivers.

The first operational study reported was conducted along westbound I-30 near downtown Dallas. Before studies were conducted during 1977 and After studies in 1979. During this period an updating of the freeway guide signing system to 1970 MUTCD standards was made. Operational studies of volumes, lane changing and erratic maneuvers were conducted to determine what effects might be attributed to the signing and what changes, if any, occurred as a result of changes in the signing. Some positive operational changes were noted but the causal relationships were clouded by the fact that the Dallas-Ft. Worth Turnpike was made into a toll free road (I-30) between the Before and After studies. Additional conclusions and recommendations for improving the new signing systems are offered.

The second operational study described was conducted along eastbound I-10 on the east side of Houston. This study was similar in many ways to the previous study. An existing guide signing system was updated to 1970 MUTCD standards during 1977. Before and After operational studies were conducted in 1977 and 1978. Fewer "pull thru" signs and less positive land

assignments were the more significant effects of changes that were studied. It was found that only minimal changes occurred with the reduced level of signing on the radial freeway section studied. Recommendations based on cost-effectiveness considerations were developed.

A third study of 1,500 out-of-state drivers from Nebraska revealed that they experienced no reported accidents while driving on Dallas or Houston freeways while attending a recent Astro-Bluebonnet Bowl football game.

The second section describes the results and findings of a physical inventory of freeway guide signing in ten cities in the United States. Four of these cities are located in the state of Texas and six are outside the state. The four Texas cities inventoried are: Dallas, Ft. Worth, Houston and San Antonio. The six out-of-state cities are: Atlanta, Chicago, Denver, Kansas City, Los Angeles and New Orleans.

The sign inventory contained a total of 2,292 freeway guide signs. A total of 1,063 are located out-of-state and 1,229 in Texas. All observations made of the freeway guide signs were obtained from routine travel runs using standard automobiles, a 35 mm camera, and a cassette voice recording unit.

Data were collected on numerous physical design features including: number of sign panels, number of concurrent routes, and bits of information. Message content and meaningfulness, as such, were not evaluated. A "bit" of information on a freeway guide sign was defined as a route number, destination name, or any one of 12 other similar message items.

The results of the study include statistical summaries of a number of variables together with comparisons between Texas and out-of-state signing systems. The base sign density results suggest that the average frequency of signs presented to motorists in Ft. Worth, Houston and Kansas City are somewhat higher than the average (2.18 signs per mile), whereas, Los Angeles has a much lower than average sign density. Graphical and tabular comparisons are presented.

Information load was defined as the total number of bits of information presented on all sign panels overhead of the main lanes on the freeway. The 50 percentile information load level was found to be 10 bits, the 85 percentile, 15 bits, and the 95 percentile level was determined to be 18 bits. Most of the high-bit level signs (those having bit rates in excess of 16 bits) were located in Texas. Out-of-state motorists have little or no driving experience with signs of 20 bits of information or greater.

Another signing variable compared between the Texas signing and the non-Texas systems was concurrent signing. A concurrent route is a highway having more than one route designation, that is, a concurrent highway has multiple route numbers. A dramatic finding of this evaluation was the tremendously large number of Interstate and concurrently marked U.S. routes found basically only in the Texas cities. There were 392 sign panels in the four Texas cities having Interstate-U.S. concurrent signing. Only one sign panel was observed to be similarly marked in 5 of the 6 out-of-state cities. Only Kansas City had concurrent signing like that found in Texas.

AASHTO's policy regarding concurrent signing was reviewed. AASHTO policy does not seem to support the continued signing of long (or unreasonably long) sections of the Interstate also as a U.S. numbered highway. Apparently, other states have responded to this policy by removing their concurrent signing, or have never used it initially.

Implementation

The Department seems justified in reducing the level of signing between major interchanges along urban freeways similar to I-10 in east Houston. Some improvements to the signing along westbound I-30 in Dallas are still possible and should be considered. Other findings of this study will be incorporated in the comprehensive freeway guide signing methodology to be developed at the conclusion of this research.

The Texas Department of Highways and Public Transportation seems justified in implementing a long-range program of systemmatically eliminating the redundant U.S. signing from most of the Interstate facilities within the state. The optimal program for achieving this objective would need to be developed but should prove successful and beneficial to the motoring public. The Interstate Business Loop routing system is widely utilized in the West and in some sections of Texas, and it could be used to guide out-of-state motorists between the Interstate and local businesses.

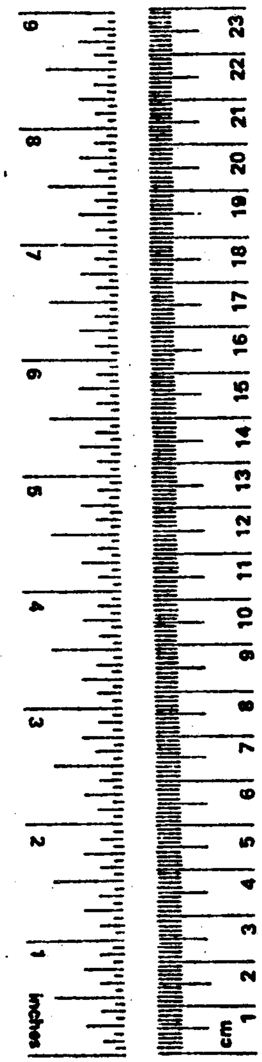
The Department has at least 15 overhead freeway guide signs in the state which have what must be considered excessive information loads on them. Efforts should begin to control the number of bits of information presented on guide sign structures and to reduce those having excessive signing.

Disclaimer

METRIC CONVERSION FACTORS

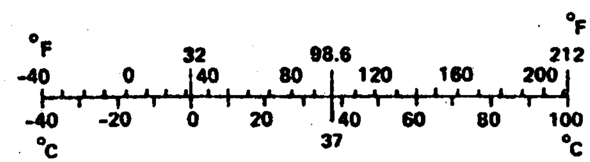
Approximate Conversions to Metric Measures

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



Approximate Conversions from Metric Measures

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



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

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SECTION A

OPERATIONAL STUDIES OF URBAN FREEWAY GUIDE SIGNING SYSTEMS

CHAPTER 1 - I-30 OPERATIONAL STUDIES IN DALLAS

SCOPE OF REPORT

This report contains the description, documentation and results of three studies conducted within this research effort. Two of the studies described in Chapter 1 and 2 were before-after types wherein the existing urban freeway guide signing was replaced or upgraded to a newer condition. One of these locations was in Dallas and the other in Houston. Each before-after study conducted will be described in detail. The third study to be described and reported in Chapter 3, was a limited scope study of the freeway accident experience of a select group of out-of-state motorists (from Nebraska) during the weekend of a recent Astro-Bluebonnet Bowl football game in Houston.

OBJECTIVE OF I-30 STUDY

Traffic operational field studies were conducted along I-30 in Dallas to determine what changes, if any, occurred in the traffic flow due to changes made in the freeway guide signing. Operational performance measures used to determine operational changes included lane volumes, lane changes and erratic maneuvers. The Before signing system had been in existence with few modifications since the freeway was constructed. The After signing system was installed during 1978 by State Department of Highways and Public Transportation.

LOCATION OF STUDY SITE

The study site was located along westbound I-30 (Interstate 30) near downtown Dallas. I-30 is the major east-west highway through downtown Dallas

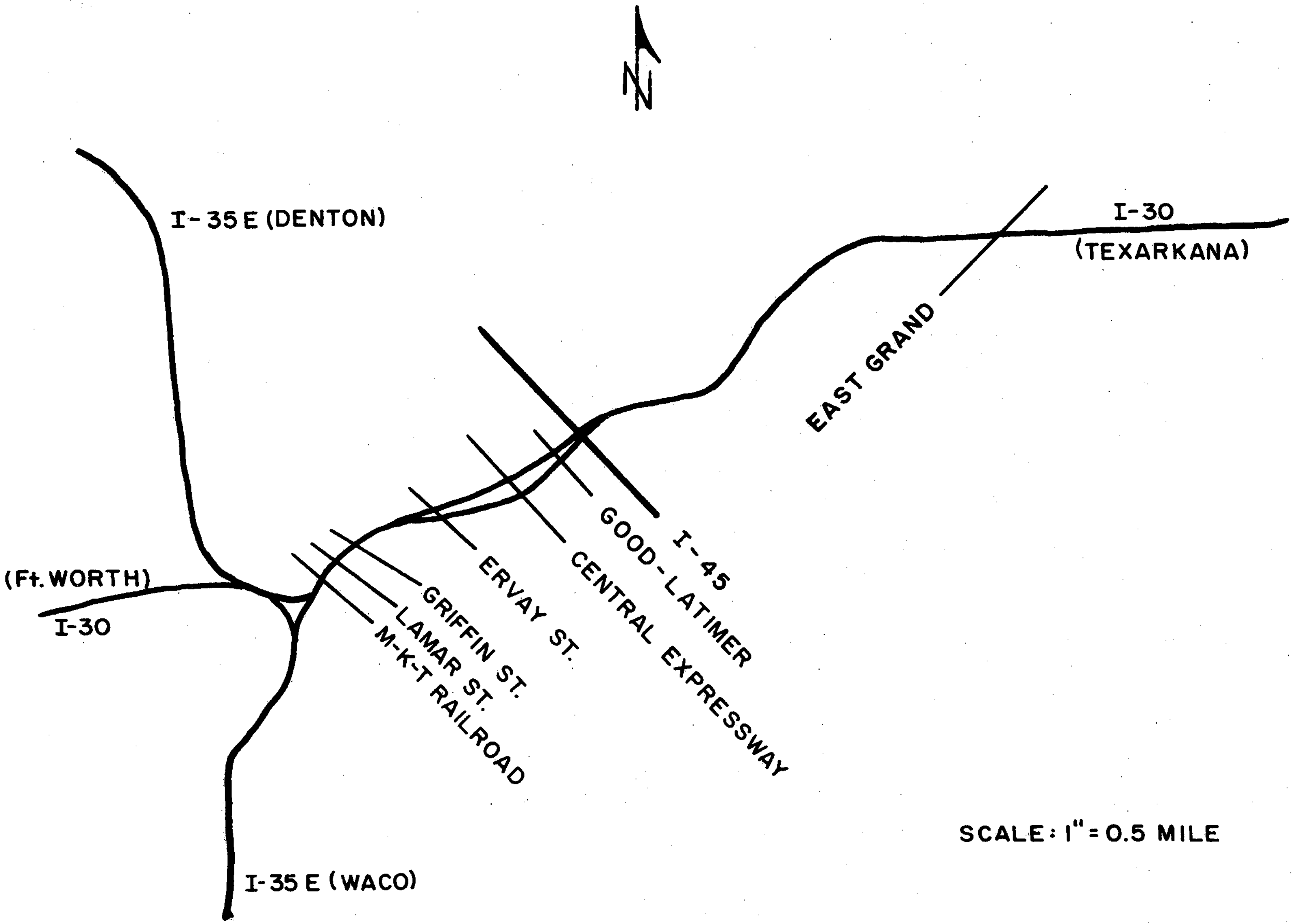


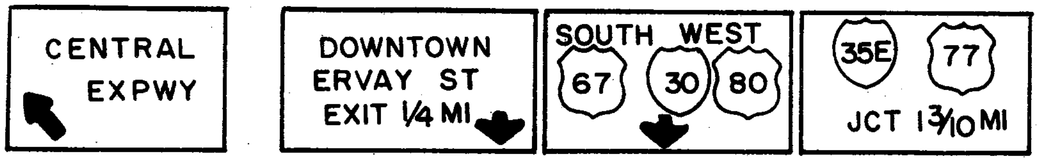
Figure 1-1. Study Area (I-30) in Dallas.

connecting Texarkana (and Shreveport to some extent) with Ft. Worth and points west. As depicted in Figure 1-1, the study section began at the Good-Latimer overcrossing and proceeded westbound past the M.K.T. railroad bridge to the I-35E interchange. The overall length of the study section was 1.2 miles long. The geometrics of this section of I-30 are basically a six-lane depressed freeway with parallel feeder roads in the depressed section. The feeder roads provide ramp connections from I-45 and U.S. 75 at Good-Latimer, and from Central Expressway upstream of Ervay Street. Thus, I-45 forms the eastern boundary and I-35E the western boundary with Central Expressway crossing near the middle of the study site.

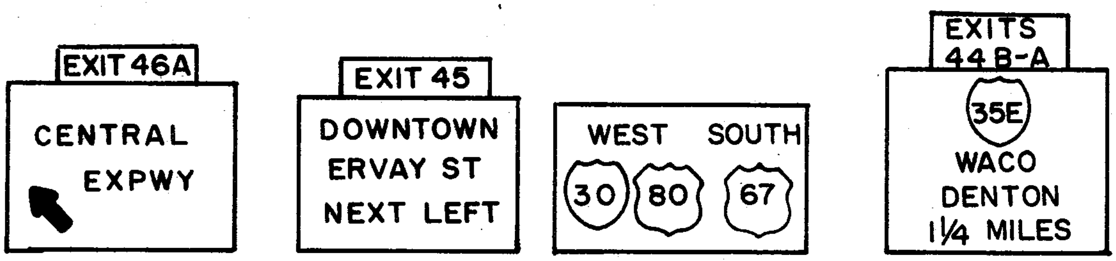
Before-After Signing

The new 1978 signing system included revised freeway guide signing from I-635 through downtown Dallas, a distance of about 10 miles. Most of the critical signing changes, however, were made in the study section. The before (1977) and after (1978) signing for the last locations approaching the I-35E interchange are presented in Figures 1-2 through 1-6.

Several factors complicate the signing demands within the study site. Three left hand exit ramps are located in the section at Central Expressway, Ervay Street and at Industrial Boulevard. The section also has concurrent freeway route numbers (I-30, U.S. 67 and U.S. 80). At the beginning of the study section, I-45 and U.S. 77 interchange with I-30 (interchange signing not shown) resulting in considerable merging and weaving traffic. Lastly, freeway motorists must travel through several overcrossing bridge structures and finally "pop-out" from the last one immediately at the gore junction with I-35E.

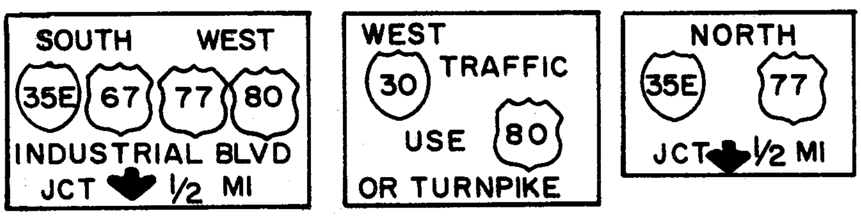


(a) 1977

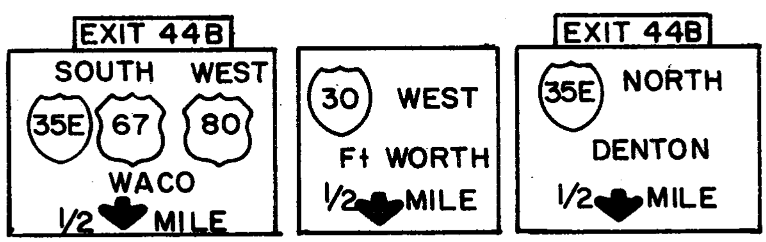


(b) 1978

Figure 1-2. Before-After Signing for Station 533+30.



(a) 1977



(b) 1978

Figure 1-3. Before-After Signing for Station 497+80.

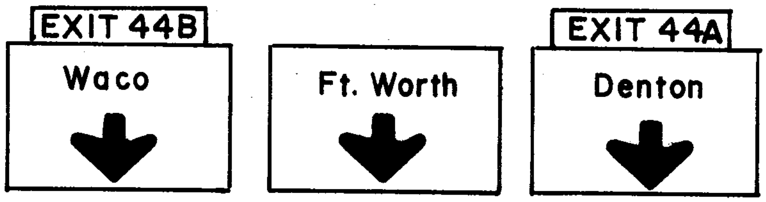
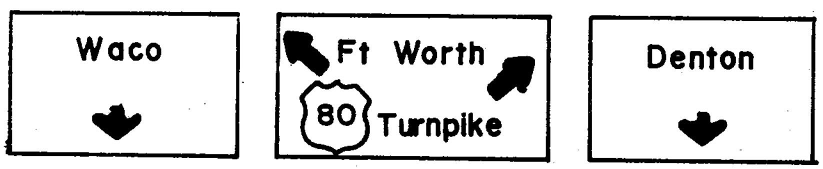
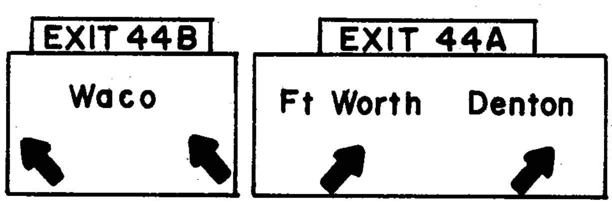


Figure 1-4. Signing for Station 487+40 Unchanged Except for Adding Exit Numer Panel.



(a) 1977



(b) 1978

Figure 1-5. Before-After Signing for Station 476+20.

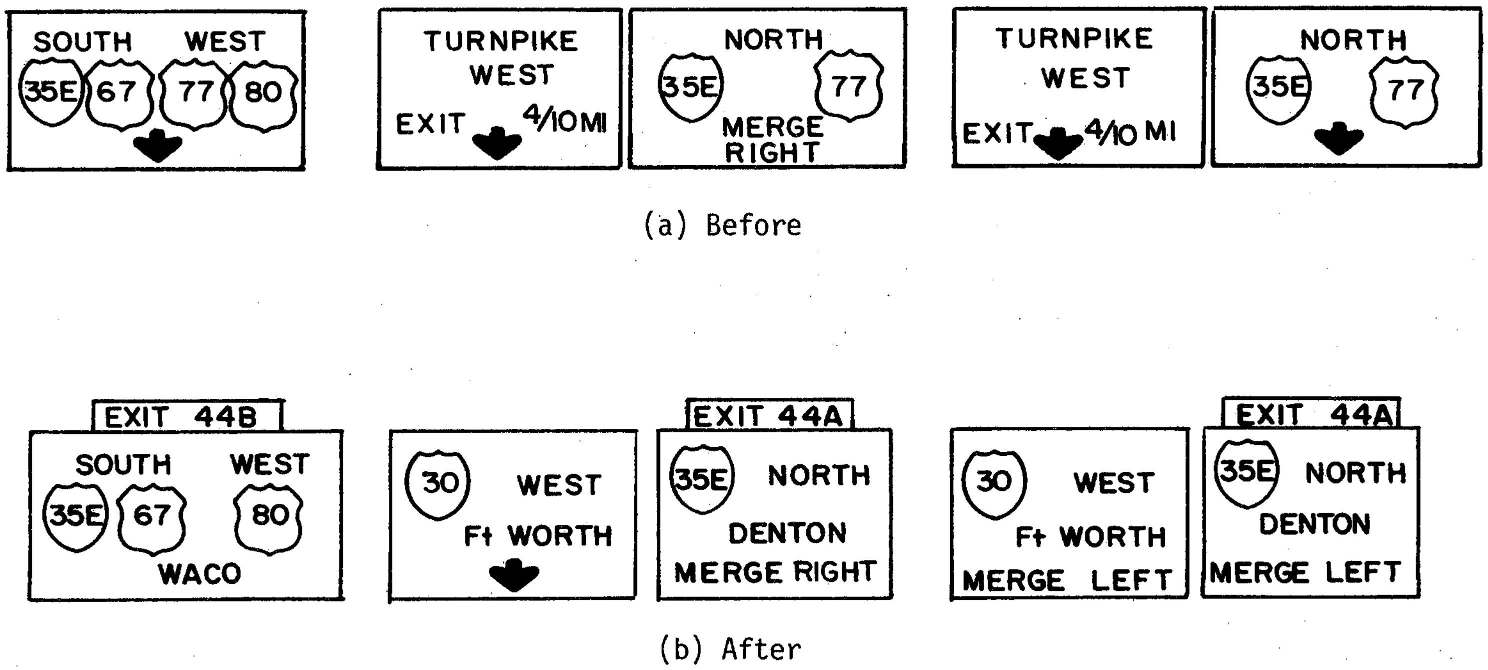


Figure 1-6. Before-After Signing of I-35E Interchange at Station 467+10.

In the Before signing system, additional complexities existed which were alleviated to a considerable extent when the new system was installed. During the Before study, I-30 ended at the I-35E junction and westbound traffic toward Ft. Worth had to switch to a "Turnpike" designation. So that a westbound "free route" was marked, U.S. 80 was emphasized (see Figure 1-3) toward the I-35E interchange. Westbound unfamiliar motorists thus were likely to be confused, surprised and uncertain as they arrived at the I-35E junction due to the optional westbound routes marked.

The After signing system was able to take advantage of several significant events. When the Dallas-Ft. Worth Turnpike became a free road on January 1, 1978, it could then be signed as I-30 to Ft. Worth. This continuation of I-30's route designation through the I-35E interchange undoubtably aided westbound motorist understanding and route following capabilities. This is in addition to the elimination of uncertainty for westbound motorists as to whether a toll road versus a free road should be taken in the first place. In addition, an unknown amount of westbound I-20 (Shreveport) traffic now is being (since 1977) diverted around the south freeway loop of Dallas (I-20 and I-635) to Ft. Worth. This has also helped reduce the number of unfamiliar motorists approaching the I-35E junction.

Study Methodology

To determine if any detectable operational changes had occurred that might be attributed to the new signing system, a relatively large scale field study was conducted. To make this determination, changes in lane volume distribution, lane changing and erratic maneuvers were observed at selected locations.

Several methods were used to record the operational data. A study team of 10 individuals was employed to observe traffic operations. Six members made manual traffic volume counts by lane at the Good-Latimer, Griffin and Lamar Streets bridges. Lane volumes and lane changes were recorded using a portable television video recording system at the Ervay St. bridge as shown in Figure 1.7. A similar video recording system was operated by two people at the M.K.T. railroad bridge adjacent to the I-35E interchange as shown in Figure 1-8.

Data recording was coordinated by the Study Supervisor using walkie talkies for communication to each location. Personnel at each manual count station made cumulative counts each five minutes beginning on the hour or half hour as appropriate. One person counted vehicles in the median lane, and the other counted vehicles in the middle and outside lane. Lane volume counts were tabulated from the video recordings made at Ervay St. and M.K.T. railroad bridge at a later date.

The Ervay St. video recordings were the only source of lane changing data. It was speculated during the formulation of the study design that this freeway location might experience a significant increase in land changing maneuvers (See Figures 1-2 and 1-3) if traffic literally followed the "Waco" advance guide signing and drifted into the right lane.

Erratic maneuvers were studied at the junction of I-30 and I-35E at the M.K.T. railroad bridge (Figure 1-8) with another video recorder. These maneuvers were classified as to their severity in three different classifications. These classifications were: (1) minor gore penetration, (2) heavy gore penetration, and (3) situations where the driver completely missed his route and backed up the shoulder to change directions. The total number of

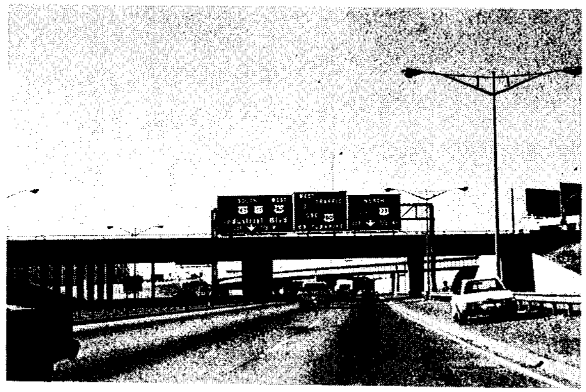


Figure 1-7. Ervay St. Location and View of Signing At The Weaving Area.

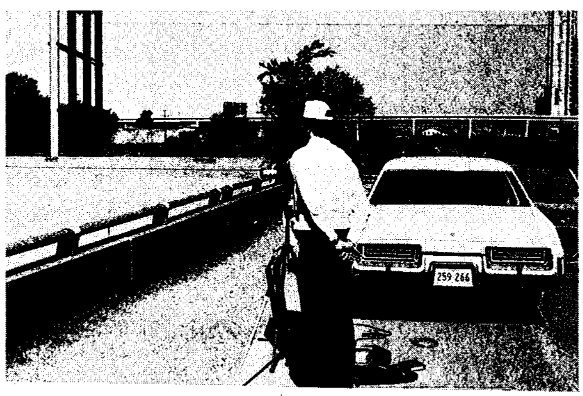


Figure 1-8. Video Recording Unit Used At M.K.T. Railroad Bridge Location.

erratic maneuvers were counted and each maneuver was classified with this three-class scheme.

The Before studies were conducted primarily on Friday, April 8, 1977 from 2:30-4:30 p.m. and on Saturday, April 9, 1977 from 9:00-11:00 a.m. Additional time was taken to start-up and close-out the studies. One hour of additional data was taken on Tuesday, April 12, 1977 to complete the study due to a malfunction of a video recorder the previous Friday.

The After studies were conducted on Friday, April 6, 1979 and on Saturday, April 7, 1979 at the same times as the Before studies. The after studies were conducted without major incident. The weather was good during both studies.

RESULTS

Study results were obtained for lane volume distributions, lane changing and erratic maneuvers. The results will be discussed in the order described. It is to be noted that the erratic maneuver data contains the more important findings.

Lane Volume Distributions

Traffic volume counts by lane were converted into percentages of total flow to discount the effects of possible variations in the general volume levels between the Before and After studies. The resulting lane distributions calculated for each location are presented in Tables 1-1 and 1-2. Table 1-1 presents the Before results; Table 1-2 gives the corresponding After results.

Two findings can be determined from these tables. First a fairly consistent trend toward increasing volumes in the shoulder lane (lane 3) at Ervay St. are noted during the After study over the four 1-hour study periods. A chain sequence of the highest percent lane 3 volume level (of total volume) of either

Table 1-1. Lane Distributions in Percent on I-30 in Dallas During Before Study.

Study Time	Study Locations	Lane 1 (Median)	Lane 2 (Middle)	Lane 3 (Shoulder)
2:30 - 3:30 p.m.	Good-Latimer	31.1	44.1	24.8
	Ervay	29.9	37.9	32.1
	Griffin	35.5	33.5	31.0
	Lamar	35.0	32.5	32.5
	M.K.T. Bridge	33.4	12.2 20.6	33.8
3:30 - 4:30 p.m.	Good-Latimer	32.8	45.2	22.0
	Ervay	30.3	36.7	33.0
	Griffin	36.5	34.4	29.1
	Lamar	37.4	31.4	31.2
	M.K.T. Bridge	34.6	13.5 19.5	32.3
9:30 - 10:30 a.m.	Good-Latimer	30.6	45.9	23.5
	Ervay	27.2	40.0	32.8
	Griffin	32.1	38.8	29.1
	Lamar	32.6	36.2	31.2
	M.K.T. Bridge	31.5	15.8 20.6	32.1
10:30 - 11:30 a.m.	Good-Latimer	29.6	44.8	25.6
	Ervay	24.0	40.2	35.9
	Griffin	31.3	38.1	30.6
	Lamar	33.1	34.6	32.3
	M.K.T. Bridge	31.1	16.4 18.7	33.8

Table 1-2. Lane Distributions in Percent on I-30 in Dallas During After Study.

Study Time	Study Locations	Lane 1 (Median)	Lane 2 (Middle)	Lane 3 (Shoulder)
2:30 - 3:30 p.m.	Good-Latimer	33.4	42.4	24.2
	Ervay	25.9	33.2	40.9
	Griffin	33.0	36.8	30.2
	Lamar	32.4	35.7	31.9
	M.K.T. Bridge	27.7	10.6 27.1	34.6
3:30 - 4:30 p.m.	Good-Latimer	36.9	42.1	21.0
	Ervay	31.4	28.6	40.0
	Griffin	37.0	35.2	27.8
	Lamar	35.5	33.7	30.8
	M.K.T. Bridge	31.9	11.0 25.3	31.8
9:30 - 10:30 a.m.	Good-Latimer	30.0	46.3	23.7
	Ervay	23.0	36.8	40.2
	Griffin	28.2	39.7	32.1
	Lamar	30.3	37.7	32.0
	M.K.T. Bridge	28.6	10.7 25.3	35.4
10:30 - 11:30 a.m.	Good-Latimer	28.4	48.5	23.1
	Ervay	22.4	37.4	40.2
	Griffin	29.3	40.5	30.2
	Lamar	30.5	38.9	30.6
	M.K.T. Bridge	29.6	11.7 26.9	31.8

Before (B) or After (A) study by 1-hour time periods illustrates this point as shown below.

Starting Time	Study Locations G-L	E	G	L	M
2:30 p.m.	B	A	B	B	A
3:30 p.m.	B	A	B	B	B
9:30 a.m.	A	A	A	A	A
10:30 a.m.	B	A	B	B	B

B = lane 3 highest in Before study

A = lane 3 highest in After study

G-L = Good-Latimer

E = Ervay St.

G = Griffin

L = Lamar

M = M.K.T. Bridge

Of the 9 cases where lane 3 lane volume distribution percentages increased, 4 were at Ervay St. In all cases, the percent of traffic rose between the Before and After studies. Since I-45 opened on February 24, 1976, traffic volumes have been rising on I-45 and this may have caused some of the increased lane utilization of lane 3 at Ervay St. The median lane (lane 1) shows a rather consistent reduction in the percent of the total traffic using it between the two studies.

Similar comparisons of the four 1-hour lane volume distributions at the Lamar St. and M.K.T. (at I-35E) bridges show increasing concentrations of traffic in the middle lane (lane 2) during the After study as compared to heavier traffic found in the outer lanes in the Before study. An analysis of the middle lane (lane 2) traffic at the I-35E split in all four 1-hour samples reveals that a greater percentage of traffic is now headed toward Ft. Worth on I-30 than toward Waco on I-35E.

Lane Changing

The lane changing portion of the studies was conducted between Ervay St. and Akard St. as traffic approached the signing shown in Figure 1-3. Traffic also was merging and weaving onto I-30 from I-45 and U.S. 75 from the right at the beginning of the study section. The lane changing study results are presented in Table 1-3 for the Before and After studies.

The data show that the percentage of total lane changing increased slightly from right-to-left, but only from lane 3 to lane 2. No change in lane changing from left-to-right was observed.

Overall, a 28% drop in lane changing was observed in the section between the Before and After studies. The largest percentage reduction consistently was right-to-left from lane 2 to lane 1 (median lane). These reductions were caused primarily by a reduction in multiple lane maneuvers due to the change in status of the Dallas-Ft. Worth Turnpike to I-30 resulting in less utilization of the median lane (lane 1) to Waco on I-35E, or perhaps west on U.S. 80.

Erratic Maneuvers

The erratic maneuver portion of the studies along I-30 at the I-35E interchange was videotaped from the M.K.T. railroad bridge. Figures 1-9, 1-10 and 1-11 show photographs of the site and erratic maneuvers observed during the Before study in April 1977. The results of the Before and After studies are presented in Table 1-4 for three levels of erratic maneuver severity: 1 = minor painted gore penetration, 2 = major painted gore penetration, and 3 = missed route and back-up. Figures 1-10 and 1-11 illustrate the occurrence of a level 3 erratic maneuver observed during the Saturday morning Before study.

The data presented in Table 1-4 indicate the following results. The frequency of erratic maneuvers is about the same in the Before and After

Table 1-3. Weaving Counts and Percentage of Total Weaving on I-30 in Dallas During Before and After Studies.

Time of Study	Weaving or Percent	Weaving Direction: Left-to-Right, From Lane 1 To Lane 2	Left-to-Right, From Lane 2 To Lane 3	Right-to-Left, From Lane 2 To Lane 1	Right-to-Left, From Lane 3 To Lane 2
1 - 3 p.m.					
	Weaving				
	Before*	120	186	543	761
	After	94	139	353	667
	%				
	Before	7.5	11.6	33.7	47.2
	After	7.5	11.1	28.2	53.2
9:30 - 11:30 a.m.					
	Weaving				
	Before+	89	135	558	848
	After	53	90	301	643
	%				
	Before	5.5	8.3	34.2	52.0
	After	4.9	8.3	27.8	59.0
Totals					
	Weaving				
	Before	209	321	1101	1609
	After	147	229	654	1310
	%				
	Before	6.4	9.9	34.0	49.7
	After	6.3	9.7	28.0	56.0

*P.M. Study dates: 4/8/77 and 4/12/77

+A.M. Study date: 4/9/77

Figure 1-9. I-35E Junction With I-30 In Dallas.

Figure 1-10. Vehicle Backing On The Gore At I-35E Location.

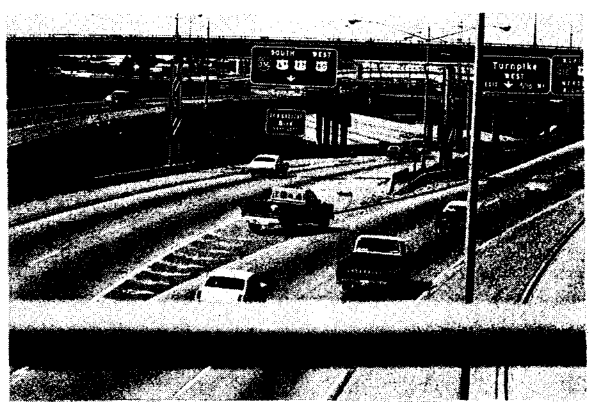


Figure 1-11. Vehicle Changing Direction At I-35E Location.

cases. A total of 79 were observed in the Before study and 73 in the After study. The directional distribution of erratic maneuvers (to right or to left) also remained about the same. However, the severity of erratic maneuvers is much lower in the After study. A total of 18 vehicles were observed during the Before study to make some type of back-up at the I-35E junction to correct their route choice. Not one case of a missed route and back-up was observed during the After study. It is recalled that most of the back-ups were of the left-to-right (Waco to Ft. Worth-Denton) variety. Also shown in Table 1-4 is a 36% reduction in level 2 erratic maneuvers (from 28 to 18). The big reduction occurred on Friday afternoon. During the After study, some increase occurred in the least severe erratic maneuver category (slight gore penetration). Overall, the severity of erratic maneuvers was reduced but remains higher than desired, especially in view of the 13 level 2 erratic maneuvers observed on Saturday morning.

Discussion

It would appear that the impact of converting the Dallas-Ft. Worth Turnpike into a free road (I-30) had a beneficial impact on traffic operations in the study area and explains much of the changes in traffic phenomena observed between the Before and After studies. This finding was not an intended study objective, as initially formulated, but seems to have occurred based on the study results. However, the new signing system appears to be directing traffic adequately into the appropriate lanes as they approach the I-35E interchange. Improvements to the signing system are still needed, however.

A discussion of the basis for these findings follows. Traffic approaching the I-35E junction in the median (lane 1) and shoulder (lane 3) lanes during the Before study was higher in 7 out of 8 cases than in the After study.

Table 1-4. Erratic Maneuvers on I-30 in Dallas at I-35E Interchange During Before and After Studies.

Time of Study	Severity Classification						Direction			
	Least Severe 1		2		Most Severe 3		To Right		To Left	
	B	A	B	A	B	A	B	A	B	A
P.M.										
2:30-3:00	6	6	5	1	4	0	7	3	3	4
3:00-3:30	6	6	4	2	3	0	4	7	7	1
3:30-4:00	2	6	7	2	2	0	8	3	6	5
4:00-4:30	5	8	3	0	3	0	10	2	5	6
	19	26	19	5	12	0	29	15	21	16
A.M.										
9:30-10:00	4	3	2	3	1	0	4	3	3	3
10:00-10:30	3	7	2	5	1	0	3	7	4	5
10:30-11:00	3	11	3	3	2	0	3	9	3	5
11:00-11:30	4	8	2	2	2	0	4	8	5	2
	14	29	9	13	6	0	14	27	15	15
Totals	33	55	28	18	18	0	43	42	36	31

B = Before, A = After

The probability for not being able to make a lane change from the median or shoulder lanes after clearing the M.K.T. railroad bridge at the junction was (and still is) low. On the other hand, more traffic during the After study generally was observed in the middle lane at the I-35E junction and headed toward Ft. Worth, thus reducing the need for a lane change and seemingly explaining why minor gore penetrations (level 1), in particular, were higher in the After study (55 to 33). Following this line of reasoning, the one case where lower volumes in the middle lane (lane 2) were observed during the After study (9:30-10:30 a.m. on Saturday in Table 1-2) also includes the one exception to lower level 1 erratic maneuvers at the I-35E interchange (9:30-10:00 a.m. in Table 1-4).

CONCLUSIONS

Traffic operations through the westbound section of I-30 from I-45 to I-35E are improved over those existing during 1977. The reasons for this improvement likely are due 1) to improved route design of I-30 through Dallas and 2) to the new freeway route guide signing system installed.

Some operational problems remain and should be treated. Excessive traffic now desires to use the outside lane (lane 3) at Ervay street (connection of I-45 with I-30). A large frequency of erratic maneuvers still occurs at the I-35E junction indicating continued route guidance and tracking problems. Further treatment of this problem should be implemented.

RECOMMENDATIONS

Several improvements to the new signing system are recommended for immediate consideration by SDHPT for westbound I-30 in Dallas. The modifications recommended based on this study are:

1. Add a post mounted median sign at Grand Avenue giving mileage to I-45 and U.S. 75 as well as to I-35E.
2. Redesign (or eliminate) the I-30 "pull thru" sign at Fair Park to be consistent with the others.
3. Eliminate I-30 "pull thru" at Central Expressway, (Figure 1-2) and enlarge I-35E advance guide sign. Move enlarged sign to middle lane.
4. Close gap in triple overhead guide sign (Figure 1-3) at Akard St. to improve readability.
5. Replace both sets of overhead destination signs at Griffin St. (Figure 1-4) and at M.K.T. (or Rock Island) railroad bridge (Figure 1-5) with the route numbers and destination names together with lane assignment arrows. Waco and Denton are <u>not</u> familiar names to out-of-state motorists and mean little to them. In a laboratory study it was determined that only 25% of the motorists key on control city information, whereas 50% of the motorists key on both control city and destination route information. By including both types of information the erratic maneuvers will be reduced. Visual coding of the "pull thru" sign at Akard St. (Figure 1-3) is misleading and should be corrected and then reinforced at Griffin and M.K.T. The visual coding, by using lane assignment arrows, has a significant effect on both lane placement and erratic maneuvers. If the lane assignment arrows are not properly located the motorist will not be in a position

to make the required response and erratic maneuvers will result.

6. The visual scene through the M.K.T. (or Rock Island) railroad bridge approaching I-35E should be improved to the extent feasible. The daytime lighting inside the tunnel should be increased. In fact, the SDHPT should determine the feasibility of removing the last 50 feet of the bridge deck of the overpass structure. The sooner motorists can see the I-35E interchange, the better.

7. The signing along this section should be above standard due to the geometrics involved throughout this study site. Erratic maneuvers will not be reduced any further without using above standard signing because of the restrictive sight distance around the Lamar Street and M.K.T. railroad bridge.

CHAPTER 2

I-10 STUDY IN HOUSTON

OBJECTIVE OF I-10 STUDY

The objective of this operational study was to determine if the changes in the overhead freeway guide signing on a freeway in Houston would significantly affect traffic flow as measured by lane distribution and lane changing. Three primary changes were to be made in upgrading the signing to the new 1970 MUTCD standards. These were 1) elimination of thru traffic lane assignment arrows, 2) reduction in the use of "pull-thru" signs, and 3) elimination of pull-thru signs. Other changes to the signing also were made during the upgrading program such as adding additional exit numbers, converting from 1/10 to 1/4 mile exiting distances, adding EXIT ONLY panels where appropriate, etc. However, in the section studied, the latter changes should have had little or no impact on the study.

LOCATION OF STUDY SITE

The urban freeway studied was eastbound I-10 in Houston extending about four miles from immediately east of the U.S. 59 interchange near downtown Houston to near the east loop of I-610. This section of the Interstate System is an 8-lane freeway section having both depressed and elevated bridge sections. The freeway is the major east-west traffic facility through Houston connecting San Antonio with Beaumont, New Orleans, and points east.

Two contiguous study locations were evaluated along I-10. Section A contained three overhead sign bridges having similar features. The three sign bridge structures existing during the Before study are presented in Figure 2-1 in sequence from the top of the figure as they appeared along the

(a)

(b)

(c)

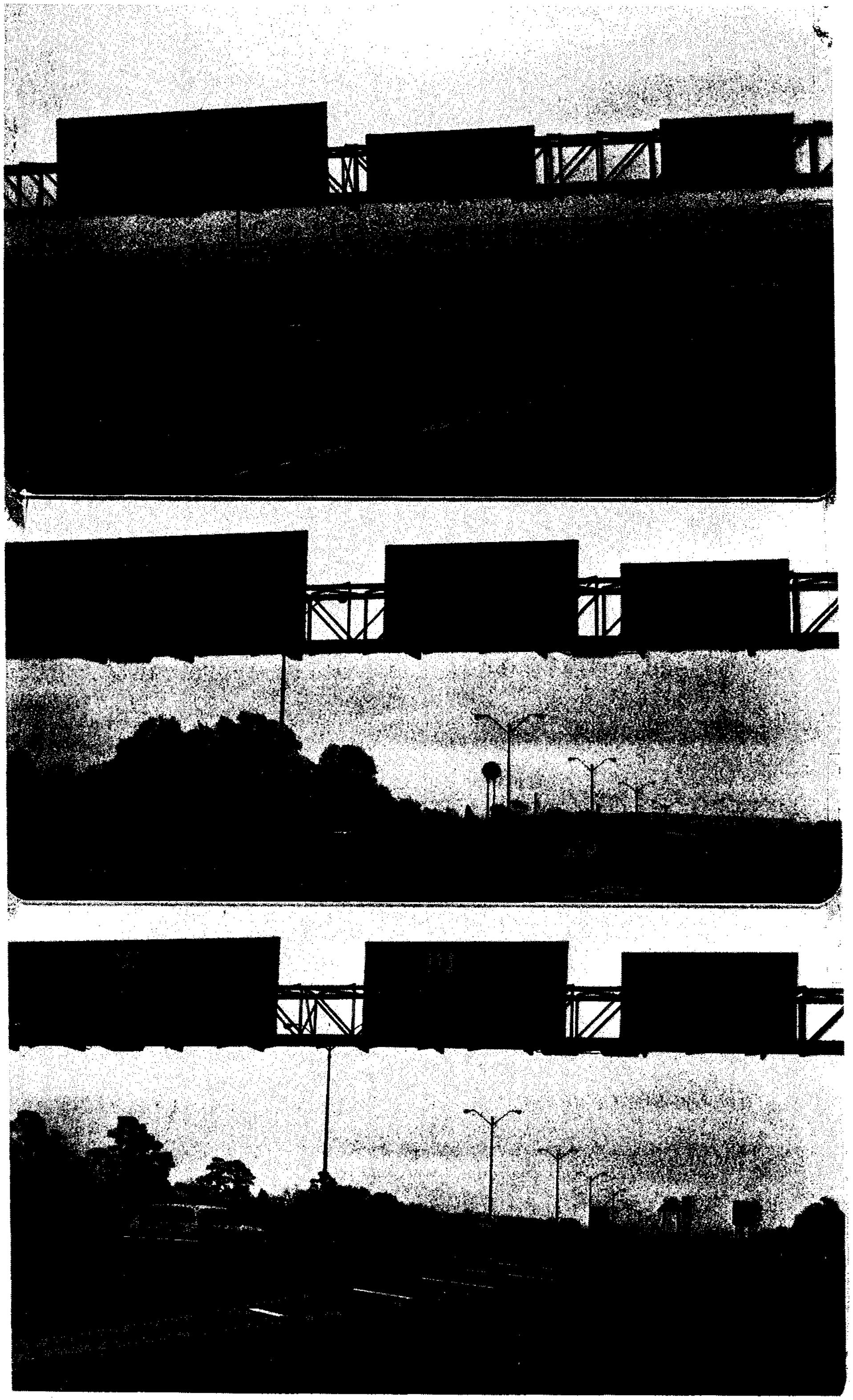


Figure 2-1. Sequence of Three Existing Overhead Sign Structures Along Section 'A' of I-10 in Houston.

freeway. Figure 2-2 illustrates the primary changes that were made during the latter half of 1977 in Section 'A' between the Before and After signs. Research existed to determine the effects that eliminating the lane assignment and "pull-thru" signs (Beaumont signs) might have on lane volume distribution along this section.

The adjacent downstream freeway study section, Section 'B', has two overhead sign bridge structures and was thought that it might have different operational response characteristics after the new signs were installed during 1977. The two sign structures existing during the Before study are presented in Figure 2-3 and the principal before and after signing being studied is shown in Figure 2-4. Research arose as to whether the existing "pull-thru" signs (Beaumont signs) were causing any (or excessive) land usage or lane changing to occur and whether any noticeable lane usage changes would occur after the two pull-thru signs were removed.

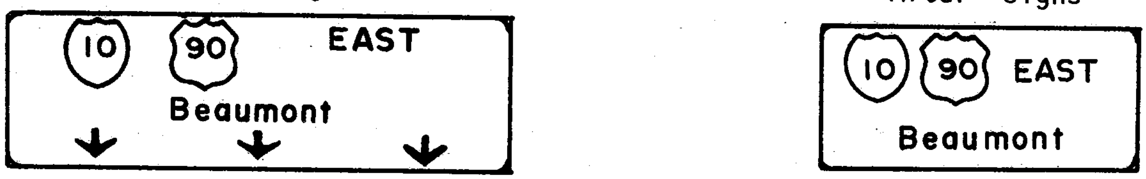
STUDY METHODOLOGY

After investigating and evaluating the existing site characteristics, it was decided to collect lane volume counts in advance of and following the five sign bridges. A combination of manual and videotape data collection methods were simultaneously employed. Manual counts were conducted at four locations using two people at each location. Two portable video recording camera systems were installed on an overhead pedestrian bridge crossing in Section B and lane volume counts were recorded at four freeway locations. The television study setup is show in Figure 2-5.

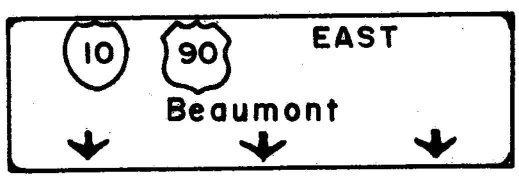
The Before volume counts were conducted on Friday, January 21, 1977 from 2-4 p.m. and on Saturday, January 22, from 9-11 a.m. The after study was conducted on Friday, March 10, 1978 and on Saturday, March 11, 1978

"Before" Signs

"After" Signs



(a) Sign Bridge No. 1 at Sta. 539+40



(b) Sign Bridge No. 2 at Sta. 569+90

(c) Sign Bridge No. 3 at Sta. 602+00

Figure 2-2. Before and After Signs Along Section 'A' of I-10 in Houston.

(a)

(a) Sign Bridge No. 4 at Sta. 651+85

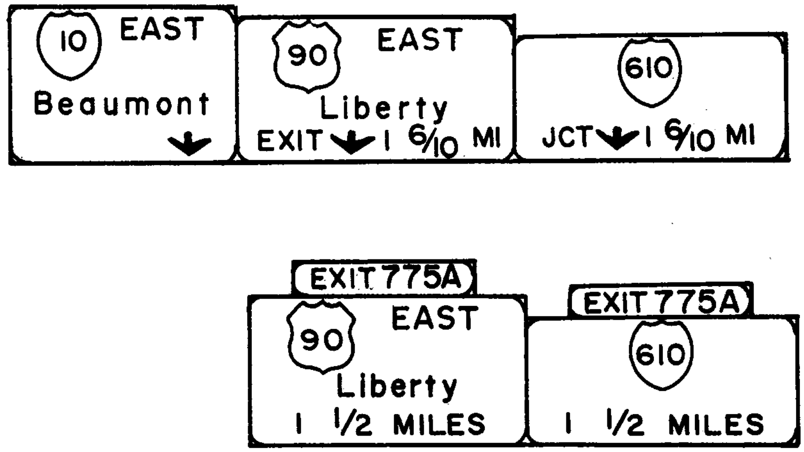
(b)

(b) Sign Bridge No. 5 at Sta. 678+60

Figure 2-3. Sequence of Two Existing Overhead Sign Structures Along Section 'B' of I-10 in Houston.

"Before" Signs

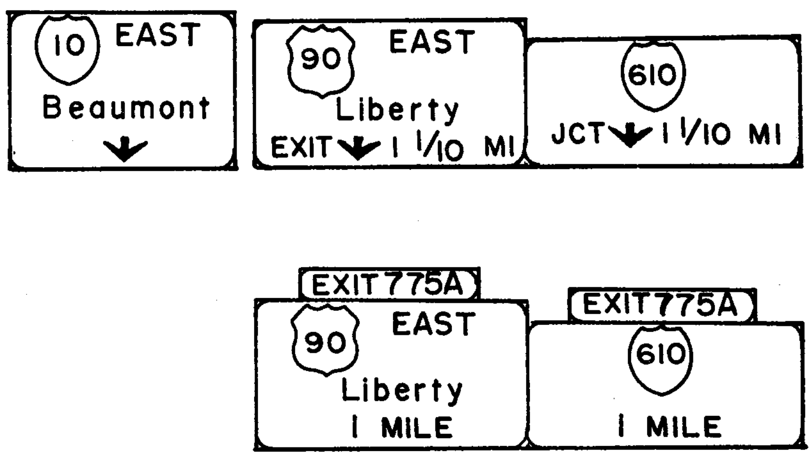
"After" Signs



(a) Sign Bridge No. 4 at Sta. 651+85

"Before" Signs

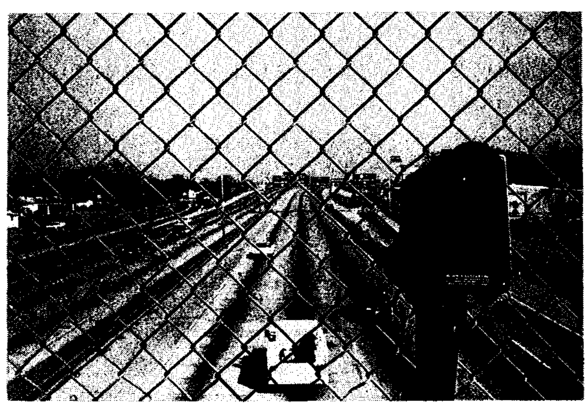
"After" Signs



(b) Sign Bridge No. 5 at Sta. 678+60

Figure 2-4. Before and After Signs Along Section 'B' of I-10 in Houston.

(a) Camera #1 view looking west toward downtown Houston



(b) Camera #2 view looking east toward Sign Bridge No. 4

Figure 2-5. Television Recording Station on Pedestrian Bridge Upstream of First Sign of Section 'B'.

due to inclement weather during January 1978. Volume counts were made for five minute intervals and summarized to hourly volumes. Weather conditions were favorable during the studies and traffic flow was not disturbed during the traffic counting period. Walkie-talkies were used to coordinate the times traffic volumes were counted. The videotape data were recorded on-site and were manually reduced at a later date.

STUDY RESULTS

Traffic operational performance measures studied included traffic volume distributions by lane, lane changes and volume flow maps. Sections 'A' and 'B' initially were analyzed separately due to differences in expected operations and data collection methodologies.

Lane Volume Distribution

Traffic volume counts by lane were converted into percentages of the total count (lane distribution) to discount the effects of volume variations between the Before and After studies. Before and After lane distribution results will be presented individually before comparisons of results are made.

Before Study. Table 2-1 presents the lane volume distribution percentages for the Before study conducted on Section 'A' (See Figure 2-2). Traffic volume percentages were light in the median lane (lane 1) at McLeary upstream of the first sign bridge (Figure 2-1) and volumes were heaviest in the shoulder lane (lane 4) due to a previous left-hand exit to U.S. 59 and a right-hand entrance from U.S. 59 immediately upstream of the beginning of the study. It is noteworthy to observe that traffic usage of all lanes rapidly becomes more balanced as the traffic moved by the Scheikhart, Callas and Lathrop count locations, the Lathrop location being downstream of the last overhead sign bridge in Section 'A'. A major difference existed in the input lane volume distribution at McLeary

Table 2-1. Lane Distributions in Percent Along Section 'A' of Eastbound I-10 in Houston During Before Study.

Time, Location	Lane 1 (Median)	Lane 2	Lane 3	Lane 4 (Shoulder)
2 - 3 p.m.				
McLeary	13.2	23.3	29.1	34.3
Scheikhart	18.8	26.4	26.9	28.0
Callas	20.1	26.3	27.6	25.9
Lathrop	21.2	27.7	26.9	24.2
3 - 4 p.m.				
McLeary	15.7	22.8	29.5	32.0
Scheikhart	22.3	26.3	25.2	26.2
Callas	23.6	26.2	26.6	23.6
Lathrop	23.9	28.1	25.6	22.4
9 - 10 a.m.				
McLeary	8.6	24.2	32.0	35.3
Scheikhart	11.2	27.1	31.6	30.1
Callas	13.4	28.9	32.2	25.5
Lathrop	14.4	27.2	28.9	29.4
10 - 11 a.m.				
McLeary	8.7	27.5	30.8	33.0
Scheikhart	13.1	26.9	31.9	28.1
Callas	15.4	28.4	29.7	26.6
Lathrop	17.0	29.5	28.1	25.4

between Friday and Saturday. This difference is attributed to the differences in the overall origin-destination pattern of the traffic for the two days and to different volume levels.

Table 2-2 presents the lane volume distribution percentages for Section 'B' of eastbound I-10. The overall distance between the Lathrop and Sign East count stations is one-fourth mile which would include initial driver responses to the first sign bridge of Section 'B'. The subsequent distance downstream to the McCarty count station is three-fourths of a mile. In general, Table 2-2 shows that traffic usage of all lanes was more uniform during these heavier volume conditions and that the median lane (lane 1) was not heavily used during lighter traffic (9:00-11:00 a.m. on Saturday). Lane 3, which is the principal lane used for traffic bound for I-610, experienced the highest usage at the McCarty count station during the Before study.

After Study. Table 2-3 presents the lane volume distribution results of the After Study conducted on Section 'A'. While a lower percentage of the total traffic remained in the median lane (lane 1) at McLeary than in the other three lanes, a more uniform balance of traffic was approaching the study section than in the Before study. This may have been due to changes in origin-destination patterns due to freeway construction on the North Loop (I-610) and on U.S. 59 during the studies.

Table 2-4 gives the After study results for Section 'B'. A higher utilization of the median lane (lane 1) existed at the beginning of Section 'B' than exited Section 'A', but the percentage of traffic using the median lane dropped as the McCarty count station (and the I-610 interchange) approached.

Comparisons. Since it was apparent that a highly unbalanced traffic flow distribution existed at the beginning of the study section at McLeary, a comparison

Table 2-2. Lane Distributions in Percent Along Section 'B' of Eastbound I-10 in Houston During Before Study.

Time, Location		Lane 1 (Median)	Lane 2	Lane 3	Lane 4 (Shoulder)
2 - 3 p.m.	Lathrop	21.2	27.7	26.9	24.2
	Ped. West	22.5	27.9	27.6	22.0
	Ped. East	21.6	27.9	28.4	22.2
	Sign East	21.9	28.2	28.3	21.6
	McCarty	19.2	27.6	32.5	20.7
3 - 4 p.m.	Lathrop	23.9	28.1	25.6	22.4
	Ped. West	23.8	28.6	26.0	21.7
	Ped. East	24.1	27.3	26.6	22.0
	Sign East	24.0	28.5	25.9	21.6
	McCarty	21.0	27.4	32.4	19.3
9 - 10 a.m.	Lathrop	14.4	27.2	28.9	29.4
	Ped. West	14.4	27.7	29.9	28.0
	Ped. East	15.5	29.5	30.5	24.5
	Sign East	15.5	29.6	29.6	25.3
	McCarty	18.0	30.6	30.9	20.5
10 - 11 a.m.	Lathrop	17.0	29.5	28.1	25.4
	Ped. West	16.8	29.9	28.5	24.8
	Ped. East	16.7	28.5	30.3	24.5
	Sign East	17.2	28.7	30.6	23.5
	McCarty	18.5	28.4	32.4	20.7

Table 2-3. Lane Distributions in Percent Along Section 'A' of Eastbound I-10 in Houston During After Study.

Time, Location	Lane 1 (Median)	Lane 2	Lane 3	Lane 4 (Shoulder)
<u>2 - 3 p.m.</u>				
McLeary	16.5	26.3	29.4	27.8
Scheikhart	17.9	25.5	28.2	28.4
Callas	20.3	28.2	27.0	24.5
Lathrop	21.8	28.1	27.4	22.7
<u>3 - 4 p.m.</u>				
McLeary	21.5	27.3	23.3	27.9
Scheikhart	21.6	26.6	25.9	25.9
Callas	23.6	27.5	25.3	23.6
Lathrop	24.1	27.4	24.8	23.7
<u>9 - 10 a.m.</u>				
McLeary	11.4	25.0	29.2	34.4
Scheikhart	12.9	28.9	31.4	26.8
Callas	14.8	29.4	30.9	24.9
Lathrop	16.3	28.0	29.8	25.9
<u>10 - 11 a.m.</u>				
McLeary	12.6	25.5	30.5	31.4
Scheikhart	13.3	27.4	30.8	28.5
Callas	14.6	28.9	30.5	26.0
Lathrop	16.6	30.0	28.3	25.1

Table 2-4. Lane Distributions in Percent Along Section 'B' of Eastbound I-10 in Houston During After Study.

Time, Location		Lane 1 (Median)	Lane 2	Lane 3	Lane 4 (Shoulder)
2 - 3 p.m.	Lathrop	21.8	28.1	27.4	22.7
	Ped. West	22.4	27.4	27.0	23.2
	Ped. East	23.0	28.1	28.1	20.8
	Sign East	23.0	27.7	27.8	21.5
	McCarty	20.9	34.0	24.0	21.1
3 - 4 p.m.	Lathrop	24.1	27.4	24.8	23.7
	Ped. West	24.5	28.0	25.6	21.9
	Ped. East	24.9	27.5	26.2	21.4
	Sign East	24.5	27.7	26.6	21.2
	McCarty	20.9	30.5	25.6	23.0
9 - 10 a.m.	Lathrop	16.3	28.0	29.8	25.9
	Ped. West	16.5	28.7	29.6	25.2
	Ped. East	16.1	29.4	30.6	23.9
	Sign East	16.2	30.2	31.2	22.4
	McCarty	14.3	30.2	34.0	21.5
10 - 11 a.m.	Lathrop	16.6	30.0	28.3	25.1
	Ped. West	17.3	29.8	29.1	23.8
	Ped. East	16.6	30.7	30.1	22.6
	Sign East	16.9	30.6	30.8	21.7
	McCarty	15.8	28.3	36.1	19.8

was made between the Before and After studies in Section 'A' to determine which signing system promoted the fastest redistribution of traffic toward equal lane volumes. Differences in lane distribution percentages (from Tables 2-1 and 2-3) from an assumed desired rate of 25.0% per lane were calculated for each signing system. The absolute values of these deviations for each lane were then taken and averaged for each count location. Differences between Before and After mean deviations were then calculated. Results of this analysis are presented in Table 2-5.

Several observations can be made from the analysis results of Table 2-5. First, there is a general trend toward a more uniform flow as traffic proceeds through Section 'A' from McLeary to Lathrop in both the Before and After studies. Second, the fact of a more uniform input flow at McLeary in the After study is evident in all four time intervals. The most noticeable case is the 3-4 p.m. time period wherein a mean deviation of 5.7% per lane (from 25.0%) existed in the Before study and a mean deviation of 2.6% in the After study for a net reduction in non-uniformity of 3.1% per lane. The third observation made is that the After (or new) signing system did not result in a more uniform distribution in traffic at Lathrop even though a more uniform flow entered Section 'A'.

An analysis of the lane distribution data for both Sections 'A' and 'B' combined revealed several interesting points. One result noted continuing the uniformity idea discussed above follows. Assume that it is desired to maintain lane utilization on the four lanes to less than 30.0%. Discounting the input station at McLeary, 4 excessive lane usage observations (i.e., 30.0% or greater) were observed in Section 'A' in the Before study and 5 in the After. In Section 'B', 8 excessive distribution rates were noted during the

Table 2-5. Average Deviation in Percent From Mean Lane Usage At Count Stations Along Section 'A' of Eastbound I-10 in Houston Between Before and After Studies By Time of Day.

Time and Location	Before Study	After Study	Average Difference
2 - 3 p.m.			
McLeary	6.7	4.2	+ 2.5
Scheikhart	3.1	3.6	- 0.5
Callas	2.4	2.6	- 0.2
Lathrop	2.3	2.8	- 0.5
3 - 4 p.m.			
McLeary	5.7	2.6	+ 3.1
Scheikhart	1.4	1.7	- 0.3
Callas	1.4	1.4	0.0
Lathrop	1.8	1.2	+ 0.6
9 - 10 a.m.			
McLeary	8.6	6.8	+ 1.8
Scheikhart	6.9	6.1	+ 0.8
Callas	5.8	5.2	+ 0.6
Lathrop	5.3	4.4	+ 0.9
10 - 11 a.m.			
McLeary	8.2	6.2	+ 2.0
Scheikhart	6.0	5.9	+ 0.1
Callas	4.8	5.2	- 0.4
Lathrop	4.0	4.2	- 0.2

Before study and 12 in the After. For the total study section, 12 critical usages existed during the Before study and 17 in the After.

A rank ordering of the four thru lanes at the eight count locations by descending lane volume distribution percentage reveals that traffic usage by lane retained most of its characteristics over the 14 month interval between the studies even including the changed signing system. This retention of characteristics over the study held for each of the four time periods. For example, the median lane (lane 1) was used the least (a rank of 4 on a scale of 1 to 4) during both time periods on Saturday at all count locations for both the Before and After studies. On Friday, only 1 of 8 ranks of the median lane were different from 2-3 p.m. and also from 3-4 p.m. between the Before and After studies. As the volume level increased on Friday, the median lane changed from the 4th to the 3rd highest utilized lane.

Further comparisons of the rank ordering of Tables 2-1 through 2-4 showed continued consistency of the data sets in most cases between the Before and After studies. On Saturday, lane 3 was generally the highest utilized lane in both studies. The average usage on Saturday of lane 3 in the Before and After studies was 30.3% and 30.9%, respectively. On Friday, consistent results were obtained from 3-4 p.m. as lane 2 was the highest utilized lane with Before and After averages of 27.5% and 27.9%, respectively. All averages discount the input station at McLeary.

The only significant variation in traffic flow and lane utilization appeared to occur from 2-3 p.m. on Friday. During the Before study, lane 3 was the highest utilized, with an average utilization of 28.3%. Lane 2 averaged 27.4%. During the After study, lane 3 averaged 27.1%, but lane 2 experienced a higher average of 28.4%. This difference in the traffic flow pattern is attributed to changes in the origin-destination pattern of motorists using I-10, particularly changes in I-610 loop traffic. During the Before study, 34.3% of the input traffic at McLeary (Table 2-1) was on the shoulder lane (lane 4). For some unknown reason, only 27.8% was observed at the same point during the After study.

Weaving

Location. A weaving and lane changing study was conducted in Section B to determine if the signing modifications shown in Figure 2-4 caused any significant changes in weaving rates with regard to the median lane (lane 1). Figure 2-5 shows the video recording systems set-up on a pedestrian bridge across the freeway about 600 feet in advance of Sign Bridge No. 4 (Figure 2-5). It was assumed the "Ped. West" observations (observations made at least 800 feet in advance of Sign Bridge No. 4) reflected normal weaving rates since the pedestrian bridge and basic legibility distances (800 feet) should have minimized driver response to the downstream sign in the Ped. West section. The study results seem to justify this assumption.

Study Rational. The initial rational for this study was as follows. If I-10 (or Beaumont) traffic were in any of the first three lanes from the center median and if the motorists interpreted the old (Before) I-10 (or Beaumont) "pull-thru" sign to mean "only Beaumont", then more traffic weaving into the median lane should occur just before Sign Bridge No. 4 in Figure 2-4 during the Before study than in the After study. A second hypothesis regarding possible operational changes dealt with the lane assignment arrows at Sign Bridge No. 4. It could be speculated that the lane assignment arrows might be interpreted as an immediate action command causing more immediate response to the lane assignments. Higher weaving rates would therefore be expected during the Before study.

Results. The weaving results of this study are presented in Table 2-6. Time intervals include Friday afternoon (2-4 p.m.) and Saturday morning (9-11 a.m.) as before. Two hour summaries are also shown. Before and After data are paired for ready comparison. All After lane change rates were reduced approximately 5% to make equal volume comparisons.

The assumption of increased weaving in the Ped. East section (between the pedestrian bridge and the sign) as compared to the Ped. West section (between the pedestrian bridge and downtown) is supported by the study results. The "weaving ratio" was used to measure this feature. The weaving ratio is the Ped. East total weaving volume divided by the Ped. West total weaving volume. Increases of 10% or more (weaving ratios of 1.10 or more) occurred in all cases with an average increase of about 18% from 2-4 p.m. on Friday and 63% from 9-11 a.m. on Saturday.

The lane changing data into the median lane (lane 1) suggest that I-10 (or Beaumont) drivers did follow the "pull-thru" sign to some extent and, as a consequence, a higher lane change rate into the median lane did occur in the Before study than in the After study where no specific lane assignment was made. During the entire Before study in the Ped. East section, a total of 153 (115+38) lane changes into the median lane (lane 1) was observed. On the other hand, only 117 (82+35) lane changes into lane 1 were noted during the After study. Thus the Before rate was 31% higher than the After rate. In the base-line Ped. West section, a total of 118 (92+26) and 116 (94+22) lane changes into the median lane were counted during the Before and After studies, respectively. These rates obviously are practically the same. The fact that the After study Ped. East rate of 117 is nearly the same as its Ped. West rate of 116 also supports the proposition that

Table 2-6. Weaving Rates in Advance of Sign Bridge No. 4 During Before and After Studies By Time of Day.

Time and Study	Pedestrian West			Pedestrian East			Weaving Ratio
	From #1	To #1	Weaving Total	From #1	To #1	Weaving Total	
2 - 3 p.m.							
Before	38	40	78	45	52	97	1.24
After	39	51	90	62	37	99	1.10
3 - 4 p.m.							
Before	63	52	115	74	63	137	1.19
After	37	43	80	55	45	100	1.25
2 - 4 p.m.							
Before	101	92	193	119	115	234	1.21
After	76	94	170	117	82	199	1.17
9 - 10 a.m.							
Before	15	12	27	25	18	43	1.59
After	15	9	24	26	14	40	1.67
10 - 11 a.m.							
Before	16	14	30	28	20	48	1.60
After	19	13	32	32	21	53	1.66
9 - 11 a.m.							
Before	31	26	57	53	38	91	1.60
After	34	22	56	58	35	93	1.66

the Before signing plan promoted a more positive driver response to lane assignments for I-10 (or Beaumont) than did the After plan.

The weaving results in Table 2-6 related to the median lane (lane 1) only do not strongly support the hypothesis that the total weaving in the Before study should be higher than the After study due to more positive lane assignments. A total of 325 vehicles (234+91) changed lanes during the Before study in the Ped. East section and 292 (199+93), an 11% decrease in lane changes were observed during the After study. Also, two of the four time periods experienced total weaving increases and two experienced decreases from Before to After study conditions.

Flow Maps

One research issue which the I-10 studies addressed was "Do motorists literally follow the "pull-thru" freeway guide signs of routes and associated destinations?" One example for study may be seen by looking back at the Before signing of the I-10, U.S. 90 and Beaumont pull-thru signing shown in Figures 2-1 and 2-3. This traffic could be in all three of the inside lanes at Lathrop (Sign Bridge No. 3) but perhaps only in the inside two lanes at McCarty (Sign Bridge No. 5).

Figure 2-6 shows the Lathrop and McCarty lane volumes on Saturday from 9-11 a.m. during the Before study. A total of 2522 vehicles used lanes 1, 2 and 3 (I-10, U.S. 90 and Beaumont at Sign Bridge No. 3) in Figure 2-2. If all the traffic at Lathrop was literally following the signs, then this traffic should be mostly in lane 1 (median lane), or possibly both lanes 1 and 2, at McCarty. An increase of only 86 vehicles (15%) was observed in lane 1 at McCarty over that counted upstream at Lathrop. The 635 count is nowhere near the 2522 that might have occurred based on the signing. If

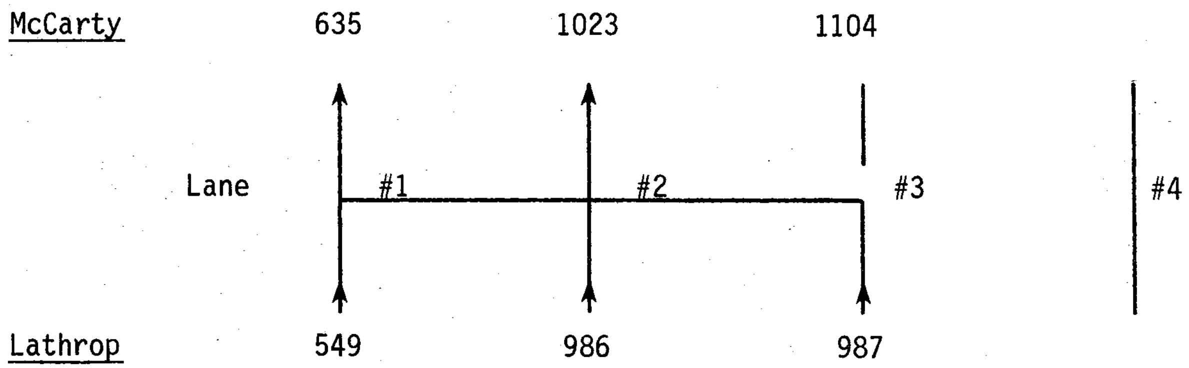


Figure 2-6. Lane Assignments of I-10 and U.S. 90 Traffic and Traffic Volumes at Lathrop and McCarty on Saturday Morning During Before Study.

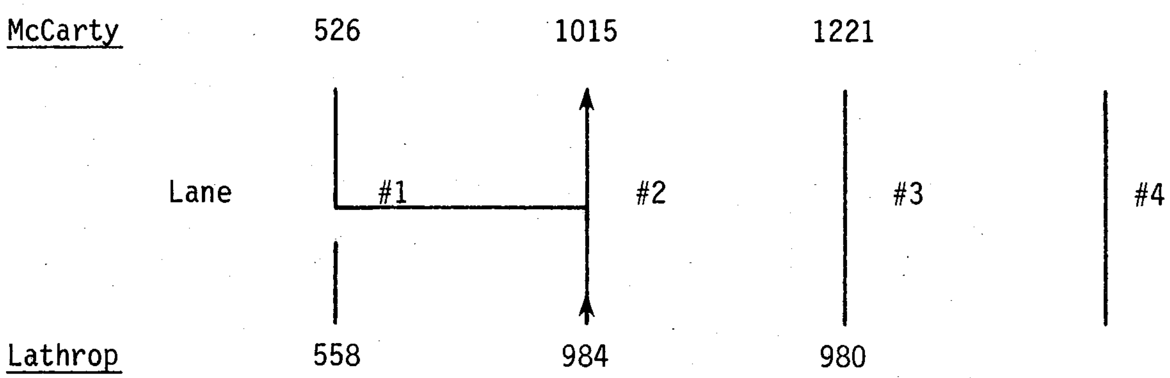


Figure 2-7. Lane Assignments of I-10 and U.S. 90 Traffic and Traffic Volumes at Lathrop and McCarty Location on Saturday Morning During After Study.

both lanes 1 and 2 at McCarty are included (for both I-10 and U.S. 90), then the total count rises to 1658 (635+1023), or 66% of the total at Lathrop.

Figure 2-7 shows similar After study volume mapping for the same locations. Volume levels were reduced approximately 3% to equivalent total across-all-lanes volume counts as in the Before study. No particular new results are evident from this figure alone.

Further lane volume comparisons of these data by location are presented in Figures 2-8 and 2-9. Figure 2-8 provides a comparison of volume counts by lane at Lathrop. The Saturday morning volume usage by lane is practically the same in the Before and After cases. Friday afternoon results (not shown) also are nearly identical. The conclusion reached is that the two signing systems produced similar lane distributions at Lathrop. No noticeable concentration of traffic occurred under the "pull-thru" sign over lane 2 at Lathrop during the After study. In fact, some slight reduction occurred over the entire study.

One operational change was noted, however. The lane volume counts in all three inside lanes increased during the Before study (Figure 2-6) from Lathrop to McCarty. The average increase was about 10%. During the After study, both lanes 2 and 3 increased an average of 14% but lane 1 (where the pull-thru sign was removed) decreased 6%. This decrease is equivalent to a 28% change in trend compared to the other lanes. The impact is modest but consistent. This change was probably caused by the I-10 (or Beaumont) pull-thru signing over lane 1 in Section B during the Before study as compared to no sign in the After study.

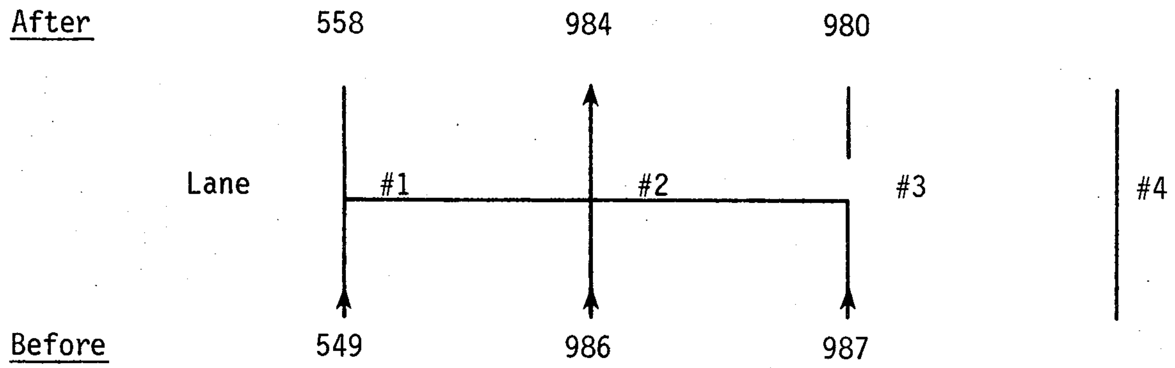


Figure 2-8. Lane Assignments of I-10 and U.S. 90 Traffic and Traffic Volumes at Lathrop on Saturday Morning for Before and After Studies.

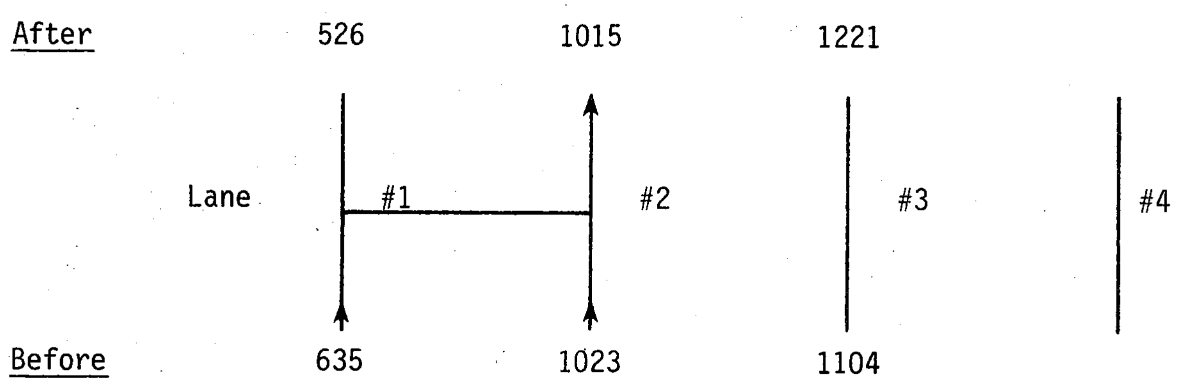


Figure 2-9. Lane Assignments of I-10 and U.S. 90 Traffic and Traffic Volumes at McCarty on Saturday Morning for Before and After Studies.

CONCLUSIONS

The following general conclusions are offered based on the I-10 study results. The elimination of the assignment of specific lanes to the freeway motorists traveling on a nominal tangent section of an 8-lane urban freeway resulted in a very slight change toward a less controlled roadway. For all practical purposes, the effect was negligible. The larger signing system used in the Before study in Section A would not appear cost-effective. A few motorists probably literally follow pull-thru signs with lane assignment arrows (like the Beaumont sign in the Before study in Section B). Most apparently do not immediately do so. This could be a serious problem unless lane assignments are used only when necessary to communicate unexpected information needs approaching complex interchanges, such as at splits and at left-hand exits.

RECOMMENDATIONS

The use of positive lane assignment signing for all lanes on a typical urban freeway outside of the immediate downtown areas of Texas cities is not recommended except at major interchanges having unexpected route guidance problems such as at splits or restricted sight distance. The benefits would be two-fold. Unnecessary or ineffective signing would be eliminated reducing sign costs. In cases where operational benefits would be expected due to the positive lane assignments, these signs would be more effective because motorists would come to recognize that these signs are used only where the information provided is needed.

A modest size "pull-thru" guide sign over the middle lane is recommended for general route confirmation applications, except at critical sign installations which will be defined later in this research effort.

CHAPTER 3

ASTRO-BLUEBONNET BOWL STUDY

INTRODUCTION

One of the difficult tasks often faced by traffic researchers is to obtain a large sample of unfamiliar motorists and to measure their responses to a selected test condition. This is especially true for testing and evaluating urban freeway guide signing. Some field testing of laboratory findings is sometimes done with less than a dozen unfamiliar subjects. Thus, when an opportunity arose to test more than a thousand unfamiliar motorists the opportunity was seized.

This special opportunity was the Astro-Bluebonnet Bowl football game played in Houston on December 31, 1976 between Texas Tech and Nebraska. It was known that many Nebraska fans would be driving thru Dallas to Houston to see the game and vacation in and around Houston. The research study objective was to determine if any of these motorist had an accident on any of the urban freeways in Dallas or Houston and, if so, were they related in any way to the quality of freeway guide signing.

STUDY

It was planned to collect accident data on all freeways in Dallas and Houston for approximately two weeks to include the expected high usage days by Nebraska traffic. This phase of the study posed no particular problem. The cities of Dallas and Houston cooperated fully with the study and provided a complete listing of all reported accidents on urban freeways.

The more difficult problem was to determine how many Nebraska vehicles drove thru Dallas and were traveling within Houston to obtain some measure of accident risk and exposure. Several methods were utilized to estimate the overall level of exposure. Just before the game, calls were placed to the University of Nebraska to determine ticket sales and air travel reservations. Their best estimate was that 6,000 tickets were sold to Nebraska fans with 821 having made air travel reservations. Thus, if 3.5 fans per vehicle on the average drove to Houston, there would be a total of 1,479 vehicles in Houston for the Astro-Bluebonnet football game assuming all 5,179 ticket holders not flying went to Houston by auto.

Several counts were made during the game to give further control totals and vehicular estimates. Crowd attendance at the game was 48,680 (near capacity). A manual count study of all gates feeding the Astrodome parking lot showed that 991 vehicles had Nebraksa license plates. A total of 12,830 vehicles were parked. The parking lot gate counts revealed that a considerable number of Nebraska fans were walking to the game from adjacent motels. Counts made at several of the adjacent motels revealed 204 Nebraska vehicles remained in motel parking lots. Thus, a total of 1,195 Nebraska vehicles were observed in and around the Astrodome during the game. Considering the fact that several major hotels in Houston were not counted from which charter bus service was available, it is estimated that a total of 1,500 vehicles having Nebraska license plates were in Houston during the Astro-Bluebonnet Bowl.

The level of driving exposure for Nebraska vehicles was estimated for both Houston and Dallas. It was assumed that Nebraska fans would drive 75 freeway miles in Houston during their stay. The minimum to-from distance just to the Astrodome is 50 miles. Multiplying 1,500 vehicles traveling 75 miles yields a total of 112,500 vehicle-miles driven by Nebraska vehicles on freeways in Houston.

Estimating Dallas vehicle-miles traveled was more difficult and somewhat less precise. The basic estimate needed was the percentage of Nebraska traffic in Houston which traveled thru Dallas. First, motels along I-35E in Dallas were observed to determine if Nebraska motorists were spending the night in Dallas on nights prior to the game as would have been expected. While no totals were kept, a sizeable number of Nebraska motorists were observed staying in Dallas. Second, a sample of 25 interviews were conducted with Nebraska fans waiting in line to enter the Astrodome before the game. A total of 19 of the 25 interviews (76%) indicated that they had come thru Dallas on their way to Houston. An equal percentage were returning thru Dallas. Thus, it is estimated that 2280 trips (0.76 x 1500 x 2) were made by Nebraska fans thru Dallas either going to or from Houston. At 25 miles travel distance thru Dallas, this would give a net exposure distance of 57,000 vehicle-miles.

STUDY RESULTS

From the viewpoint of research expectations of accidents, the results are a bit discouraging. From a safety standpoint, they are somewhat encouraging. In Dallas, for example, there were 37 accidents involving out-of-state vehicles reported on freeways from December 26, 1976 thru January 8, 1977. Only one reported accident was from Nebraska and it was a tractor truck on the frontage road. A detailed investigation of the other accidents was not conducted. Of the 20 accidents reported on Houston's freeways from December 20, 1976 to January 8, 1977 involving out-of-state motorists, none were Nebraska drivers or vehicles. Most were from Louisiana and Florida.

A review of the accident reports leaves a lot to be desired with regards to urban freeway guide sign research. It seems that the officer concentrates on the vehicle, geometry and general traffic violations or, in other words, on what happened and where did it happen. It would be near impossible from looking at the accident report to tell if the guide signing per se had anything to do with any of the accidents. For example, operational comments like ...he made a sudden lane change and hit me... and ...I didn't see him coming... provide little meaningful information to anyone much less to someone trying to identify causal relationships to accidents.

SUMMARY

Since no accidents were reported by Nebraska motorist in Dallas and Houston, what does this indicate? For one thing, it indicates the difficulty traffic engineers are constantly faced with - that being system failures having a low probability of occurrence. For example, a total of 169,500 vehicle-miles of travel were estimated to be driven by Nebraska fans in Dallas and Houston combined. Using an average accident rate on urban freeways of 194 accidents per 100 million vehicle miles of travel, one would expect only 0.3 accidents to have occurred in Dallas and Houston. None did. The probability of no accidents occurring at the given average rate of 194/100 MVM is 72% for 169,500 vehicle miles of travel. Thus, it cannot be said that the freeways studied are safer or more hazardous than normal based on these study results.

CHAPTER 4

STUDY SUMMARY

INTRODUCTION

This report has described three field studies dealing with operational impacts of urban freeway guide signing. The description, documentation and results of these three research activities have been presented in the previous chapters. Two of these studies were before-after types wherein the existing urban freeway guide signing was replaced or upgraded to a newer condition. One of these studies was in Dallas and the other in Houston. The third study was a limited scope evaluation of the freeway accident experience of Nebraska football fans during a recent Astro-Bluebonnet Bowl football game in Houston.

The first operational study reported was conducted along westbound I-30 near downtown Dallas. Before studies were conducted during 1977 and After studies in 1979. During this period an updating of the freeway guide signing system to 1970 MUTCD standards was made. Operational measures of volumes, lane changing and erratic maneuvers were collected to determine what effects might be attributed to the signing and what changes, if any, occurred as a result of changes in the signing. Some positive operational changes were noted but the causal relationships were clouded by the fact that the Dallas-Ft. Worth Turnpike was made into a free road (I-30) between the Before and After studies.

The second operational study described was conducted along eastbound I-10 on the east side of Houston. This study was similar in many ways to the previous study. An existing guide signing system was updated to 1970 MUTCD standards during 1977. Before and After operational studies were conducted in 1977 and 1978. Fewer "pull thru" signs and less positive lane assignments were the more significant changes studied.

CONCLUSIONS

Traffic operations through the westbound section of I-30 in Dallas from I-45 to I-35E were improved over those existing during 1977. The reasons for this improvement likely were due 1) to improved route design of I-30 through Dallas and 2) to the new freeway route guide signing system installed.

Some operational problems remain along I-30 in Dallas and should be treated. Excessive traffic now desires to use the outside lane (lane 3) at Ervay Street (connection of I-45 with I-30). A large frequency of erratic maneuvers still occurs at the I-35E junction indicating continued route guidance and tracking problems. Further treatment of this problem should be implemented.

The following general conclusions are offered based on the I-10 study conducted in Houston. The elimination of the assignment of specific lanes to the freeway motorists traveling on a nominal tangent section of an 8-lane urban freeway resulted in a very slight change toward a less controlled roadway. For all practical purposes, the effect was negligible. The larger signing system used in the Before study in Section 'A' would not appear cost-effective. A few motorists probably literally follow pull-thru signs with lane assignment arrows (like the Beaumont sign in the Before study in Section 'B'). Most apparently do not immediately do so. This fact could be a serious problem unless lane assignments are used only when necessary to communicate unexpected information needs approaching complex interchanges, such as splits and at left-hand exits.

A study of 1,500 out-of-state drivers from Nebraska revealed that they experienced no reported accidents while driving on Dallas or Houston freeways while attending a recent Astro-Bluebonnet Bowl football game.

RECOMMENDATIONS

Several improvements to the new signing system are recommended for immediate consideration by SDHPT for westbound I-30 in Dallas. The modifications recommended based on this study are:

1. Add a post mounted median sign at Grand Avenue giving mileage to I-45 and U.S. 75 as well as to I-35E.
2. Redesign (or eliminate) the I-30 "pull thru" sign at Fair Park to be consistent with the others.
3. Eliminate I-30 "pull thru" at Central Expressway, (Figure 1-2) and enlarge I-35E advance guide sign. Move enlarged sign to middle lane.
4. Close gap in triple overhead guide sign (Figure 1-3) at Akard St. to improve readability.
5. Replace both sets of overhead destination signs at Griffin St. (Figure 1-4) and at M.K.T. (or Rock Island) railroad bridge (Figure 1-5) with the route numbers and destination names together with lane assignment arrows. Waco and Denton are <u>not</u> familiar names to out-of-state motorists and mean little to them. Visual coding of "pull thru" signs at Akard St. (Figure 1-3) is misleading and should be reinforced at Griffin and M.K.T.
6. The visual scene through the M.K.T. (or Rock Island) railroad bridge approaching I-35E should be improved to the extent feasible. The <u>daytime</u> lighting inside the tunnel should be increased. In fact, the SDHPT should determine the feasibility for removing the last 50 feet of the bridge deck of the overpass structure. The sooner motorist can see the I-35E interchange, the better.

The use of positive lane assignment signing for all lanes on a typical urban freeway outside of the immediate downtown areas of Texas cities is not recommended except at major interchanges having unexpected route guidance problems such as at splits or restricted sight distance. The benefits would be two-fold. Unnecessary or ineffective signing would be eliminated reducing sign costs. In cases where operational benefits would be expected due to the possible lane assignments, these signs would be more effective because motorists would come to recognize that these signs are used only where the information provided is needed.

A modest "pull thru" guide sign over the middle lane is recommended for general route confirmation applications, except at critical sign installations which will be defined in a later report in this research effort.

SECTION B

ANALYSIS OF EXISTING URBAN FREEWAY GUIDE SIGNING SYSTEMS IN SELECTED CITIES IN THE UNITED STATES

CHAPTER 5 - INVENTORY OF URBAN FREEWAY GUIDE SIGNING IN SELECTED CITIES IN THE UNITED STATES

INTRODUCTION

The motoring public traveling urban freeways in Texas has a wide variety of driving experiences and navigational information needs. Local motorists usually are very familiar with the freeway networks within the metropolitan area and therefore use freeway guide signing only to a modest extent, primarily as landmarks to initiate what they have already planned to do. Complex freeway geometric design and signing are anticipated and do not surprise the local freeway motorist. The semi-familiar freeway driver, say a driver from another Texas city, uses the guide signing to a greater extent, requires more time to read and respond to the signing, and may become confused by unexpected complex operational circumstances. The out-of-state driver (businessman) on the other hand, may have never driven in one particular Texas city. He would have maximum information needs, and therefore would have to rely totally on the guide signing to navigate through the freeway network. The unfamiliar freeway driver cannot be expected to anticipate complex freeway geometrics and signing requirements and therefore will be surprised when they occur.

The level of surprisal experienced by these out-of-state motorists depends upon the urban freeway driving experiences that they have been exposed to in cities of comparable size in their region of the country, or in which they may have recently driven through on their trip to Texas. Where Texas' urban freeway guide signing characteristics are significantly different than in other cities of the country, these differences, cannot be anticipated by out-of-state motorists and will surprise the unfamiliar motorist resulting in increased response times and probabilities of driving errors (1). A traffic accident and/or loss of travel time are the usual consequences.

OBJECTIVES

The objectives of this study are to determine basic urban freeway guide signing design characteristics found in Texas cities and in selected cities around the U.S. having similar population and geographic features. These data were then evaluated to determine the degree of similarity of selected sign design parameters. The degree of surprisal of each parameter was to be estimated. Basic findings of this study are to provide inputs toward developing a level of service evaluation methodology to be produced at the conclusion of this research study on August 31, 1980.

SCOPE

An inventory of selected physical design characteristics of urban freeway guide signing was conducted in ten major cities during 1979. The six cities are located outside the state of Texas. These cities are: Atlanta, Chicago, Denver, Kansas City, Los Angeles and New Orleans. The four Texas cities inventoried are: Dallas, Ft. Worth, Houston and San Antonio. A moving vehicle inventory procedure was used to collect the data. A total of 2,292 signs were inventoried.

MEASUREMENT PROCEDURE

All observations made of the freeway guide signing were obtained from routine travel runs made along the freeways using standard automobiles.

Mileage measurements were read from the odometer. Precise measurements of distances, as could have been obtained using distance measuring instruments (DMI's), were not deemed necessary. Each guide sign's physical characteristics and message design were recorded using a 35 mm camera. Film processing was completed with 2x2 color slides developed for each sign. An oral "blow-by-blow" description of each travel run was recorded on 60-minute cassette tape for confirming the slide sequences. Also, some minor freeway guide signs were orally inventoried but were not photographed. These were usually ground-mounted supplemental guide signs located on the shoulder of the freeway.

Data were collected on the following guide sign features: location of sign structure, cross-section position (median, overhead, shoulder), number of sign panels, bits of information per panel, total bits of information on sign structure, maximum bits of information on panel, number of concurrent route sign panels and, lastly, the maximum number of concurrent routes on a panel. Message content and meaningfulness, as such, were not evaluated in this study.

The unit used to measure information load on a freeway guide sign was called a "bit". This term was selected for convenience and is being loosely used from a strictly theoretical viewpoint based on information theory (2). Other researchers (3, 4) have used similar descriptions such as "familiar words" (3) or "units of information" (4). A bit of information on a freeway guide sign in this study was defined as the existence on the guide sign for each and every one of the following items.

- o Route Number
  "I-30"
- o Cardinal Direction
  "North"
- o Destination Name
  "Miami"
- o Route Name (1 or 2 bits)
  "Central Expressway"
- o Street Name
  "Park Street"
- o Next Right (Left) (2 Bits)
- o Junction, To, Next
- o Exit Number
  (or exit number panel)
- o Command
  "Exit", "Use"
- o Exit Mileage
  "1¼ Miles"
- o Exit Only (2 bits)
  "Exit Only"
- o Mileage
  "2 Miles"
- o All Lane Use Arrows
  (To same route)
- o Business

Some variation in results may be expected in application of this measurement scheme, although good consistency was obtained after only modest instructions were given. Some discretion is also provided particularly on route and street names. Excessively long or possibly confusing route names such as Santa Barbara Freeway or Central Expressway may be considered two (2) bits of information or load as far as estimating the degree of difficulty in the reading task.

Concurrent route markings is a troublesome signing problem in most Texas cities since many urban freeways are often marked as Interstate as well as U.S. Highway routes. The extent of this complicating signing problem is quantified in the results section to follow using the measure - number of concurrent panels.

STUDY RESULTS

The results of the inventory effort are described according to the basic measures previously described. A brief summary of the number and types of signs inventoried by city will introduce the section. A more detailed analysis of information statistics follows. An analysis of concurrent signing practices concludes the results section.

Inventory Mileage

A total of 1,053 miles of freeways were inventoried in the 10 cities. The total mileage within Texas was approximately equal to the out-of-state mileage. A breakdown of the mileage by city is given in Table 1 together with the total number of signs inventoried. The mileages shown represent almost all radial oriented freeways in each city, perhaps with Los Angeles being the exception. Very little loop (beltway) freeway mileage around the cities were observed.

Sign density rates, or the number of sign structures per mile, are also given in Table 1. The average number of sign structures per mile in the Texas inventory was found to be 2.31 sign structures per mile while the out-of-state sign density was 12 percent or 2.04 sign structures per mile. The base sign density results suggest that the average frequency of signs presented to motorists in Ft. Worth, Houston and Kansas City are somewhat higher than the average; whereas, Los Angeles has a much lower than average sign density.

A plot of the sign density rates of Table 1 by miles of freeway inventoried is presented in Figure 1 to investigate what effect, if any, sample size might have had on the frequency of signs observed per mile. One can note some trend toward lower densities with increased inventory mileage. Consideration of the data shown in Figure 1 suggests that Houston and Ft. Worth have the highest frequency of signing with Houston's average sign density of 3.15 signs per mile (or one sign every 1,676 feet on the average) being the highest value. It should be noted that the sign densities in Dallas, San Antonio and Los Angeles are a little misleading. All three of these cities are undeveloped belt routes resulting in very few signs.

Table 5-1. Inventory Mileage and Number of Overhead Guide Signs Observed by City.

Name of City	Miles of Inventory	Number of Signs*	Signs* Per Mile
Out-of-state			
Atlanta	59.0	142	2.41
Chicago	103.5	249	2.41
Denver	69.0	176	2.55
Kansas City	66.7	192	2.88
Los Angeles	187.1	220	1.18
New Orleans	35.9	84	2.34
Subtotal	521.2	1,063	2.04
Texas			
Dallas	151.2	280	1.85
Ft. Worth	106.1	310	2.92
Houston	97.7	308	3.15
San Antonio	176.9	331	1.87
Subtotal	531.9	1,229	2.31
Totals	1,053.1	2,292	2.18

* Signs are the same as sign structures in this report. A sign structure may have more than one sign panel.

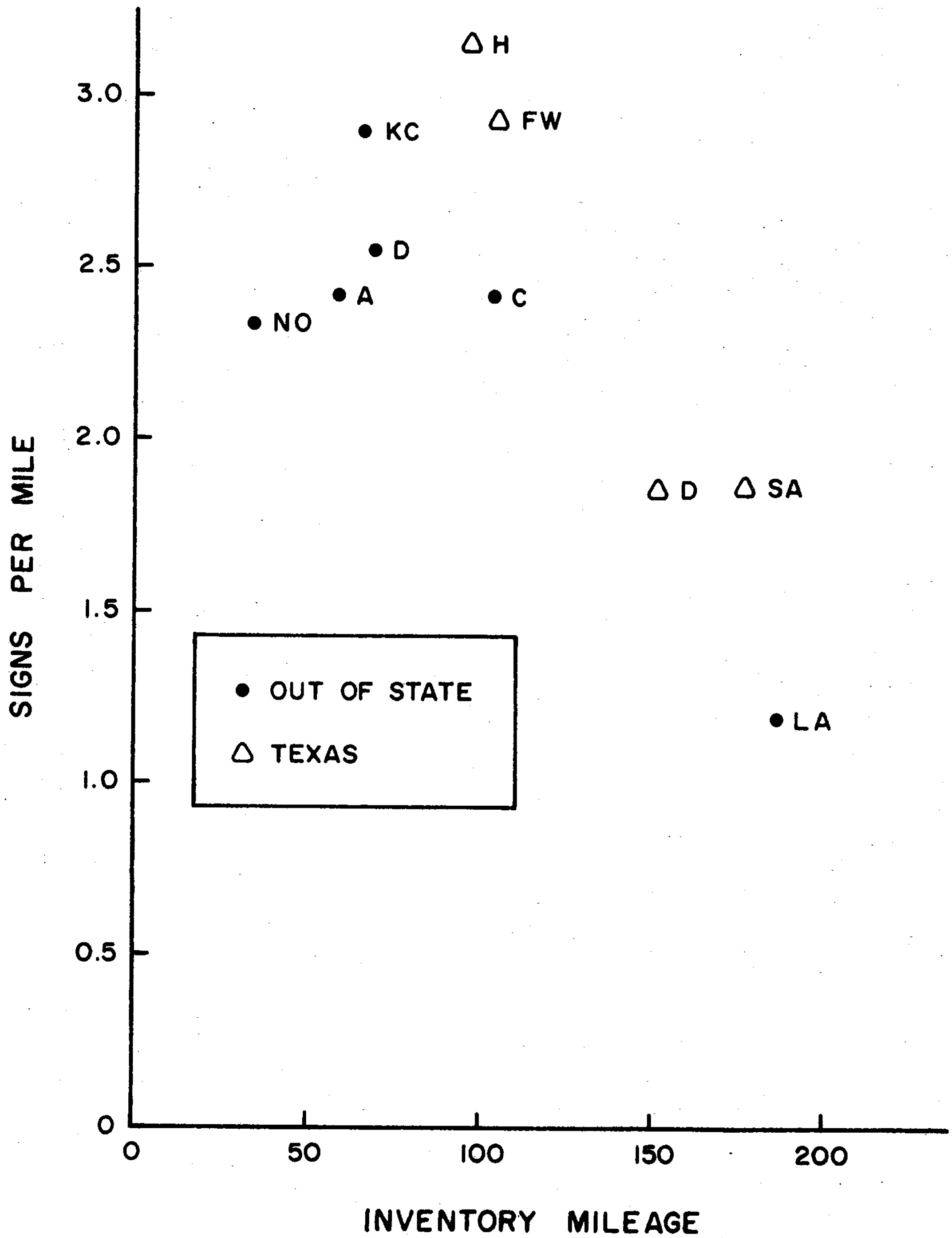


Figure 5-1. Sign Density in Signs Per Mile Related to Inventory Mileage for Ten Cities in the United States.

General observations drawn from these data are that none of these rates are excessive on the whole but rather reflect the more frequent usage of the exit ramps in Texas. In general, the most severe sign density problems are found near the downtown area of the central city due to the unusual high frequency of access ramps and freeway-to-freeway interchanges. Near the downtown areas, sign densities of over 4.0 signs per mile are likely to occur.

The following calculations are provided for comparison to the previously discussed results and for future reference. Let sign density be also expressed as its reciprocal characteristic - sign spacing - in feet per mile. Assuming sign spacings of urban freeways guide signs are distributed along the freeway according to the negative exponential distribution with an average spacing of 2,422 feet (2.18 signs/mile) and a minimum spacing of 750 feet, the cumulative percent of freeway miles having a sign-spacing of a given value or less would be as follows:

Sign Density (Signs/Mile)	Sign Spacing (Feet/Sign)	Cumulative Percent (Σ%)
1 or less	5280 or more	7%
2 or less	2640 or more	32%
3 or less	1760 or more	55%
4 or less	1320 or more	71%
5 or less	1060 or more	83%
6 or less	880 or more	93%
7 or less	750 or more	100%

Sign Types

A summary of the types of sign observed in the 10 U.S. cities inventoried is presented in Table 2. Median signs included all guide signs located in the median of the freeway. The most common median sign observed was the ground-mounted exit and distance sequence signs. Shoulder signs included all single ground-mounted signs located on the right shoulder of the freeway, all T-mounted exit gore signs, and all ramp exit signs. All signs located on a single overhead sign bridge over the freeway main lanes were classified as "Overhead", except for over-the-shoulder ramp exit signs.

The primary purpose of this phase of the inventory was to determine the usage characteristics of the median mounted exit and distance sequence signs. The results in Table 2 show that Los Angeles and Houston have the most median signs. These signs seemed to be more consistently used on the freeway in Los Angeles, although the average density of utilization was higher in Houston due to the higher frequency of exit ramps exiting on most Texas urban freeways. One new signing job along I-25 in southern Denver made extensive use of the sequential exit signs post-mounted on the concrete median barrier. With the exception of the usage of median mounted signing in Los Angeles and Houston, the aggregate usage characteristics per mile of freeway inventoried was very similar.

Information Load

A study of accuracy of route selection and reading times in a human factors laboratory conducted within this study (5) indicated that overhead guide sign structures with one or more panels having over 20 bits of information are unsatisfactory and that guide signs having more than 16 bits are not desirable. One of the objectives of this study was to quantify the degree of signing infor-

Table 5-2. Number of Urban Freeway Guide Signing Observed by Type and City.

Name of City	Median	Type of Signing Overhead	Shoulder	Total Number of Signs
Out-of-State				
Atlanta	1	39	102	142
Chicago	9	135	105	249
Denver	10	65	101	176
Kansas City	1	119	72	192
Los Angeles	68	58	94	220
New Orleans	2	41	41	84
Subtotal	91	457	515	1,063
Texas				
Dallas	2	156	122	280
Ft. Worth	5	146	159	310
Houston	52	153	103	308
San Antonio	1	112	218	331
Subtotal	60	567	602	1,229
Totals	151	1,024	1,117	2,292

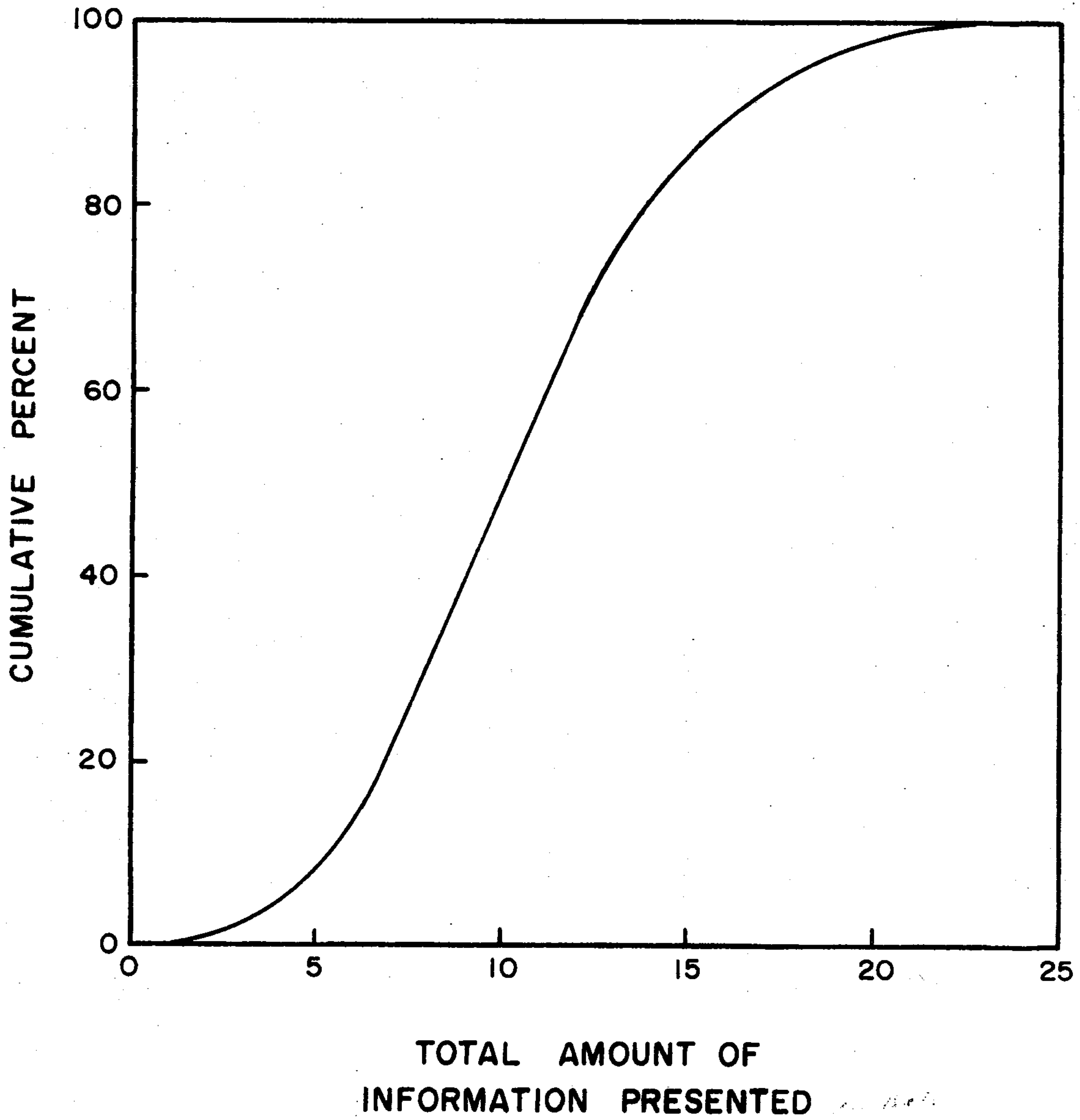


Figure 5-2. Cumulative Percent of Signs Observed Having Total Information Bit Level Shown or Less.

mation displayed on urban freeway guide signs in representative cities around the country. There was concern that Texas signing frequently has excessive information loads which the unfamiliar driver is not expecting. A statistical analysis of 1,005 overhead guide signs reveals some relevant findings regarding information levels being used. A cumulative percentage curve by increasing information bit level of the 1,005 signs is presented in Figure 2. Information loading did not include any ramp exit signing over the shoulder of the freeway. The curve shows that the 50 percentile (median) information load is 10 bits. The modal, or most frequently observed value, was also 10 bits.

The cumulative curve in Figure 2 provides important statistics regarding the frequency of applications of large information loads. As the percentage of all signs less than or equal to a value increases, the less likely a motorist would expect (due to exposure) a larger sign to arise. The curve shows that 85 percentile of all signs had information bit levels of about 15 bits or less. The 95 percentile level was determined to be 18 bits; that is, 5 percent or less of all signs had 19 bits or more. (It turns out that most of these signs are located in Texas). Less than 1 percent of all signs had more than 21 bits of information.

A more detailed breakdown of the distribution of information loads on signs reveals that the Texas cities tend to be the leaders in information loading. The cumulative percent curves for the six non-Texas cities are presented in Figure 3. A wide variety of signing designs apparently exist among these six cities. Four cities (Denver, Kansas City, Los Angeles and New Orleans) had no signs with more than 20 bits of information. Atlanta had only one sign in this above 20 bits category; Chicago had 7.

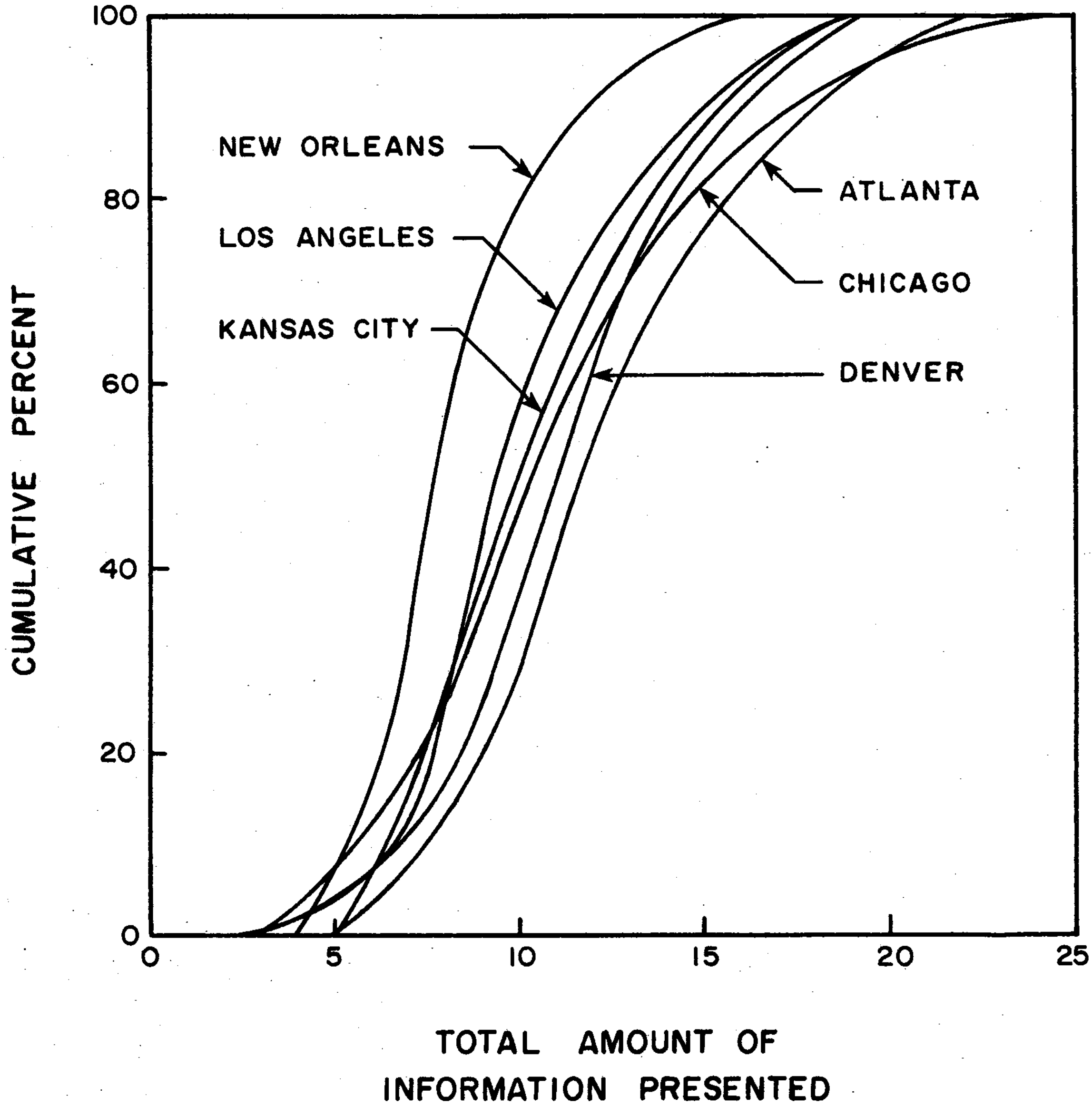


Figure 5-3. Cumulative Percent of Signs Observed in Out-of-State Cities Having Total Information Bit Level Shown or Less.

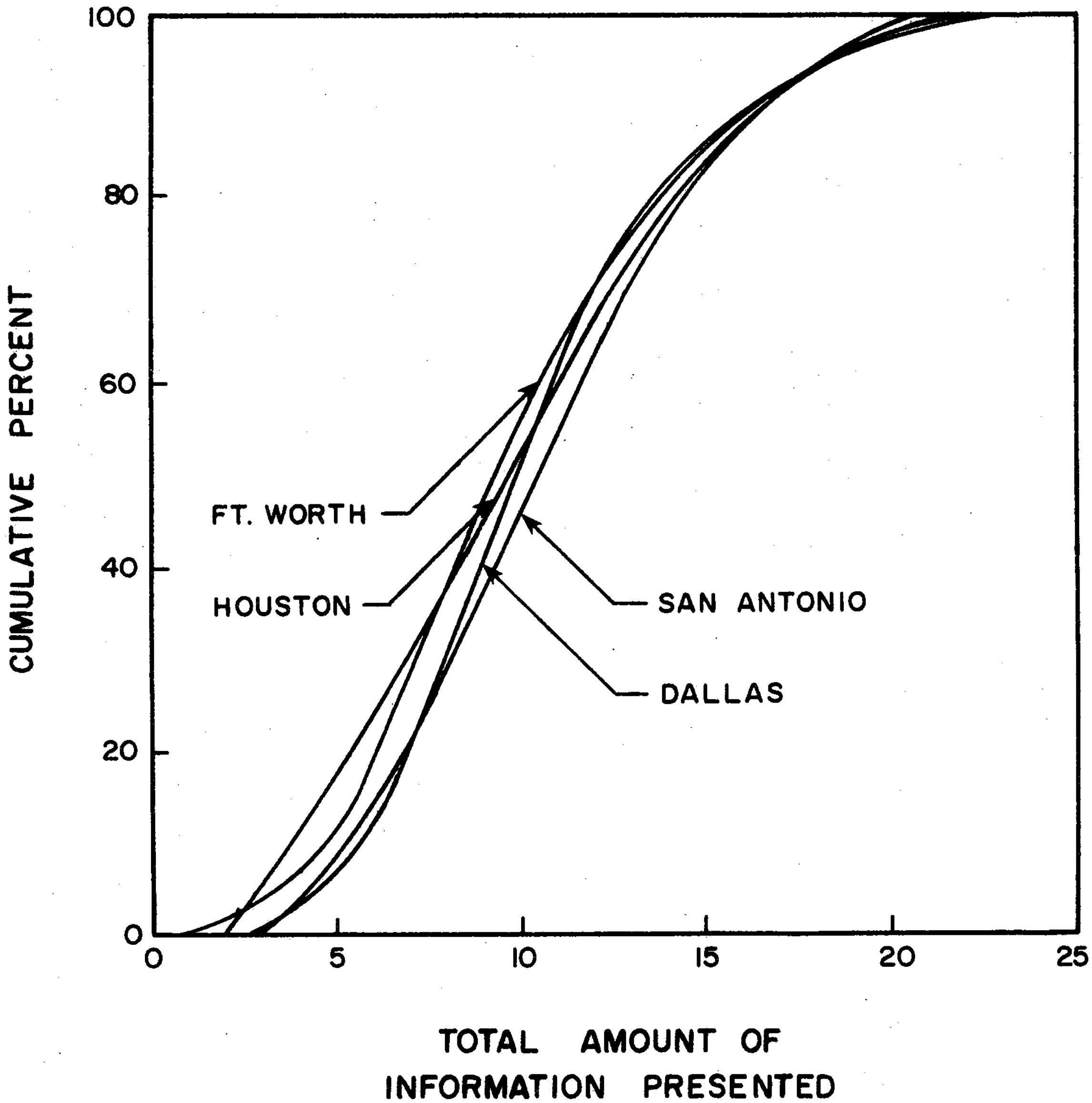


Figure 5-4. Cumulative Percent of Signs Observed in Texas Cities Having Bit Level Shown or Less.

Table 5-3. Number of Signs Having Given Information Bit Rate by City.

Name of City	Bits of Information on Overhead Guide Sign									
	16	17	18	19	20	21	22	23	24	Subtotal
Out-of-State										
Atlanta	2	3	2	2	0	0	1	0	0	10
Chicago	7	2	1	3	2	2	2	0	1	20
Denver	2	1	0	1	1	0	0	0	0	5
Kansas City	2	6	1	1	0	0	0	0	0	10
Los Angeles	4	1	1	2	0	0	0	0	0	8
New Orleans	1	0	0	0	0	0	0	0	0	1
Subtotal	18	13	5	9	3	2	3	0	1	54
Texas										
Dallas	6	4	4	1	2	0	1	1	1	20
Ft. Worth	5	3	6	0	1	1	2	0	1*	19
Houston	6	6	5	1	3	3	0	0	0	24
San Antonio	7	4	3	4	0	2	2	0	1	23
Subtotal	24	17	18	6	6	6	5	1	3	86
Total	42	30	23	15	9	8	8	1	4	140

*25 bits

The cumulative curves of information loads existing in the four Texas cities are presented in Figure 4. The signing characteristics of the Texas cities are all very similar, reflecting similar signing problems and design procedures. Every Texas city inventoried had more than 1 guide sign with more than 20 bits on it.

A detailed breakdown of the previous information bit data by number of signs observed is presented in Table 3 for each city. Since the total freeway miles of inventory of in-state versus out-of-state are about equal (532 vs. 521), direct numerical comparisons are justifiable on an aggregate basis. A total of 15 signs in the four Texas cities had information bit loads of greater than 20 bits. Only 6 signs in the six out-of-state cities were observed to be so cluttered. Five of these six signs were located in Chicago. Thus, most out-of-state motorists (possibly 67% or more) who travel Texas freeways would have little or no driving experience with signs having greater than 20 bits of information. This will result in an increase of erratic maneuvers on the part of the unfamiliar motorist.

Since 16 bits of information has been tentatively established (5) as the maximum desirable level, this value was used to rank order the ten cities by the number of freeway guide signs observed in each city having more than 16 bits. The results of this ranking of cities are presented in Table 4. The four Texas cities trail the field. Not one Texas city had fewer cluttered signs (greater than 16 bits) than any out-of-state city inventoried. Clearly, Texas' signing has much higher information loading than usual and efforts need to be made to reduce the sign clutter along the urban freeways in Texas.

Table 5-4. Rank Order of Cities Inventoried By Number of Overhead Sign Structures Observed to Have More Than 16 Bits of Information.

Rank Order	Name of City	Number of Signs
1	New Orleans	0
2	Denver	3
3	Los Angeles	4
4	Atlanta	8
5	Kansas City	8
6	Chicago	13
7	Ft. Worth	14
8	Dallas	14
9	San Antonio	16
10	Houston	18

Table 5-5. Summary Statistics for Overhead Freeway Guide Signs by City.

Inventory Location	Average Bits of Information Per Sign Panel	Bit Rate for Maximum Sign Panel by Percentile 50%	85%	Number of Panels with Bit Rate Greater than 8 Bits
Out-of-State				
Atlanta	4.86	5	7	3
Chicago	4.70	5	7	4
Denver	4.99	6	7	2
Kansas City	4.35	5	7	0
Los Angeles	4.60	6	8	7
New Orleans	3.74	4	5	0
Average	4.54	5	7	
Texas				
Dallas	4.30	5	6	9
Ft. Worth	4.11	5	7	2
Houston	4.09	5	7	1
San Antonio	4.31	5	8	10
Average	4.20	5	7	

the New Orleans data are omitted from comparisons, then the four Texas cities all had average bit levels per panel less than any of the remaining five out-of-state cities. Little practical significance is associated with the differences observed in the average values.

Further statistical analysis was conducted considering only the overhead guide sign panel having the largest information content of all sign panels located on the sign structure. The maximum information bit rate per panel for each sign in each city was tallied and rank ordered by cumulative percent with respect to increasing bit levels. The third and fourth columns in Table 5 present the resulting 50%-tile and 85%-tile bit rates, respectively. It can be observed that the median (50%-tile) information bit level for the "busiest" sign panel per sign is about 5 bits; whereas, the 85%-tile busiest panel would contain about 7 bits in all of the cities. Very little difference among cities was noted. However, Dallas and San Antonio have 19 signs between them that have over 8 bits of information on one sign panel. Only a few of the large California sign panels in Los Angeles came close to being so loaded. Certainly, most out-of-state motorists would be surprised by the high bit rate (i.e., greater than 8 bits) found in some Texas cities.

The data presented in Table 5 suggest, based on the driver expectancy concept (1), that a desirable maximum information bit level per panel is about 5 to 6 bits, and that an absolute maximum is about 7 to 8 bits. Information bit rates exceeding 8 bits should be avoided based on driver expectancy.

Concurrent Signing

Another signing variable compared between the Texas signing and the non-Texas systems was concurrent signing. Concurrent signing occurs when a freeway is included in more than one route numbering system. That is, the freeway

Table 5-6. Number of Concurrent Urban Freeway Guide Sign Panels.

Inventory Location	Type of Concurrent Route Signing						Subtotal
	I+I	I+U.S.	U.S.+U.S.	I+S	U.S.+S	None	
Out-of-State							
Atlanta	20	0	1	0	0	57	78
Chicago	44	0	15	3	4	104	170
Denver	6	1	4	0	4	77	92
Kansas City	11	72	9	0	0	116	208
Los Angeles	3	0	0	0	0	159	162
New Orleans	0	0	0	0	0	64	64
Subtotal	84	73	29	3	8	577	774
Texas							
Dallas	23	93	1	0	0	105	222
Ft. Worth	0	69	19	0	6	75	169
Houston	0	95	0	0	9	89	193
San Antonio	4	135	5	2	0	105	251
Subtotal	27	392	25	2	15	374	835
Total	111	465	54	5	23	951	1,609

Notes: I = Interstate, U.S. = United States, None = 1 Route Number has multiple route numbers, such as I-10 and U.S. 90.

Table 6 presents the results of the concurrent signing comparison for all overhead freeway guide signs having route numbers. A dramatic finding of this evaluation is the tremendously large number of Interstate and U.S. concurrent freeway routes (sign panels) found in Texas when compared to the out-of-state systems. There are 392 sign panels in the four Texas cities having Interstate-U.S. concurrent signing compared to only 73 panels in the out-of-state systems. Almost all of this concurrent Texas signing is redundant concurrent signing having limited navigational value. That is, the Interstate route and the U.S. route have been coincident for many miles and are, for practical purposes, the same route. Only Kansas City has somewhat similar signing problems. Ft. Worth and Chicago were observed to have concurrent U.S. designated highways which was somewhat unusual. With the exception of Chicago's Interstate-Interstate concurrent signing, few other differences exist in the data. Focusing on the critical finding in summary, the results of Table 6 show that Texas stands almost alone with regard to the redundant application of concurrent Interstate signing. All four Texas cities suffer from this problem which most other states have managed to avoid or correct.

Statistics were also developed of the percentage of overhead freeway guide signs that have 0, 1, 2 and 3 sign panels with concurrent route numbers on them. Aggregate percentages of the six out-of-state cities were calculated and compared to the four Texas cities. It was found that an average of 24% of all out-of-state signs have one concurrent sign panel on them while 38% of the signs in Texas are so numbered. A summary of the percentages of all overhead guide sign structures having 0, 1, 2 and 3 sign panels with concurrent routes on them is as follows:

Sign Location	Number of Concurrent Panels			
	0	1	2	3
Out-of-State	66%	24%	10%	0%
Texas	40%	38%	18%	4%

One may note that 18% of Texas' signs have two (2) concurrent routes (panels) signed and about 4% of the total Texas population of overhead freeway guide sign structures have three (3) concurrent routes. Most of these latter cases (3 panels) are found in Houston and Ft. Worth.

CHAPTER 6

POLICY, CONCLUSION AND RECOMMENDATIONS

AASHTO POLICY

AASHTO policy appears to be in conflict regarding concurrent Interstate-U.S. routes. According to AASHTO's "Purpose and Policy in the Establishment and Development of United States Numbered Highways" (6) dated September 15, 1970 states that:

> "Those sections where the Interstate system is developed over an existing U.S. numbered route, both the U.S. and the Interstate system shields and route numbers shall be used to mark those sections which are concurrent."

However, AASHTO's Interstate Purpose and Policy (7) revised to August 10, 1973, states that:

> "U.S. Route numbers may be used in conjunction with Interstate Route markers where the U.S. Route leads into the Interstate Route, follows it for a reasonable distance, and then departs again from the Interstate Route."

Previously reported laboratory data conducted within this research study (5) demonstrated the wisdom of the latter AASHTO policy statement. We believe that a "reasonable distance" is not greater than about 50 miles. This 50 miles distance is the result obtained from a laboratory study in which the motorists were asked how far after they had joined an interstate and how far in advance of this exit would they like to have concurrent information presented. It would appear that continuous redundant Interstate-U.S. concurrent signing is not required nor suggested in AASHTO's Interstate Policy. Toward this precept, other states including California, have wisely eliminated redundant U.S. signing such as U.S. 90, U.S. 80 and U.S. 66 from Interstates. So have most of the other states inventoried in this research effort.

CONCLUSIONS

The conclusions to follow are drawn from the field inventory data of the ten selected cities in the United States and previously reported research (5) and are founded heavily on basic precepts of driver expectancy (1).

1. Ft. Worth and Houston have more signs per mile than would be expected by most out-of-state drivers.
2. Sign spacings of 1000 feet or less would not be expected by most urban freeway motorists.
3. Los Angeles and Houston are the only two cities that extensively use median mounted destination and distance sequence signs. Denver has installed one system of these signs.
4. The 85%-tile and 95%-tile bit levels of all overhead guide signs, excluding the ramp exit panel, were found to be 15 bits and 18 bits, respectively. Less than 1% of all signs had more than 21 bits of information on them.
5. Texas cities tend to have most of the large, cluttered signs observed in the United States. Only one sign having more than 20 bits of information on them.
6. Texas has a slightly higher usage of the larger multi-panel signs. There were 45 signs in the Texas inventory having 4 main-lane sign panels while there were only 22 such signs observed in the total out-of-state inventory.

7. The "busiest" sign panels per sign, on the whole, are found in Texas. Dallas and San Antonio have 19 sign panels with over 8 bits of information on them.
8. The median (50%-tile) information bit level per largest panel was found to be 5 bits and the 85%-tile level was about 7 to 8 bits.
9. Texas stands almost alone in the continued use of redundant concurrent signing of an Interstate freeway with U.S. route numbers. A total of 392 sign panels in Texas were observed to contain Interstate and U.S. route numbers. In five of the six out-of-state cities, only one (1) similar sign panel was observed. Only Kansas City has similar signing problems.
10. A total of 4% of all of the Texas guide sign inventory had signs with three (3) route (panels) containing concurrent route information. No such signing was noted in the out-of-state inventory.
11. There are a few signing locations in Texas where the combination of a large number of concurrently signed intersecting routes are combined with a high-speed, large multi-lane freeway facility to result in signing plans which are likely to surprise and overload unfamiliar out-of-state motorists.
12. AASHTO's Interstate signing policy does not appear to support the redundant, concurrent signing of an Interstate with a U.S. route over a long distance (say over 50 miles) as is commonly found in Texas.

RECOMMENDATIONS

The following recommendations are offered as tentative guidelines and direction for improving the quality of urban freeway guide signing in Texas' urban cities:

1. A desirable maximum bit rate of about 16 bits per sign is still recommended based on driver expectancy considerations. (See Reference 5.)
2. An absolute maximum bit range of 20 bits per sign is likewise still recommended (5).
3. A desirable maximum bit rate per panel of 6 bits, and an absolute maximum of 8 bits per panel are recommended.
4. Begin a well planned systemmatic reduction of redundant U.S. numbered routes from the Interstate freeways of Texas.
5. Identify and improve the quality of signing along the urban freeways of Texas that have signing attributes which are unexpected by out-of-state motorists.
6. Unfamiliar motorists, at present, are forced to read all of the guide signs as they approach a large urban area. With the increase in the number of guide signs and the volume of traffic approaching and within these large urban areas it is becoming increasingly difficult for these motorists to do this. We recommend that Advance Sequence Guide Sign, similar to that in Figure 6-1, page 6-5, be used as ground mounted signs several miles away from the first major interchange. In this way the unfamiliar motorist is alerted to the fact that they will travel several miles before they get to their destination. This type of signing would allow the drivers more time to drive their vehicles and free them from reading a large number of signs until they get to the location at which they must find the appropriate sign to guide them to their destination.

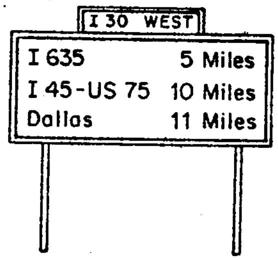


Figure 6-1 - Advance Sequence Guide Sign

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CHAPTER 7

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